Review of

Cardiac Anesthesia

With 2,100 MCQs

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For All Examinations in Cardiac Anesthesia

DM FNB FIACTA and Perioperative TEE Fellowship Examinations

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K Muralidhar **Rajiv Juneja** **Naman Shastri**

Foreword

Navin C Nanda

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Review of Cardiac Anesthesia with 2,100 MCQs

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Dedicated to

My father and family

Dr KK Malhotra
(4.7.1929–4.1.2011)

My mentor, guide and inspiration in life
An extraordinary physician and human being with boundless affection, witty, hardworking and godly qualities

Foreword

It gives me an immense pleasure to write a foreword of *Review of Cardiac Anesthesia with 2,100 MCQs* written by Dr Poonam Malhotra Kapoor of All India Institute of Medical Sciences, New Delhi, India.

It is also pleasing to see an MCQ book entirely devoted to in-depth coverage of all aspects of cardiac anesthesia with traditional topics on drugs for cardiovascular diseases to congenital heart disease, embryology and rheumatic problems of valves pertinent to the Indian subpopulation. The book also has MCQs on rapidly developing areas like extracorporeal membrane oxygenation (ECMO), critical care and echocardiography which placed good coverage in this book. Explanations to the MCQs also add value to the book.

Setting MCQs for an examination is not an easy task. The author has done a good job to make them topic-wise, relevant and realistic for examination purpose. It shall be very useful to the students especially for those preparing for various competitive examinations. I feel Dr Malhotra's long stint at AIIMS, has honed her expression as an author and skills as a teacher, helping to prepare candidates for examinations in the superspecialty field of cardiac anesthesia. With her academic and research experience, she has added the freshness of a young teacher to the perspective of the book which has also been benefited tremendously by a very experienced faculty of cardiac anesthetists in India as section editors like Dr Yatin Mehta, Dr Deepak Tempe, Dr K Muralidhar, Dr R Gopinath, Dr Rajeev Juneja and Dr Naman Shastri. These globally renowned teachers have enriched the flavor of this objective mode of assessment in examinations. The 'MCQ Pattern' added great value to the book. Medical students in India are traditionally depended upon Western books for knowledge and information. The situation is changing now with many Indian authors coming up in all subjects but this is the first book of its kind in cardiac anesthesia and all concerned are masters on the subject. I myself have been an active onlooker of the Society of Cardiac Anesthesia, Delhi and NCR Branch (in the last two years), under whose 'aegis' this book is being promoted. It is a young and vibrant academic society and it is inspiring to see senior and founder members of the association, come together and fill a void in MCQ assessment by writing the book.

I congratulate the authors and hope that the book gains success, it deserves. I strongly recommend this student-friendly book to all examinees and examiners of cardiac anesthesia.

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President, International Society of Cardiovascular Ultrasound (ISCU)

Preface

The book containing 2,100 MCQs in cardiac anesthesia is the first of its kind in the young subject of cardiac anesthesia. It is an important contribution about the study of the subject from the examination point of view. I am delighted with this interactive assessment book entitled *Review of Cardiac Anesthesia with 2,100 MCQs*. Examination on any subject is a must for progress. The backbone of any examination today is multiple choice questions. They guide the examinees toward the examination trends. The book is a powerful and most welcome statement about the place of examination trending in the evolving and ever-growing subject of cardiac anesthesia and the 3 sections have contributors as section editors from renowned names in cardiac anesthesia like Dr Yatin Mehta, Dr Deepak Tempe, Dr R Gopinath, Dr K Muralidhar, Dr Rajiv Juneja and Dr Naman Shastri. I shall always remain indebted to each of them for their contribution.

The book is a compilation of echocardiography information and transesophageal echocardiography (TEE) stills and videos from perioperative TEE and transthoracic echocardiography (TTE) with explanations in Section 2 and about 250 questions in Section 3 on upcoming topics like critical care and ECMO.

Competing technology, miniaturization, real time 3D TTE and TEE, extracorporeal membrane oxygenation (ECMO) (Perioperative and postoperative), critical care and infection control are modern tools of cardiac anesthesia, which have enhanced the position of a cardiac anesthetist from a mere giver of drugs to a perioperative physician performer doing activities like performing local, GA and hemodynamic monitoring, pain relief and patient outcome monitor measures in ICU—making him all incharge of the patient. Also, with the growing field has come a growth in examinations. The book aims at the latter with videos, tables and figures in a simplistic manner for each of the 37 chapters. Explanation in the echocardiography section, makes Section 2—easy and good reading. I hope you enjoy the basic book on *Review of Cardiac Anesthesia with 2,100 MCQs* which is informative and easy-to-use.

I am sure, the book will fully meet the requirements of students preparing for all examinations in cardiac anesthesia like DM, FNB, FIACTA and perioperative TEE examinations.

Poonam Malhotra Kapoor

Acknowledgments

I would like to thank my office staff at All India Institute of Medical Sciences, New Delhi, India, consisting of Sandeep Kumar, Pradeep Kumar, Sachin, Poonam and Manoj Mishra for their continuous, laborious arduous, day-to-day compilation of this manuscript. Without their ongoing enthusiastic efforts, this book would not have seen this day. I would especially like to thank Dr Yatin Mehta, Dr Naman Shastri, Dr Varun Kapoor and Pranav Kapoor who inspired me into putting the book together.

I would like to acknowledge the residents of Cardiac Anesthesia Department, All India Institute of Medical Sciences, New Delhi, India, and students of FIACTA and those seeking Fellowship examinations in TEE for providing the much-needed stimulus that animated my efforts.

My family whom, I take for granted every second and my senior and junior colleagues in Department of Cardiac Anesthesia, All India Institute of Medical Sciences, New Delhi, India, deserve a heartfelt 'Thank you'. The SCA–Delhi and NCR is an ever-growing Banyan tree founded by Professor Nita Saxena and Dr Yatin Mehta, under whose aegis, academics and research will also flourish. Seniors like them, are rare. My good luck.

Finally, I would like to express my gratitude to Shri Jitendar P Vij (Group Chairman), Mr Ankit Vij (Managing Director), Mr Tarun Duneja (Director-Publishing) and staff of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India, for their guidance in making this book.

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Section 2: Perioperative TEE and Transthoracic Echocardiography

Section 3: Extracorporeal Membrane Oxygenation and Critical Care

1

Applied Anatomy and Physiology

1. Each of the following is located in the mediastinum, except the:
   a. Aorta
   b. Esophagus
   c. Heart
   d. Pancreas
   e. Trachea

2. Which of the following is the body cavity that contains the pituitary gland?
   a. Abdominal
   b. Cranial
   c. Pleural
   d. Spinal
   e. Thoracic

3. Which of the following closes and seals off the lower airway during swallowing?
   a. Alveoli
   b. Epiglottis
   c. Larynx
   d. Uvula
   e. Vocal cords

4. Which of the following controls body temperature, sleep, and appetite?
   a. Adrenal glands
   b. Hypothalamus
   c. Pancreas
   d. Thalamus
   e. Thyroid gland

5. Which of the following is a substance that aids the transmission of nerve impulses?
   a. Acetylcholine
   b. Cholecystokinin
   c. Deoxyribose
   d. Oxytocin
   e. Prolactin

6. Where is the sinoatrial node located?
   a. Between the left atrium and the left ventricle
   b. Between the right atrium and the right ventricle
   c. In the interventricular septum
   d. In the upper wall of the left ventricle
   e. In the upper wall of the right atrium

1. d 2. b 3. b 4. b 5. a 6. e

7. Exhaled air, when compared with inhaled air, contains more:
   a. Carbon dioxide and less oxygen
   b. Nitrogen and less carbon dioxide
   c. Oxygen and less carbon dioxide
   d. Oxygen and less carbon monoxide
   e. Oxygen and less nitrogen

8. In the lungs, gas exchange occurs in tiny one-celled air sacs called:
   a. Alveoli
   b. Bronchi
   c. Bronchioles
   d. Capillaries
   e. Pleurae

9. A structure composed of two or more tissues is termed:
   a. Organ
   b. Serous membrane
   c. Complex tissue
   d. Organ system

10. The visceral pleura:
    a. Is the membrane lining surface of the lungs
    b. Is the membrane lining the wall of the thoracic cavity
    c. Is the fluid around the lungs
    d. Is the thinnest portion of the peritoneum

11. The anatomical position is characterized by all of the following except:
    a. Arms facing posterior
    b. Thumbs pointing laterally
    c. Face pointing anteriorly
    d. Body standing upright

12. Which of the following lies fully ipsilateral to the left iliac region?
    a. Epigastric region
    b. Left hypochondriac region
    c. Right inguinal region
    d. Hypogastric region

13. The "basic unit of life" is:
    a. The atom
    b. Water
    c. The cell
    d. The chemical level of organization

14. A homeostatic imbalance:
    a. Must be restored by negative feedback mechanisms
    b. Is considered the cause of most diseases
    c. Is when the internal conditions of the body become more stable
    d. Only occur when positive feedback mechanisms are overwhelmed

15. Which of the following is NOT a characteristic of life?
    a. Growth
    b. Responsiveness
    c. Reproduction
    d. Organ systems

16. The sum of all chemical reactions in the body is termed:
    a. Homeostasis
    b. Physiology
    c. Dynamic feedback
    d. Metabolism

17. A vertical plane through the body dividing it into right and left is termed:
    a. Sagittal
    b. Lateral
    c. Transverse
    d. Frontal

7. a 8. a 9. a 10. a 11. a 12. b 13. a 14. b
15. d 16. d 17. a

18. Which of the following is an example of applied physiology?
    a. Measuring the length of the femur on a fetus using ultrasound
    b. Locating an injury to a tendon in the shoulder using CT imaging
    c. Describing the process of how a toxin interferes with nerve impulse conduction
    d. Identifying the types of cells found in a biopsy sample of lung tissue

19. The elbow is _____ to the wrist:
    a. Distal
    b. Lateral
    c. Ventral
    d. Proximal

20. The heart is ____ to the lungs:
    a. Superior
    b. Dorsal
    c. Medial
    d. Lateral

21. What is the function of serous membranes?
    a. To prevent fluid loss from an organ
    b. To reduce friction between internal organs
    c. To circulate blood around the organ
    d. To conserve heat within the organ

22. Histology is the study of:
    a. Cells and membranes
    b. Skin
    c. Organs and organ systems
    d. Tissues

23. Which of the following involves the injection of radioisotopes into the body?
    a. Radiography
    b. PET
    c. Plain CT scan
    d. Echocardiograph

24. _____ occurs when carbon dioxide is eliminated faster than it is produced.
    a. Respiratory alkalosis
    b. Respiratory acidosis
    c. Metabolic acidosis
    d. Metabolic alkalosis

25. The most important ECF buffer of HCl is _____.
    a. CO_2
    b. Sodium bicarbonate
    c. Heparin
    d. Progesterone

26. Molecules that can act reversibly as acids or bases depending upon the pH of their environment are called _____.
    a. Amphoteric
    b. Phosphoric
    c. Buffer
    d. Acidotic

27. Arterial blood pH below 7.35 is called _____.
    a. Alkalosis
    b. Respiratory alkalosis
    c. Acidemia or acidosis
    d. Respiratory acidosis

28. _____ reduces blood.
    a. Atrial natriuretic peptide
    b. Brain natriuretic peptide
    c. Procalcitonin
    d. Rennin

18. c 19. d 20. c 21. b 22. d 23. a 24. a 25. b
26. a 27. c 28. a

29. When the blood becomes hypertonic (too many solutes), ADH is released. What is the effect of ADH on the kidney tubules?
    a. The release of ADH causes the kidney tubules to reabsorb excess water, resulting in the excretion of concentrated urine.
    b. Excretion of dilute urine
    c. Acidosis
    d. Alkalosis

30. Only _____ muscle cells are always multinucleated.
    a. Skeletal
    b. Gastric
    c. Cardiac
    d. Neural

31. The time in which cross bridges are active is called the period of _____.
    a. Relaxation
    b. Contraction
    c. Insertion
    d. Excursion

32. Only _____ muscle cells commonly branch.
    a. Skeletal
    b. Cardiac
    c. Neural
    d. Gastric

33. A smooth, sustained contraction is called _____.
    a. Tetanus
    b. Relaxation
    c. Contraction
    d. Limping

34. The AV node is found near which two valves?
    a. MV and AV
    b. MV and TV
    c. MV and PV
    d. AV and PV

35. The blood supply to the AV node is:
    a. Branch of RCA
    b. Branch of LAD
    c. Branch of LM artery
    d. Branch of circumflex

36. The duration of action potential from the SA node to the ventricular muscle is:
    a. 1-2 ms
    b. 4-5 ms
    c. 200-300 ms
    d. 300-400 ms

37. The automatic innervations of the heart is from the:
    a. Stellagate ganglion alone
    b. Vagus nerve alone
    c. Both stellate ganglion and vagus
    d. None of the above

38. Noradrenaline binds to which receptors on pacemaker cells of SA node to enhance Ca^{2+} influx:
    a. α_1 receptors
    b. β_1 receptors
    c. α_2 receptors
    d. β_2 receptors

39. The AP conduction velocities in the cardiac conduction system across the different tissues of the heart is maximum for:
    a. SA Node
    b. AV node
    c. Purkinje system
    d. Bundle of HIS

29. a 30. a 31. b 32. b 33. a 34. b 35. b 36. d
37. c 38. b 39. c

40. The concentration of Ca^{2+} in the ECF and the SR is _____ than the concentration in cardiomyocyte cytoplasm:
    a. Greater than 10,000
    b. Less than 10,000
    c. Same
    d. None of the above

41. In a pressure volume loop relationship in a cardiac cycle, the area under the curve represents:
    a. Cardiac output
    b. Oxygen delivery
    c. Stroke work
    d. Peripheral resk

42. M_1, M_2, M_3 receptors are related to:
    a. Epinephrine
    b. Norepinephrine
    c. Acetylcholine
    d. Dopamine

43. Under physiological conditions both noradrenaline and adrenaline mediate coronary vasodilation due to their:
    a. β1 effect
    b. β2 effect
    c. α1 effect
    d. α2 effect

44. Acetylcholine is a potent coronary:
    a. Vasodilator
    b. Vasoconstrictor
    c. Both
    d. None of the above

45. Control of microcirculation is heterogenous between different vascular microdomain and is modulated by all, except:
    a. Endothelial
    b. Metabolic
    c. Neurogenic
    d. Nonmyogenic

46. Flow dependent vasodilation of intermediate arteriols and small arteries (140-300 μm):
    a. ↑ coronary blood flow
    b. ↑ oxygen supply
    c. Both the above
    d. None of the above

47. "Snow storm" appearance is a USG finding seen in:
    a. Ectopic pregnancy
    b. Hydatidiform mole
    c. PCOD
    d. Incomplete abortion

48. According to WHO, low birth weight means weight less than:
    a. 1 kg
    b. 2 kg
    c. 2.5 kg
    d. 3 kg

49. All of the following are morphologic features of apoptosis except:
    a. Cell shrinkage
    b. Chromatin condensation
    c. Inflammation
    d. Apoptotic bodies

50. All of the following are true about internal jugular vein except:
    a. Inferior thyroid vein drains into it
    b. Superior thyroid vein drains into it
    c. Vagus nerve is posteromedial to it in carotid sheath
    d. Use by the surgeon as a guide in neck dissection for lymph node removal

51. Best investigation to detect pneumoperitoneum is:
    a. Plain X-ray abdomen, erect
    b. Left lateral decubitus
    c. Plain X-ray chest, erect
    d. CT Scan

40. a 41. c 42. c 43. a 44. a 45. d 46. c 47. d
48. c 49. c 50. a 51. c

52. Beta-blocker toxicity is treated by:
    a. Glucagon
    b. Isoproterenol
    c. Atropine
    d. Dopamine

53. Blood agar is an example of:
    a. Enrichment media
    b. Enriched media
    c. Selective media
    d. Transport media

54. Myocardial oxygen demand is maximally increased with:
    a. Halothane
    b. Ether
    c. TCE
    d. N_2O

55. Fast anterograde transport occurs at a rate of about:
    a. 40 mm/day
    b. 400 mm/day
    c. 1 mm/day
    d. 10 mm/day

56. The resting cardiac muscle cell is most permeable to:
    a. Na
    b. K
    c. Ca
    d. Cl

57. The membrane potential of cardiac muscle cells is most affected by even a small change in plasma concentration of:
    a. Na
    b. K
    c. Cl
    d. Ca

58. Hypokalemia would be expected to result in:
    a. Increased neuronal excitability
    b. A more negative RMP
    c. No change in RMP
    d. A decrease in firing level of neurons

59. The number of Na channels per square micrometer of membrane in myelinated mammalian neurons is maximum in the:
    a. Cell body
    b. Dendritic zone
    c. Initial segment
    d. Node of Ranvier

60. The site of origin in the nerve of conducted impulses is the:
    a. Dendritic zone
    b. Axon hillock
    c. Node of Ranvier
    d. Terminal buttons

61. In motor neurons, the portion of the cell with the lowest threshold for the production of a fullfledged action potential is:
    a. Initial segment
    b. Soma
    c. Dendritic zone
    d. Node of Ranvier

62. Action potential conduction velocity is influenced by:
    a. Axon diameter
    b. Temperature
    c. Myelination
    d. All of the above

63. In the CNS, the membranes that wrap around myelinated neurons are those of:
    a. Schwann cells
    b. Oligodendroglia
    c. Endothelial cells
    d. Astrocytes

52. a 53. b 54. a 55. b 56. b 57. b 58. b 59. d
60. b 61. a 62. d 63. b

64. The duration of action potential in a skeletal muscle fiber is typically:
    a. 5 ms
    b. 25 ms
    c. 200 ms
    d. 250 ms

65. When heart rate is about 75 beats per minute, what is the mean duration of action potential in ventricular muscle cells?
    a. 5 ms
    b. 25 ms
    c. 200 ms
    d. 250 ms

66. The force of muscle contraction cannot be increased by:
    a. Increasing the frequency of activation of motor units
    b. Increasing the number of motor units activated
    c. Increasing the amplitude of action potentials in motor neurons
    d. Recruiting larger motor units

67. An excitable cell has an RMP of -70 mV and a firing level of - 50 mV. This cell would be inexcitable when its membrane potential is:
    a. - 30 mV
    b. - 55 mV
    c. - 70 mV
    d. - 90 mV

68. For the same conditions (as in the above question), the cell would be most excitable when its membrane potential is:
    a. - 30 mV
    b. - 55 mV
    c. - 70 mV
    d. - 90 mV

69. Although the equilibrium potential of Na is + 60 mV, the membrane potential does not reach this value during the overshoot because:
    a. The concentration gradient of Na is reversed
    b. Na channels undergo rapid inactivation
    c. K efflux commences immediately after the upstroke
    d. The membrane is impermeable to Na

70. Which one of the following statements about electrotonic potentials is incorrect?
    a. They are graded responses
    b. They are local (non-propagated) responses
    c. They may be depolarizing or hyperpolarizing
    d. They are produced by a threshold stimulus

71. Thin filaments do not contain:
    a. Actin
    b. Myosin
    c. Troponin
    d. Tropomyosin

72. The ATPase activity of which of the following proteins is altered to regulate skeletal muscle contraction?
    a. Actin
    b. Myosin
    c. Troponin
    d. Tropomyosin

73. The activity of which contractile protein is altered to regulate smooth muscle contraction?
    a. Actin
    b. Myosin
    c. Calmodulin
    d. Tropomyosin
    e. All of the above

64. a 65. d 66. c 67. a 68. b 69. d 70. b 71. b
72. b 73. c

74. Smooth muscle lacks:
    a. Actin
    b. Myosin
    c. Troponin
    d. Tropomyosin

75. An example for non-syncytial smooth muscle is:
    a. Iris
    b. Sphincter of Oddi
    c. Vas deferens
    d. Uterus

76. The twitch duration in fast type skeletal muscle fibers is about:
    a. 10 ms
    b. 50 ms
    c. 100 ms
    d. 250 ms

77. The major source of calcium for contraction of skeletal muscle is:
    a. ECF
    b. Cytosol
    c. Mitochondria
    d. Sarcoplasmic reticulum (SR)

78. Ryanodine receptor is located in the:
    a. Sarcolemma
    b. T-tubule
    c. Terminal cisterns of sarcoplasmic reticulum
    d. Cytosol

79. Which of the following blocks the ryanodine receptor?
    a. Dantrolene
    b. Curare
    c. Cocaine
    d. Hexamethonium
    e. All of the above

80. Which of the following slow the relaxation process in skeletal muscle?
    a. Slow myosin ATPase
    b. Inhibition of Ca-Mg ATPase
    c. ATP depletion
    d. None of the above

81. Rigor mortis is due to:
    a. Damage to actin and myosin
    b. Rapid sequestration of Ca in ER
    c. Increased myosin ATPase
    d. ATP depletion

82. Staircase phenomenon (Treppe) is due to:
    a. Increased availability of calcium
    b. Summation
    c. Tetanus
    d. Increased excitability

83. Which of the following statements regarding type I muscle fibers is incorrect?
    a. They are rich in myoglobin
    b. Their oxidative capacity is high
    c. Their myosin ATPase activity is high
    d. Their glycolytic capacity is moderate

84. Which of the following is incorrect about type II muscle fibers?
    a. They are called slow fibers
    b. Their myosin ATPase activity is high
    c. They contain little myoglobin
    d. They are rich in glycolytic enzymes

74. a 75. a 76. d 77. c 78. a 79. e 80. b 81. a
82. c 83. a 84. c

85. Which of the following statements is incorrect?
    a. Contraction against a constant load with approximation of the ends of the muscle is called isotonic contraction
    b. Contraction can occur without an appreciable decrease in the length of the muscle
    c. Isometric contractions do work whereas isotonic contractions do not
    d. Muscles can lengthen while doing work

86. The smallest amount of muscle that can contract in response to excitation of a single motor neuron is:
    a. 1 muscle fiber
    b. A muscle fasciculus
    c. The entire muscle
    d. All muscle fibers supplied by that neuron

87. The size of the motor unit is smallest in:
    a. Type II muscle fibers
    b. Single-unit smooth muscle
    c. Orbicularis oculi
    d. Soleus

88. Gradation of force in skeletal muscle is not achieved by:
    a. Increasing intracellular calcium
    b. Recruitment of motor units
    c. Size principle
    d. Asynchronous firing of motor units
    e. Varying release of calcium from SR

89. Regarding the ionic basis of action potential in cardiac muscle cells, which one of the following is incorrect?
    a. Phase 0: Na influx
    b. Phase 1: K influx
    c. Phase 2: Ca influx
    d. Phase 3: K efflux

90. When heart rate is about 75 beats/min, the duration of absolute refractory period of cardiac muscle is:
    a. 50 ms
    b. 100 ms
    c. 200 ms
    d. 300 ms

91. When heart rate is about 75 beats/min, the duration of ventricular systole is about:
    a. 0.1 s
    b. 0.2 s
    c. 0.3 s
    d. 0.5 s

92. Which of the following muscle types is the 'fastest'?
    a. Skeletal muscle
    b. Smooth muscle
    c. Cardiac muscle

93. Which of the following characteristics is exhibited only by skeletal muscle?
    a. Gradation of force production
    b. Refractoriness
    c. Beneficial effect
    d. Staircase phenomenon
    e. None of the above

94. Non-linearity of length-tension relationship is most evident in:
    a. Skeletal muscle
    b. Smooth muscle
    c. Cardiac muscle

85. d 86. c 87. c 88. b 89. c 90. c 91. a 92. c
93. b 94. c

95. In adults, intravesical pressure rises suddenly when intravesical volume reaches about:
    a. 100 mL
    b. 200 mL
    c. 300 mL
    d. 400 mL

96. The latch-bridge mechanism in smooth muscle is responsible for:
    a. Fast muscle twitch
    b. Sustained muscle contraction
    c. Excitation-contraction coupling
    d. Unstable membrane potential

97. The minimum stimulus strength that produces a compound action potential in nerve or muscle is:
    a. Rheobase
    b. Chronaxie
    c. Twice rheobase
    d. Twice chronaxie

98. Which one of the following accelerates contraction as well as relaxation of heart muscle?
    a. Norepinephrine
    b. Calcium
    c. Digoxin
    d. Potassium

99. Which of the following statements about cardiac muscle is incorrect?
    a. Summation cannot occur
    b. It is a 'fast' muscle
    c. Slow myosin ATPase activity
    d. It contains myoglobin

100. Which nerve fiber type is most susceptible to conduction block by local anesthetics?
    a. Type A
    b. Type B
    c. Type C
    d. Type D

95. b 96. a 97. a 98. b 99. c 100. c

2

Cardiac Embryology and Anatomy

1. The heart develops entirely from the:
   a. Splanchnic mesoderm
   b. Endocardial germ cells
   c. Bulbis cordis
   d. Endothelial cells

2. The heart starts to beat in the:
   a. 3rd week of gestation
   b. 4th week of gestation
   c. 2nd week of gestation
   d. 5th week of gestation

3. All of the following close at birth, except:
   a. Umbilical vessels
   b. Ductus venosus
   c. Foramen ovale
   d. Ductus arteriosus

4. Opposite the foramen ovale lays the opening of tone of the important structures of the heart:
   a. SVC
   b. IVC
   c. RA
   d. LA

5. The fetal circulation differs from the adult circulation in that:
   a. High SVR
   b. Low SVR
   c. High PVR
   d. Low PVR

6. After birth, in transitional circulation, the PVR=SVR at:
   a. 10 hrs
   b. 24 hrs
   c. 36 hrs
   d. 48 hrs

7. The oblique sinus is:
   a. A blind recess behind the LA bounded by the four pulmonary veins and the IVC
   b. A blind recess between the aorta and PA
   c. A blind recess between the 2 layers of pericardium
   d. A blind recess between the RA, RV, and small strip of LV

8. The anterior cardiac veins drain into the:
   a. Anterior part of RV
   b. Anterior part of LV
   c. Posterior part of LV
   d. Posterior part of RV

1. a 2. a 3. c 4. b 5. c 6. b 7. a 8. a

9. The apex of the heart is supplied by branches from the:
   a. Circumflex artery
   b. LAD
   c. LMA
   d. RCA

10. Which one of the following statements is true about coronary sinus?
   a. Majority of venous blood drains via the coronary sinus into the RA
   b. It is 2-3 cm in length
   c. It lies adjacent to the circumflex artery in the left posterior A-V groove
   d. All of the above are correct

11. One of the following statements is false:
   a. The venous drainage of the anterior RV always enters the coronary sinus
   b. The posterior descending artery arises from the right coronary artery in 85% of patients
   c. In the fetal circulation, oxygenated blood is directed across the foramen ovale into the LA to supply the head and arms
   d. The RCA arises from the anterior aortic sinus

12. A derivative of the intra-embryonic coelom:
   a. Foregut
   b. Allantois
   c. Midgut
   d. Pericardial cavity
   e. Hindgut

13. Paired heart tubes are derived from:
   a. Ectoderm
   b. Endoderm
   c. Neural crest
   d. Notochord
   e. Mesoderm

14. Paired heart tubes are derived from:
   a. Paraxial mesoderm
   b. Intermediate mesoderm
   c. Cardiogenic mesoderm
   d. Somatic mesoderm
   e. Splanchnic mesoderm

15. The parietal pericardium is derived from:
   a. Paraxial mesoderm
   b. Intermediate mesoderm
   c. Head mesenchyme
   d. Lateral plate somatic mesoderm
   e. Lateral plate splanchnic mesoderm

16. The visceral pericardium is derived from:
   a. Paraxial mesoderm
   b. Intermediate mesoderm
   c. Head mesenchyme
   d. Lateral plate somatic mesoderm
   e. Lateral plate splanchnic mesoderm

17. Lymphatic vessels are derived from:
   a. Surface ectoderm
   b. Endoderm
   c. Neural crest
   d. Neural ectoderm
   e. Mesoderm

18. Blood vessels are derived from:
   a. Surface ectoderm
   b. Endoderm
   c. Neural crest
   d. Neural ectoderm
   e. Mesoderm

9. b 10. c 11. a. 12. d 13. e 14. c 15. d 16. e
17. e 18. e

19. Incomplete fusion of the endocardial cushions is usually associated with which of the following types of atrial septal defects?
    a. Primum
    b. Secundum
    c. Probe patent
    d. Common atrium
    e. Sinus venosus

20. The fetal left atrium is mainly derived from the:
    a. Sinus venosus
    b. Right pulmonary vein
    c. Primitive pulmonary vein
    d. Primitive atrium
    e. Sinus venarum

21. The most common type of defect of the cardiac septa is a:
    a. Muscular ventricular septal defect
    b. Primum atrial septal defect
    c. Secundum atrial septal defect
    d. Sinus venosus atrial septal defect
    e. Membranous ventricular septal defect

22. Lymphatic vessels are derived from:
    a. Lateral plate mesoderm
    b. Somitic mesoderm
    c. Mesenchyme
    d. Intermediate mesoderm
    e. All of the above

23. Closure of the foramen primum results from the fusion of the:
    a. Septum primum and the septum secundum
    b. Septum primum and the endocardial cushions
    c. Septum secundum and the septum spurium
    d. Septum secundum and the endocardial cushions
    e. Septum primum and the right sinoatrial valve

24. The fetal right atrium is mainly derived from the:
    a. Primitive pulmonary vein
    b. Primitive atrium
    c. Sinus venarum
    d. Sinus venosus
    e. Right pulmonary vein

25. The cardiovascular system reaches a functional state at the end of the _____ week:
    a. First
    b. Second
    c. Third
    d. Fourth
    e. Fifth

26. The most common congenital malformation of the heart and great vessels associated with the congenital rubella syndrome is:
    a. Coarctation of the aorta
    b. Tetralogy of Fallot
    c. Patent ductus arteriosus
    d. Atrial septal defect
    e. Ventricular septal defect

27. The 3rd pair of aortic arches gives rise to which of the following arteries ?
    a. External carotid
    b. Common carotid
    c. Superficial temporal
    d. Laryngeal
    e. Subclavian

19. a 20. c 21. e 22. e 23. b 24. d 25. c 26. c 27. b

28. In the fetal circulatory system mixing of oxygenated and deoxygenated blood occurs in all of the following, except:
    a. Ductus arteriosus
    b. Inferior vena cava
    c. Left atrium
    d. Liver
    e. Lungs

29. Which of the following statements is not correct?
    a. The sinus venosus serves as the pacemaker of the heart of the young embryo
    b. The septum primum completely divides the developing atrium into right and left compartments
    c. In the adult heart, the sinus venous is represented by the sino-atrial node
    d. The two endocardial cushions divide the atrioventricular (AV) canal into the right tricuspid and left bicuspid (mitral) canals
    e. The fusion of the right superior truncus swelling with the left inferior truncus swelling forms the aorticopulmonary septum

30. Which of the following statements is not correct?
    a. The trabeculated portion of the right atrium is derived from the right horn of the sinus venosus
    b. The coronary sinus is derived from the left horn of the sinus venosus
    c. The epicardium is synonymous with the visceral layer of pericardium (visceral pericardium)
    d. At the fourth week, each horn of the sinus venosus receives blood from the vitelline (omphalomesenteric) vein, the umbilical vein, and the common cardinal vein
    e. The valve of the inferior vena cava is derived from the right venous valve of the right horn of the sinus venosus

31. Which of the following is not part of the tetralogy of Fallot?
    a. Pulmonary infundibular stenosis
    b. Interventricular septal defect
    c. Aorta arising from both ventricular cavities (dextroposition of the aorta)
    d. Hypertrophy of the right ventricular wall
    e. Interatrial septal defect

32. Which of the following statements is not correct?
    a. The heart and great vessels originate from mesoderm
    b. The ostium secundum defect may be due to excessive resorption of the septum primum
    c. The ostium secundum defect may be due to inadequate development of the coronary sinus
    d. Failure of the truncoconal septum to follow its normal spiral course can lead to transposition of the great vessels
    e. The septum primum is located to the left of the septum secundum (in the anatomical position)

33. Which of the following statements is not correct:
    a. The third aortic arch forms the common carotid artery and the first part of the internal carotid artery
    b. On the left, the fourth aortic arch forms part of the arch of the aorta between the left common carotid artery and the left subclavian artery
    c. On the right, the fourth aortic arch forms the most proximal segment of the right subclavian artery
    d. On the left side, the sixth aortic arch forms the ductus arteriosus
    e. The maxillary artery is formed from the second aortic arch

28. c 29. c 30. a 31. e 32. c 33. e

34. Which of the following statements is not correct:
    a. The atrioventricular node and atrioventricular bundle of His are derived from cells in the left wall of the sinus venosus and from cells in the atrioventricular canal
    b. Probe patency of the foramen ovale does not permit shunting of blood from the right atrium to the left atrium in the neonate
    c. The ostium primum lies between the septum primum and the endocardial cushions
    d. The muscular portion of the interventricular septum is derived from the tissue of the endocardial cushions
    e. Most interventricular septal defects involve the membranous part of the interventricular septum

35. Tetralogy of Fallot includes each of the following except:
    a. Overriding aorta
    b. Right ventricular out flow obstruction
    c. Interventricular septal defect
    d. Transposition of the pulmonary artery
    e. Right ventricular hypertrophy

36. The sino-atrial node, the atrioventricular node, and the purkinje fibers of the heart develop from:
    a. Neurons from the spinal cord which migrate into the mesenchyme of the developing myocardium
    b. Cells from the neural crest which migrate into the developing myocardium
    c. Connective tissue fibers which are intrinsically capable of generating electrical activity
    d. Ectodermal cells which are intrinsically capable of generating electrical activity
    e. Mesodermal cells of the myocardium which become specialized conducting cardiac muscle cells

37. The tunica media of vessels of all types develops from the layer of the trilaminar embryo known as:
    a. Scleroderm
    b. Entoderm
    c. Mesoderm
    d. Ectoderm
    e. Neural crest

38. Arteries and veins of all caliber appear first in the embryo as typical:
    a. Arteries
    b. Lymphatic ducts
    c. Capillaries
    d. Veins
    e. Vasa vasorum

39. In the embryo, after the closed vascular system develops, new vessels always form:
    a. By "budding" from pre-existing vessels
    b. By the formation of mesenchymal "tubes" which connect to pre-existing channels
    c. By the invagination of ectodermal sprouts which connect to larger vessels
    d. By the evagination of ectodermal tubes which become arterial for the most part
    e. From the vacuolization of neural crest cell cylinders which form the model for new vessels

40. All of the following are dilatations formed in the primitive heart tube as the first indication of chamber formation except the:
    a. Sinus venosus
    b. Bulbus cordis
    c. Dorsal aorta
    d. Ventricle
    e. Aortic sac

34. d 35. d 36. e 37. c 38. c 39. a 40. c

41. The venous end of the primitive heart tube receives blood from all of the following, except:
    a. Vitelline arteries
    b. Vitelline veins
    c. Left umbilical vein
    d. Common cardinal vessels
    e. Right umbilical vein

42. The pulmonary trunk and aorta are formed by division of the truncus arteriosus by the formation of the:
    a. Septum primum
    b. Septum secundum
    c. Ventricular septum
    d. Aorticopulmonary septum
    e. Crista terminalis

43. The ductus arteriosus is a remnant of the left:
    a. Sixth aortic arch
    b. Fifth aortic arch
    c. Second aortic arch
    d. First aortic arch
    e. Third aortic arch

44. The pulmonary arteries are derivatives of the:
    a. First aortic arch
    b. Second aortic arch
    c. Fourth aortic arch
    d. Fifth aortic arch
    e. Sixth aortic arch

45. The third aortic arch arteries become on both sides of the:
    a. Pulmonary arteries
    b. Paired dorsal aorta
    c. Arch of the aorta
    d. Common carotid arteries
    e. Brachiocephalic arteries

46. The common iliac arteries are derived from enlargements of:
    a. A portion of the seventh cervical intersegmental arteries
    b. The fifth lumbar intersegmental arteries
    c. The middle sacral artery
    d. The intercostal arteries
    e. The umbilical arteries

47. The fetal left umbilical vein has an adult intrahepatic remnant known as the:
    a. Ligaments teres (hepatic)
    b. Ligamentum venosum
    c. Ligamentum arteriosum
    d. Inferior vena cave
    e. Falciform ligament

48. Capillaries, like all vessels, develop from embryonic:
    a. Endoderm
    b. Mesoderm
    c. Ectoderm
    d. Neural crest
    e. Notochord

49. Which of the following mesodermal populations gives rise to the cell mass from which the myocardium develops?
    a. Somatopleuric mesoderm
    b. Hypomeric mesoderm
    c. Epimeric mesoderm
    d. Splanchnopleuric mesoderm
    e. Prechordal plate mesoderm

41. a 42. d 43. a 44. e 45. d 46. b 47. b 48. b 49. d

50. During the remodeling of the inflow end of the heart, which of the following embryonic structures gives rise to the coronary sinus?
    a. Left horn of the sinus venosus
    b. Right anterior cardinal vein
    c. Left vitelline vein
    d. Right horn of the sinus venosus
    e. Left posterior cardinal vein

51. The definitive right atrium (excluding the right auricle) arise from the:
    a. Right pulmonary vein
    b. Left pulmonary vein
    c. Right vitelline vein
    d. Right horn of the sinus venosus
    e. Right anterior cardinal vein

52. During embryonic development, blood vessel formation by the process of vasculogenesis (*in situ* vesicle formation and fusion) begins first in which of the following embryonic tissues?
    a. Extraembryonic mesoderm of the primary yolk sac
    b. Extraembryonic endoderm of the definitive yolk sac
    c. Intraembryonic splanchnopleuric mesoderm
    d. Prechordal plate mesoderm
    e. Neural crest ectomesenchyme

53. In humans, the left fourth aortic arch gives rise to a portion of which of the following structures?
    a. Ductus arteriosus
    b. Arch of the aorta
    c. Left subclavian artery
    d. Left common carotid artery
    e. Left external carotid artery

54. The right recurrent laryngeal nerve loops under a derivative of which of the following aortic arches?
    a. Second aortic arch
    b. Third aortic arch
    c. Fourth aortic arch
    d. Fifth aortic arch
    e. Sixth aortic arch

55. The definitive renal arteries arise directly from:
    a. Vessels that sprout from the aorta at the pelvic level where the kidneys (metanephroi) originate
    b. Vessels that sprout from the aorta at the definitive, lumbar level of the kidneys (metanephroi)
    c. Vessels that initially sprout from the aorta to vascularize the suprarenal glands
    d. Arteries of the vitelline system
    e. Intersegmental arteries in the lumbar region

56. Which of the following embryonic vessels gives rise to the ductus venosus?
    a. Right umbilical vein
    b. Left umbilical vein
    c. Right and left umbilical veins
    d. Right and left vitelline veins
    e. Right and left supracardinal veins

57. The definitive thoracic duct of the lymphatic system is derived from which of the following combinations of embryonic lymphatic vessels?
    a. The caudal segment of the right lymphatic duct and the cranial segment of the left lymphatic duct
    b. The caudal and cranial segments of the right lymphatic duct
    c. The caudal segment of the left duct and the cranial segment of the right duct
    d. The caudal and cranial segments of the left duct
    e. The caudal and cranial segments of the right and left ducts

50. a 51. d 52. c 53. b 54. d 55. b 56. d 57. a

58. The ductus arteriosus is derived from the:
    a. Left fourth aortic arch
    b. Right fourth aortic arch
    c. Left fifth aortic arch
    d. Right fifth aortic arch
    e. Left sixth aortic arch

59. The arch of the aorta is derived from the:
    a. Left fourth aortic arch
    b. Right fourth aortic arch
    c. Left fifth aortic arch
    d. Right fifth aortic arch
    e. Left sixth aortic arch

60. The right auricle of the heart is derived from the:
    a. Primitive pulmonary vein
    b. Sinus venosus
    c. Right pulmonary vein
    d. Sinus venarum
    e. Primitive atrium

61. During embryonic development, blood vessel formation by the process of blood island formation begins first in which of the following tissues?
    a. Extraembryonic endoderm of the primary yolk sac
    b. Extraembryonic splanchnic mesoderm of the definitive yolk sac
    c. Intraembryonic splanchnic mesoderm of the definitive yolk sac
    d. Prechordal plate mesoderm
    e. Neural crest

62. The ductus arteriosus has an adult remnant known as the:
    a. Ligamentum teres
    b. Ligamentum venosus
    c. Ligamentum arteriosum
    d. Inferior vena cava
    e. Falciform ligament

63. All of the following statements are true with respect to development of the cardiovascular system except:
    a. Angioblasts (mesenchyme cells) condense to form blood islands in the extraembryonic mesoderm of the definitive yolk sac
    b. Angioblasts in the center of the blood islands form nucleated blood cells and plasma
    c. Blood formation begins in week 5 in the embryonic yolk sac, at week 6 in the liver, at 2.5 months in the spleen, and 2-3 months in the bone marrow
    d. Blood formation normally continues in the liver and spleen after birth
    e. Fetal hemoglobin predominates at birth

64. Vitelline vessels form:
    a. At the cranial end of the embryo
    b. At the caudal end of the embryo
    c. In the connecting stalk
    d. In the chorion
    e. On the yolk sac

65. The anterior cardinal vein forms:
    a. At the cranial end of the embryo
    b. At the caudal end of the embryo
    c. In the connecting stalk
    d. In the chorion
    e. On the yolk sac

66. The posterior cardinal vein forms:
    a. At the cranial end of the embryo
    b. At the caudal end of the embryo
    c. In the connecting stalk
    d. In the chorion
    e. On the yolk sac

58. e 59. a. 60. e 61. b 62. c 63. d 64. e 65. a 66. b

67. Umbilical vessels form:
    a. At the cranial end of the embryo
    b. At the caudal end of the embryo
    c. In the connecting stalk
    d. In the chorion
    e. On the yolk sac

68. Which of the following appear as a single vessel during early embryogenesis?
    a. Vitelline
    b. Cardinal
    c. Umbilical
    d. Branchial aorta
    e. None of the above

69. Which vessels carry the highest oxygenated blood?
    a. Aorta
    b. Umbilical arteries
    c. Vitelline veins
    d. Umbilical veins
    e. Cardinal veins

70. All of the following are true with respect to vessel formation except:
    a. Blood vessels arise from the aortic sac to supply each branchial arch
    b. The fifth aortic arch arteries persist as the subclavian arteries
    c. The left fourth arch artery persists as a part of the arch of the aorta
    d. The right sixth aortic arch becomes the right pulmonary artery
    e. The left sixth aortic arch becomes the left pulmonary artery and the ductus arteriosus

71. All of the following statements are true except:
    a. Two vitelline veins pass from the yolk sac to the sinous venosus of the heart
    b. Blood from the left umbilical vein becomes the predominant flow from the placenta
    c. The left umbilical vein crosses the liver to the inferior vena cava through the ductus venosus
    d. The left fourth arch artery persists as a part of the arch of the aorta

72. All of the following statements are true except:
    a. Two umbilical veins pass through the septum transversum from the placenta to the sinous venosus
    b. As the liver forms, a connecting branch develops between each umbilical vein and the vitelline vein network
    c. Even though these new (umbilical-vitelline) channels have formed, the umbilical veins still retain direct connections to the sinous venosus
    d. Blood from the left umbilical vein becomes the predominant flow from the placenta
    e. The left umbilical vein crosses the liver to the inferior vena cava through the ductus venosus

73. All of the following statements are true except:
    a. The portal veins forms from an anastomotic network of vitelline veins around the duodenum
    b. The portion of the left vitelline vein nearest the liver disappears
    c. Vestige of the left umbilical vein can be recognized as the fibrous ligamentum teres
    d. Vestige of the ductus venosus is the ligamentum venosum
    e. Two additional sets of veins develop near the cardinal veins: a ventral network called the subcardinal veins and a dorsal network called the supracardinal veins

74. The following is/are a derivative of the supracardinal veins:
    a. Renal veins
    b. Gonadal veins
    c. Suprarenal veins
    d. Iliac veins
    e. Hemiazygous vein

67. c 68. e 69. d 70. b 71. a 72. c 73. b 74. e

75. All of the following are true except:
    a. The oblique vein of the heart develops from an oblique connecting vessel between the two anterior cardinal veins
    b. The suprarenal vein develops from the subcardinal vein
    c. The hemiazygous vein and azygous vein are derivatives of the supracardinal veins
    d. The iliac veins are derivatives of the caudal portion of the posterior cardinal veins
    e. The gonadal veins develop from the supracardinal veins and anastomosis

76. All the following are true with respect to early heart development except:
    a. Paired endocardial heart tubes form from mesenchymal cardiogenic cords
    b. Surrounding splanchnic mesenchyme will later form the myocardium and epicardium
    c. The endocarial heart tubes remain paired to form the right and left sides of the heart
    d. The primitive heart is anchored at both ends: to the septum transversum caudally and to the aortic sac and aortic arches cephalically
    e. The outflow tract is composed of the truncus arteriosus and the bulbus cordis

77. The dilations of the embryonic heart tube consist of all of the following except:
    a. The primitive ventricle
    b. Truncus arteriosus
    c. The aortic sac
    d. The sinous venosus
    e. The primitive atrium

78. All the following are true with respect to heart development except:
    a. During weeks 2-3 the single heart tube is divided into four chambers
    b. The right and left sides of the heart are separated from each other by the endocardial cushions
    c. The endocardial cushions appear on the dorsal and ventral walls of the heart tube in the midline, grow toward one another, and fuse
    d. Fusion of the endocardial cushions result in the right and left atrioventricular canals
    e. Fusion of the endocardial cushions initiates the separation of the atria and ventricles of the heart

79. All the following are true with respect to heart development except:
    a. Two atria form when the septum primum grows from the dorsal wall and fuses with the endocardial cushion
    b. As the septum primum grows, the intervening gap between the wall and the cushion is called the foramen primum
    c. The foramen secundum appears in the superior border of the septum primum
    d. The foramen primum allows blood to flow from the left atrium to the right atrium
    e. Backflow of blood in the atria is prevented by the septum secundum which grows from the ventral wall and the right of the septum primum

80. All the following are true with respect to heart development except:
    a. The embryonic atrium is identifiable in the adult as the auricle
    b. The auricle is that region of the atrium with a smooth wall
    c. In the right atrium the smooth walls are tissues originating from the incorporated right horn of the sinus venosus
    d. The smooth wall of the left atrium is derived from the incorporated pulmonry veins
    e. The inferior border of the septum secundum is called the crista dividens

75. b 76. c 77. c 78. a 79. d 80. b

81. All the following are true with respect to heart development except:
    a. The muscular portion of the interventricular septum forms in the midline and grows towards the endocardial cushion
    b. The interventricular foramen persists until week 7, allowing communication between the two ventricles
    c. The interventricular foramen closes by the fusion of three membranes: the interventricular septum, the bulbar ridge, and the aorticopulmonary septum, forming the membranous part of the interventricular septum
    d. The smooth parts of the right and left ventricles are those regions of the bulbar ridge and the aorticopulmonary septum
    e. The right ventricle is formed primarily from the primitive ventricle, while the left ventricle forms from the bulbus cordis

82. All the following are true with respect to heart development except:
    a. The bulbus cordis and truncus arteriosus are separated longitudinally by a straight septum
    b. The bulbus cordis and truncus arteriosus form the ascending aorta and pulmonary trunk
    c. The sinoatrial node originally forms in the wall of the right horn of the sinus venosus. When the right horn is incorporated into the right atrium, the node is also incorporated
    d. The atrioventricular node and bundle form from cells in the atrioventricular canal region and the sinus venosus
    e. The sinoatrial node, and the atrioventricular node and bundle become richly innervated

83. All the following are true with respect to heart development except:
    a. As the bulboventricular loop forms, the primitive atrium is carried behind (dorsal to) the primitive ventricle
    b. The sinous venosus attached to the primitive atrium has a left and right horn with three vessels entering each horn
    c. The vessels entering each horn of the sinus venosus are the supracardinal, subcardinal, and posterior cardinal veins
    d. As the two atria form, the right horn of the sinus venosus which has enlarged is incorporated into the wall of the right atrium
    e. The embryonic atrium persists as the right auricle, the rough-walled appendage of the atrium

84. All the following are true with respect to heart development except:
    a. The smaller left horn of the sinus venosus forms the coronary sinus
    b. The right anterior cardinal vein contributes to the inferior vena cava
    c. The right vitelline vein contributes to the inferior vena cava
    d. The common cardinal veins contribute to the superior vena cava
    e. The left common cardinal vein forms the oblique vein of the heart

85. All the following are true with respect to heart development except:
    a. All of the valves of the heart form differently
    b. Subendocardial tissue swellings form at the site of the future valves
    c. These swellings subsequently hollow out to form cusps
    d. The valves of the aorta and truncus arteriosus form as the spiral septum separates the two vessels
    e. Originally four endocardial cushions arise, but two of the cushions are pinched and divided in half as the vessels form resulting in two sets of tricuspid valves

81. e 82. a 83. c 84. b 85. a

86. All the following are true with respect to fetal vascular supply except:
    a. The ductus venosus acts as a liver bypass to shunt blood to the heart
    b. Blood returning from the placental in the umbilical vein is deoxygenated
    c. As blood enters the fetus through the umbilical vein it is split into two halves
    d. Approximately half of the umbilical vein blood is directed through the portal sinus to the portal vein and through the heptic sinusoids. The blood then drains into the inferior vena cava
    e. The other half of the umbilical vein blood bypasses the liver by entering the ductus venosus and passing directly into the inferior vena cava

87. All the following are true with respect to fetal vascular supply except:
    a. The foramen ovale acts to shunt blood to the inflated lungs
    b. In the inferior vena cava, deoxygenated blood from the lower limbs, abdomen, and pelvis mixes with oxygenated umbilical vein blood and blood from the hepatic sinusoids
    c. Upon entering the right atrium of the heart, most of the blood from the inferior vena cava is directed through the foramen ovale by the inferior border of the septum secundum (crista dividens).
    d. After blood enters the left atrium, it mixes with a small amount of blood from the uninflated lungs.
    e. The blood in the left atrium then passes into the left ventricle and into the ascending aorta to supply the heart, head, neck, and upper extremities

88. All the following are true with respect to fetal vascular supply except:
    a. A small amount of blood in the right atrium mixes with deoxygenated blood from the superior vena cava and coronary sinus
    b. This small amount of right atrial blood passes into the right ventricle and into the pulmonary trunk
    c. Because of the high pulmonary resistance, most of this blood bypasses the lungs and passes through the ductus arteriosus into the aorta
    d. Approximately half of blood passing through the ductus arteriosus supplies the abdomen, pelvis, and lower limbs
    e. Approximately half of blood from the ductus arteriosus returns via the two umbilical veins to the placenta and is deoxygenated

89. All of the following are true with respect to vascular changes at birth except:
    a. At birth, the lungs expand and pulmonary resistance is reduced
    b. Decreased pulmonary resistance means a greatly increased blood flow passes through the pulmonary arteries to the lungs
    c. The ductus arteriosus then closes and will eventually form the fibrous ligamentum arteriosus of the adult
    d. The ductus venosus can remain patent as a developmental anomaly
    e. Blood returning through the pulmonary veins into the right atrium causes a decrease in pressure in the left atrium

90. All of the following are true with respect to vascular changes at birth except:
    a. Blood returning through the pulmonary veins into the left atrium causes an increase in pressure in the left atrium
    b. Increased pressure in the left atrium causes the septum primum to be pressed against the septum secundum
    c. The foramen ovale then remains functionally open
    d. In the adult, the site of the former septum primum is the floor of the fossa ovalis
    e. In the adult, the site of the former inferior edge of the septum secundum (crista dividens) is located at the limbus fossae ovalis (anulus ovalis)

86. b 87. a 88. e 89. e 90. c

91. All of the following are true with respect to vascular changes at birth except:
    a. During postnatal development, most of the umbilical vessels within the infant become ligamentous
    b. The umbilical vein forms the ligamentum teres
    c. Distally the umbilical arteries form the medial umbilical ligaments
    d. The ductus venosum forms the falciform ligament
    e. Proximally the umbilical arteries form the superior vesical arteries

92. All of the following are true with respect to congenital malformations of the heart and great vessels except:
    a. High atrial septal defect is due to persistance of the foramen ovale
    b. Low atrial septal defect is due to persistance of the interventricular foramen.
    c. A persistant foramen ovale can be caused by underdevelopment of the septum secundum
    d. A persistant foramen ovale can be caused by excessive resorption of the septum primum
    e. A persistant foramen ovale can be caused by a combination of c and d

93. Blood vessels eventually form in which of the following mesodermal tissues:
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. Extraembryonic mesoderm of the definitive yolk sac
    2. Prechordal plate mesoderm
    3. Intraembryonic splanchnopleuric mesoderm
    4. Neural crest ectomesenchyme

94. The adult inferior vena cava forms from the following primordia:
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. A terminal portion from the right vitelline vein and hepatic vein and sinusoids
    2. A segment cranial to the renal segment which is derived from the right subcardinal vein
    3. A renal segment formed from the anastomosis of the subcardinal and supracardinal veins
    4. A segment caudal to the renal segment formed from the right supracardinal vein

95. The foramen ovale consists of the following:
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. Septum secundum
    2. Septum primum
    3. Foramen secundum
    4. Forament primum

96. Vessels directly entering each horn of the sinus venosus include:
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. Common cardinal veins
    2. Supracardinal veins
    3. Vitelline veins
    4. Subcardinal veins

91. d 92. b 93. b 94. e 95. a 96. b

97. Vessels directly entering each horn of the sinus venosus include:
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. Supracardinal veins
    2. Vitelline veins
    3. Subcardinal veins
    4. Umbilical veins

98. Vessels directly entering each horn of the sinus venosus include:
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. Supracardinal veins
    2. Anterior cardinal veins
    3. Subcardinal veins
    4. Common cardinal veins

99. Which of the following are true with respect to heart development?
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. The early ventricular wall is composed of three layers: an outer myoepicardial mantel, a middle layer of cardiac jelly, and an inner layer of endothelial tissue
    2. Ingrowths from the myoepicardial mantel spread into the cardiac jelly
    3. The endothelial tissue grows out and ensheathes the myoepicardial ingrowths with epithelium
    4. The cardiac jelly disappears and the epithelial covered myoepicardial ingrowths form the trabeculae carneae, papillary muscles, and the chordae tendineae

100. Which of the following are shunts in the fetal cardiovascular system which cause blood to bypass the liver and the lungs?
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. Ductus venosus
    2. Foramen ovale
    3. Ductus arteriosus
    4. Ductus teres

101. Which of the following are shunts in the fetal cardiovascular system which cause blood to bypass the liver and the lungs?
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. Ductus teres
    2. Interventricular foramen
    3. Foramen primum
    4. Ductus arteriosus

102. Which of the following is/are shunts in the fetal cardiovascular system which cause blood to bypass the liver and the lungs?
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. Ductus teres
    2. Interventricular foramen
    3. Foramen primum
    4. Ductus venosus

97. c 98. d 99. e 100. a 101. c 102. d

103. Which of the following is/are possible complications associated with tetralogy of fallot?
    a. If 1, 2, and 3 are correct
    b. If 1 and 3 are correct
    c. If 2 and 4 are correct
    d. If only 4 is correct
    e. If all are correct
    1. Pulmonary valve stenosis
    2. An overriding aorta
    3. A ventricular septal defect
    4. Hypertrophy of the right ventricle

104. How many shunts are there in the fetal cardiovascular system which cause blood to bypass the liver and the lungs?
    a. 1
    b. 3
    c. 5
    d. 7
    e. 9

    Notes: knowledge there are three shunts in the fetal cardiovascular system: ductus venosus shunts blood through the liver to the inferior vena cava, the foramen ovale connects the right atrium with the left atrium, and the ductus arteriosus connects the pulmonary trunk with the aorta

105. In the fetal circulatory system, which of the following vessels or organs would contain the most highly oxygenated blood?
    a. Ascending aorta
    b. Ductus arteriosus
    c. Left atrium
    d. Right ventricle
    e. Umbilical vein

    Notes: Analysis the umbilical vein coming from the placenta would contain the most highly oxygenated blood.

106. Closure of the interventricular foramen with formation of the interventricular membranous septum results from the fusion of tissue from three sources:
    a. Coronary sinus, myocardium, and endocardial cushions
    b. Left bulbar ridge, right bulbar ridge, and the endocardial cushions
    c. Septum primum, septum secundum, and endocardial cushions
    d. Septum primum, septum secundum, and myocardium
    e. Sinus venarum, crista terminalis, and endocardial cushions

    Notes: Comprehension answers a, d, and e are unrelated to the interventricular septum. Ans c is related to septation in the atria. Ans b, the left and right bulbar ridges and the endocardial cushions compose the interventricular membranous septum.

103. e 104. b 105. e 106. b

3

Cardiac Receptors

1. 3/5th of the myocardium institium contains?
   a. Collagen
   b. Connective tissues (fibroblasts, mast cells, stem cells)
   c. Ground substance
   d. Blood vessels (coronary veins/arteries/capillaries)

2. The Bowditch effect refers to:
   a. An increase in HR causing positive inotropy
   b. LV pressure impinging on RV
   c. RV pressure impinging on LV
   d. An increase in HR causing negative inotropy

3. Sequestration of Ca^{++} from cytosol back into the sarcoplasmic reticulum is an active process:
   a. False
   b. True

4. Cardiomyocytes are found mainly in:
   a. The heart equivalent of tunica adventitia
   b. Endocardium
   c. Epicardium
   d. Myocardium

5. Myosin heads bind to the myosin binding site on actin when ATP is present:
   a. True
   b. False

6. When action potential reaches T-tubules in myocytes, Ca^{++} ions are released from the sarcoplasmic reticulum. Where do these ions bind that allows for contraction to occur?
   a. Myosin head
   b. Troponin
   c. Myosin light chain
   d. Tropomyosin

7. The mechanical energy of contraction to propel fluid into circulation is achieved by:
   a. Thickening of the ventricular walls only
   b. Circumferential shortening on the ventricular walls only
   c. Circumferential shortening and thickening of ventricular walls
   d. Circumferential shortening and thinning of ventricular walls

1. d 2. a 3. b 4. d 5. b 6. b 7. c

8. Increased myocardial contractility (Positive inotropy) due to increased 'afterload' is known as?
   a. Extrinsic regulation
   b. Cardiac power output regulation
   c. Anrep effect
   d. Starling's law

9. During ischemia, heart is a net extractor of lactate:
   a. True
   b. False

10. Angina during anaerobiosis is caused by excess presense of?
   a. CO_2
   b. Pyruvate
   c. Ketone bodies
   d. Lactate

11. Which statement in respect to Starling's law is incorrect?
   a. Increased contractility would increase End systolic volume
   b. The stretching of the ventricular walls during diastole is proportional to the strength of contraction during systole
   c. Ventricular compliance is lowered when scar tissue is present
   d. Increased End diastolic volume would have a positive inotropic effect

12. The 'dub' sound heard during ausculation is produced by the:
   a. Opening of the semilunar valves
   b. Opening of the A/V valves
   c. Closing of the A/V valves
   d. Closing of the semilunar valves

13. In steady state, cardiac output (CO) is:
   a. More in the RV
   b. More in the LV
   c. The same in both ventricles

14. Stroke volume =
   a. End-systolic Volume - End-diastolic volume
   b. Heart rate × End systolic volume
   c. Heart rate × End diastolic volume
   d. End-diastolic volume - End systolic volume

15. The ejection fraction (EF) for the left ventricle (LV), LVEF is calculated by:
   a. Stroke volume/End systolic volume
   b. Stroke volume/End diastolic volume
   c. End systolic volume/Stroke volume
   d. End diastolic volume/Stroke volume

16. Isovolumetric contraction occurs:
   a. During late ventricular systole when pressure in ventricle is greater than arterial pressure
   b. During atrial systole when pressure in atria is greater than ventricles
   c. During ventricular diastole when ventricles fill up passively
   d. In early ventricular systole when A/V valve and pulmonary/aortic valves are shut

17. The T-Q interval in an ECG is a measurement of the:
   a. Duration of ventricular systole
   b. Delay between atrial and ventricular depolarization
   c. Duration of ventricular diastole
   d. Duration of atrial diastole

8. c 9. b 10. d 11. a 12. d 13. c 14. d 15. b
16. d 17. b

18. Which statement regarding sinus arrhythmia is true?
    a. Tachycardia during inspiration
    b. Heart rate increases during expiration
    c. Heart rate constant during breathing-cycle
    d. Vagal activity increased during inspiration

19. Which type of junction within the intercalated discs of the myocardium allows for the functional syncitium occurring?
    a. Tight junction's
    b. Desmosomes
    c. Focal adhesion
    d. Gap junctions

20. Action potential initiated by SA node propogates to the AV node via?
    a. Purkinje fibers
    b. Internodal pathways
    c. Left bundle of His
    d. Right bundle of His

21. The Bernheim effect is due to the left ventricle impinging and effecting blood flow in the right ventricle:
    a. False
    b. True

22. Medical intervention should be carried out if the structure is abnormal, regardless of function:
    a. False
    b. True

23. The cirulatory system consists of:
    a. Conduction portion only
    b. Exchange portion only
    c. Conduction portion + lympathic system
    d. CVS + lymphatic system

24. Coronary arteries are effectively:
    a. Anatomical (True) end arteries
    b. Functional end arteries

25. Darcy's Law states that blood flow (Q) is:
    a. Proportional to resistance, but inversely proportional to change in pressure
    b. Proportional to change in pressure, but inversely proportional to resistance

26. Which coronary artery is the main supply of blood to the heart during diastole?
    a. Left coronary artery
    b. Right coronary artery

27. The increase in local blood flow in response to an increase in local metabolic activity is called?
    a. Active hypertension
    b. Passive hyperemia
    c. Passive hypertension
    d. Active hyperemia

28. Which statement regarding Autonomic-Nervous-System regulation of the heart is correct?
    a. Parasympathetic NS innervates SA and AV node NOT ventricular myocardium
    b. Parasympathetic NS innervates SA, AV nodes and ventricular myocardium
    c. Sympathetic NS innervates SA node and ventricular myocardium only NOT AV node
    d. Sympathetic NS innervates SA and AV node NOT ventricular myocardium

29. Cardiac functional reserve is?
    a. Maximum level of cardiac pumping capability/Basal resting level
    b. Maximum level of cardiac pumping capability * Basal resting level
    c. Maximum level of cardiac pumping capability + Basal resting level
    d. Maximum level of cardiac pumping capability - Basal resting level

18. a	19. d	20. b	21. b	22. a	23. d	24. b	25. b
26. a	27. d	28. a	29. d				

30. Cardiac power output (CPO) =
    a. Cardiac output * HR
    b. Stroke volume * Mean blood pressure
    c. Cardiac output/Stroke volume
    d. Cardiac output * Mean blood pressure

31. The lymph nodes along the lateral thoracic vessels are:
    a. The pectoral lymph nodes
    b. The lateral lymph nodes
    c. The subscapular lymph nodes
    d. The central lymph nodes
    e. The apical lymph nodes

32. Concerning the muscles of the upper limb, which is false?
    a. The supinator muscles forms the floor of the cubital fossa
    b. The median nerve passes between the two heads of pronator teres as it leaves the cubital fossa
    c. The median nerve passes to the hand through the carpal canal
    d. The ulnar nerve enters the forearm superficial to the two heads of flexor carpi ulnaris
    e. The deltoid muscle is supplied by the axillary nerve

33. Which muscle is innervated by both the ulnar and median nerves?
    a. Flexor digitorum superficialis
    b. Pronator quadratus
    c. Flexor digitorum profundus
    d. Supinator
    e. None of the above

34. A fall on the elbow fractures the medial epicondyle and damages important adjacent structures. Among the deficits listed below, select the one most likely to be encountered in this patient:
    a. Inability to flex the wrist
    b. Inability to extend the wrist
    c. Inability to oppose the thumb
    d. Inability to grasp a piece of paper tightly between the extended 2nd and 3rd finger
    e. Inability to abduct the wrist

35. Concerning the basilic vein, which is true?
    a. Begins at the ulnar side of the dorsal venous network of hand
    b. Begins at the radial part of the dorsal venous network of hand
    c. Ascends along the lateral part of the arm
    d. Pass through the groove between the pectoralis major and deltoid
    e. End in the subclavian vein

36. The cephalic vein:
    a. Arises from the medial side of dorsal venous rete of hand
    b. Accompany the radial artery
    c. Drain into the brachial vein
    d. Receives the superficial veins of the hand and the medial side of the forearm
    e. Runs along the lateral side of the biceps brachi

37. Which nerve injured can lead to?
    a. Musculocutaneous nerve
    b. Median nerve
    c. Ulnar nerve
    d. Axillary nerve
    e. Radial nerve

30. d 31. a 32. d 33. c 34. d 35. a 36. e 37. c

38. Which nerve injured can lead to?
    a. Musculocutaneous nerve and median nerve
    b. Median nerve and ulnar nerve
    c. Ulnar nerve and axillary nerve
    d. Axillary nerve and radial nerve
    e. Radial nerve

39. Which nerve passes through the quadrilateral foramen?
    a. Musculocutanous nerve
    b. Median nerve
    c. Ulnar nerve
    d. Radial nerve
    e. Axillary nerve

40. The axillary artery:
    a. Begins from the medial border of the first rib
    b. Gives off the internal thoracic artery
    c. Ends at the lower border of the teres minor
    d. Its branches distribute to the pectoralis major muscle only
    e. Gives off the anterior intercostal artery

41. Which nerve arises from the lateral cord of brachial plexus:
    a. Musculocutaneous nerve
    b. Ulnar nerve
    c. Medial pectoral nerve
    d. Radial nerve
    e. Thoracodorsal nerve

42. The apex of axilla is bounded by:
    a. Lateral 1/3rd of clavicle
    b. Medial border of scapula
    c. Lateral border of first rib
    d. Head of humerus
    e. Pectoralis major

43. Which structure accompany with radial nerve passing through humeromuscular tunnel:
    a. Nutrient vessels of humerus
    b. Deep brachial artery
    c. Radial artery
    d. Ulnar artery
    e. Brachial artery

44. Regarding the median nerve, which is true?
    a. Arises from brachial plexus with the lateral and medial root
    b. Lies to the medial side of axillary artery
    c. Lies to the lateral side of brachial artery all through
    d. Accompanies the deep brachial vessles along the arm
    e. Lies to the lateral side of brachial artery in the cubital fossa

45. Deep palmar arch:
    a. Is formed by the anastomosis of the terminal part of the radial artery with deep branch of the ulnar artery
    b. Is formed by the anastomosis of the terminal part of the ulnar artery with deep branch of the radial artery
    c. Lies superficial to the tendons of flexor muscles
    d. Lies superficial to the lumbricales
    e. Gives off three common palmar digital arteries

38. e 39. e 40. c 41. a 42. c 43. b 44. a 45. a

46. Concerning musculocutaneous nerve, which is true?
    a. Arises from medial cord of brachial plexus
    b. Innervates triceps brachii
    c. Innervates posterior group of muscles of arm
    d. Perforates the coracobrachialis and controls it
    e. Accompanies deep brachial vessels

47. Regarding the radial nerve, which is true?
    a. It arises from the medial cord of the brachial plexus
    b. It lies to the medial side of the brachial artery
    c. It has no branches in the arm
    d. It is easily injured when the fracture of the surgical neck of humerus
    e. It runs posteriorly with the deep brachial artery

48. Concerning biceps brachii, which is true?
    a. It lies deep to the lower half of the coracbrachialis
    b. It is the chief extensor of the forearm
    c. Its long head can also extend the shoulder joint
    d. The short head arise from the coracoid process
    e. It flexes the wrist joint

49. Which one does not pass through the carpal canal?
    a. The common flexor sheath
    b. The tendons of the flexor digitorum superficialis
    c. The tendon of flexor pollicis longus
    d. The median nerve
    e. The ulnar nerve

50. While performing a radical mastectomy, the surgeon injured the long thoracic nerve. Which of the following muscles will be affected due to injury to the long thoracic nerve?
    a. Anterior scalene
    b. Middle scalene
    c. Serratus anterior
    d. Subscapularis
    e. Teres major

51. Branches of the brachial artery contribute to the anastomotic circulation around the:
    a. Acromioclavicular joint
    b. Elbow joint
    c. Glenohumeral joint
    d. Head of the humerus
    e. Scapula

46. d 47. e 48. d 49. e 50. c 51. b

4

Cardiac Anesthesia

1. The balloon of a pulmonary artery catheter can be inflated with:
   a. Normal saline
   b. Air
   c. 5% dextrose solution
   d. All of the above
   e. None of the above

2. The conventional high dose or Hammersmith dose regime for aprotinin is:
   a. 2 million units loading dose after induction of anesthesia followed by a continuous infusion of 500,000 units/hour and additional 2 million units added to the prime volume
   b. 2 million units loading dose after induction of anesthesia followed by a continuous infusion of 500,000 units/hour
   c. 1 million units lading dose after induction of anesthesia followed by a continuous infusion of 500,000 units/hour and additional 1 million units added to the prime volume
   d. 2 million units lading dose after induction of anesthesia followed by a continuous infusion of 500,000 units/hour and additional 1 million units added to the prime volume
   e. None of the above

3. All of the following can be used as alternatives to heparin except:
   a. Low molecular weight heparin
   b. Dermatan sulfate
   c. Ancord
   d. Hirudin
   e. Recombinant factor VIIa

4. The colloquial expression "pump head" means:
   a. Head scan after CABG
   b. Neurocognitive dysfunction after CPB
   c. Roller pump head used on CPB machine
   d. None of the above

5. The first successful use of cardiopulmonary bypass on May 6, 1953, to enable surgical closure of an atrial septal defect was described by:
   a. JH Gibbon
   b. Cabrol
   c. Fontan
   d. DeBackey
   e. None of the above

1. b 2. a 3. e 4. b 5. a

6. For instituting CPB, the surgeon performs arterial cannulation first followed by venous cannulation because:
   a. Arterial cannula can be used to withdraw autologous blood rapidly
   b. It provides a means for transfusing volume rapidly to the patient in case an inadvertent complication of bleeding occurs
   c. It is easier to cannulate aorta before venous cannulation
   d. It is not necessary to do so
   e. All of the above
   f. None of the above

7. The peak pressure gradient across the mitral valve is calculated using the Bernoulli equation, which is:
   a. Peak pressure gradient = 4 $(V\ max)^2$ where V is diastolic flow velocity
   b. Peak pressure gradient = 6 $(V\ max)^2$
   c. Peak pressure gradient = 3 $(V\ max)^2$
   d. None of the above

8. Trans-mitral flow on pulsed wave Doppler in a patient with normal mitral valve and normal left ventricular function shows:
   a. Early diastolic filling characterized by 'E' wave and late diastolic filling characterized by 'A' wave
   b. Systolic or 'S' waveform and diastolic or 'D' waveform
   c. Only diastolic 'D' waveform
   d. None of the above
   e. All of the above

9. The biological homeostasis of the fetoplacental system in a pregnant lady can be compromised during CPB due to all of the following except:
   a. Hypothermia
   b. Hemodilution
   c. Continuous blood flow
   d. Inhibition of coagulation
   e. Temperature of cardioplegia

10. All of the following should be followed while conduction of CPB in a pregnant patient except:
   a. CPB must be performed at high flow
   b. If gestational age is >20 weeks, the patient must be positioned in left lateral recumbent position during operation
   c. Agents inducing uterine contraction should be avoided
   d. Alpha-stat method of blood gas analysis should be adopted

11. The following statement/s regarding Doppler interrogation of flow across the mitral valve is/are correct:
   a. The E-phase corresponds to early diastolic phase and A phase to atrial contraction
   b. The reversal of E/A ratio indicates impaired early left ventricular filling
   c. The E phase is absent in atrial fibrillation
   d. In mitral stenosis there is early deceleration from the peak velocity

12. The following statements related to pulmonary venous flow patterns are not correct:
   a. It is used to quantify the degree of mitral regurgitation
   b. In any given patient with mitral regurgitation there can be no significant disparity between right and left venous patterns
   c. Systolic flow reversal can occur in patients with severe mitral regurgitation
   d. None of the above

6. b 7. a 8. a 9. e 10. d 11. a & b 12. b

13. The following statement/s about the mediastinum is/are not correct:
    a. It extends superiorly to the thoracic inlet and inferiorly to the diaphragm and bounded laterally by the adjacent mediastinal parietal pleura
    b. It is divided into superior and inferior mediastina by an imaginary plane passing from the sternal angle anteriorly to the lower border of the body of the 4th thoracic vertebra posteriorly
    c. The anterior mediastinum is in continuity with superior mediastinum it is also known as anterosuperior mediastinum
    d. None of the above

14. In a patient with mediastinal mass with airway compression undergoing thoracotomy, the following are not necessary:
    a. Double lumen endobronchial tube
    b. Fiberoptic bronchoscope
    c. An emergency tracheostomy set
    d. At least 8 units of whole blood
    e. None of the above

15. The ACC/AHA guidelines recommend waiting for the following duration after MI, to perform elective noncardiac surgery:
    a. 1 week
    b. 4-6 weeks
    c. 3 months
    d. 6 months

16. Classical anginal pain has following characteristics except:
    a. The pain is of strangulating nature
    b. Often occurs with exercise, emotional stress or during meals and is relieved with rest
    c. Associated with vomiting
    d. May radiate to left arm, chin or epigastrium

17. All of the following statements related to laboratory changes associated with MI are correct except:
    a. The CKMB level is a fairly accurate method of diagnosing acute MI
    b. GOT and LDH are not specific enzymes
    c. Skeletal muscle injury can increase the concentration of CK MB
    d. The increase in CK MB persists for 72 hours
    e. Plasma troponin concentration increases after 24 hours

18. While evaluating the cardiovascular system on chest X-ray, the following statements are correct, except:
    a. The right border of the heart is formed by superior vana cava and the right atrium
    b. In mitral stenosis, the left atrium and left ventricle are enlarged
    c. The enlargement of left atrium leads to displacement of LA appendage laterally and the left bronchus upwards
    d. The lateral view of chest is most useful in detecting the RV enlargement

19. The following statements about QT interval on ECG are correct, except:
    a. QT interval represents interval between beginning of Q wave and beginning of T wave
    b. The normal value is 0.44 to 0.5 seconds
    c. Sevoflurane, thiopentone and suxamethonium can prolong QT interval
    d. Emotional stress or sympathetic stimulation can induce ventricular fibrillation

13. d 14. d 15. b 16. c 17. e 18. b 19. a

20. The following statements related to the beta adrenergic receptors are true except:
    a. There are two types; beta-1 and beta-2
    b. Beta-1 receptors predominate in the skeletal muscles and bronchi
    c. Stimulation of beta-1 receptors leads to increased myocardial contractility and heart rate
    d. Epinephrine stimulates both beta-1 and beta-2 receptors
21. The major difference between epinephrine and norepinephrine is:
    a. Norepinehrine is synthetic catecholamine
    b. Norepinephrine is a predominantly alpha stimulating effect leading to profound increases in SVR
    c. Norepinephrine can be administered via left atrium
    d. Norepinephrine is not useful in cardiac surgery
22. The following statements about dopexamine are correct except:
    a. It stimulates DA1 and DA2 receptors
    b. It has little effect on beta-1 and no effect on alpha receptors
    c. It increases renal perfusion by selective renal vasodilatation
    d. It does not increase heart rate even in higher doses
    e. It is useful to improve myocardial performance in patients with septic shock
23. The following statements about amrinone are correct except:
    a. It is a phosphodiesterase type III inhibitor
    b. It is not useful if heart has a reduction in beta-1 receptors
    c. It has a prolonged half life and is administered as an intravenous loading dose followed by an infusion
    d. It may produce precipitous hypotension after the bolus loading dose
24. Milrinone is different than amrinone in the following respects except:
    a. It is much more potent than amrinone
    b. It is a pulmonary vasodilator and leads to decrease in PVR
    c. It produces increase in cardiac output and decrease in SVR without any significant increase in heart rate
    d. It is not yellow in color
25. The following statements related to vasodilators are correct except:
    a. The vasodilators that are feely available and commonly used in India are sodium nitroprusside and nitroglycerin
    b. Venodilators decrease the preload
    c. They can lead to loss of hypoxic pulmonary vasoconstriction
    d. They may lead to metabolic acidosis
    e. The arterial vasodilators decrease SVR and increase cardiac output
26. Intra-aortic balloon pump cannot be used in all the following conditions except:
    a. Aortic regurgitation
    b. Aortic dissection
    c. Cardiogenic shock
    d. Severe peripheral vascular disease
27. Identify the wrong statement related to intra-aortic balloon counter-pulsation:
    a. The balloon is inflated with carbon dioxide
    b. The balloon is deflated during diastole
    c. It can be inserted via subclavian artery
    d. It can lead to vascular complications such as aneurysm
    e. None of the above

20. b 21. b 22. d 23. b 24. c 25. d 26. c 27. b

28. Intrathecal morphine produces intense and prolonged analgesia by stimulating:
    a. Opioid receptors in the substantia gelatinosa of the posterior spinal cord
    b. Non-opioid receptors in the substantia gelatinosa of the posterior spinal cord
    c. Opioid receptors in the substantia gelatinosa of the anterior spinal cord
    d. Opiod receptors in the substantia gelatinosa of the anterior and posterior spinal cord
    e. All of the above

29. The use of packed cells instead of whole blood gives these advantages:
    a. Reduced phosphate load
    b. Reduced sodium and water load
    c. Reduced risk of hepatitis
    d. Reduced risk of hemolysis due to anti-A and anti-B
    e. Hematocrit of 0.8 to 0.95
    f. Fewer febrile transfusion reactions
    1. a and b
    2. a and c
    3. b and d
    4. c and f
    5. All of the above

30. With blood stored for 12 days, you expect:
    a. Increased $[K^+]$ to about 10 mmols/l
    b. pCO2 more than 60 mm Hg (8.0 kPa)
    c. Platelets markedly depleted
    d. Significant reduction in fibrinogen
    e. Decreased levels of Factor II and VII
    1. a, b and c
    2. a, c and d
    3. b, c and d
    4. c and f
    5. All of the above

31. Factor 8 levels in stored blood at 14 days:
    a. 95%
    b. 80%
    c. 75%
    d. 30%
    e. < 10%

32. Febrile reaction with blood transfusion:
    a. Is greater in multiple than primary
    b. Is reduced if red cells are used instead of whole blood
    c. Can be prevented by the use of steroids and anti-histamines
    d. Less frequent if patient on anti-histamines

33. Cryoprecipitate contains:
    a. Factor VIII
    b. Fibrinogen
    c. Platelet aggregating factor
    d. Factor XIII
    e. All of the above

34. A patient receives massive transfusion of 40 units of whole blood over a few hours. The complication least likely to be present after the first hour of transfusion is:
    a. Hyperkalemia
    b. Hypothermia
    c. Coagulation defects
    d. Metabolic acidosis
    e. Metabolic alkalosis due to citrate toxicity

28. a 29. d 30. c 31. c 32. a 33. e 34. e

35. The specific treatment of hypofibrinogenemia is:
    a. Whole blood
    b. Cryoprecipitate
    c. FFP
    d. Salt poor albumin

36. Least likely complication of 6Units of FFP:
    a. Hemolytic transfusion reaction
    b. Allergic reaction
    c. Hepatitis (C) virus infection/HIV transmission
    d. Citrate toxicity
    e. Febrile reaction

37. Which of the following is used to decrease pulmonary artery pressure?
    a. Nitrous oxide
    b. Nitrogen dioxide
    c. Nitric oxide
    d. Nitrogen

38. A 4½ year girl child has to wear warm socks even in summer. On physical examination she is seen to have high blood pressure and femoral pulse is weak compared to radial and carotid pulse. A chest radiograph shows notching of ribs along the lower borders. The provisional diagnosis is:
    a. Femoral artery thrombosis
    b. Co-arctation of aorta
    c. Raynaud's disease
    d. Takayasu's arteritis

39. The following is true about packed red blood cells:
    a. Has a packed cell volume of 0.65-0.75
    b. Causes fewer febrile transfusion reactions
    c. Contains a negligible amount of platelets and white cells
    d. Can have saline, adenine, glucose and mannitol added as an additive solution
    1. a, b and c
    2. a, c and d
    3. b, c and d
    4. All of the above

40. Best technique to convert atrial fibrillation to sinus rhythm before coming off bypass in mitral valve surgery:
    a. Xylocard
    b. Beta-blocker
    c. Verapamil
    d. Digitalis
    e. Cardioversion

41. Echocardiographically mitral valve area is calculated by which method:
    a. Pressure half time
    b. Planimetry
    c. Continuity equation
    d. All of the above
    e. None of the above

42. Ideal treatment of intraoperative hypotension in a case of MS:
    a. Volume therapy
    b. Vasoconstrictor therapy
    c. Volume therapy and/or inotropes
    d. All of above
    e. None of above

43. Ideal treatment of intraoperative hypotension in a case of MS:
    a. Volume therapy
    b. Vasoconstrictor therapy
    c. Volume therapy and/or inotropes
    d. All of above
    e. None of above

35. b 36. d 37. c 38. b 39. d 40. e 41. d 42. c
43. c

44. Characteristics of WPW syndrome:
    a. Presence of Delta waves on ECG
    b. History of syncope
    c. Episode of atrial tachycardia
    d. All of the above
    e. None of the above

45. Hyperkalemic ECG changes:
    a. Tall peaked T waves
    b. Decreased P waves
    c. Atrial asystole
    d. QT widening
    e. None of the above

46. Most commonly performed valvular heart surgery in GB Pant hospital is:
    a. MVR
    b. DVR
    c. AVR
    d. BMV

47. Most potent internal mammary artery constrictor is:
    a. Thromboxane
    b. Serotonine
    c. Norepinepherine
    d. KCL

48. Diagonal artery is a branch of :
    a. PDA
    b. Cx
    c. LAD
    d. OM

49. Minimum accepted MAP during OPCABG is:
    a. 40–60 mm Hg
    b. 60–80 mm Hg
    c. 80–100 mm Hg
    d. 100–120 mm Hg

50. It is not true about the thoracic epidural anesthesia in OPCABG:
    a. Increases the diameter of epicardial arteries
    b. Improves the outcome of the patient
    c. Decreases the myocardial oxygen demand
    d. Decreases the incidence of rate of chest infection

51. In postoperative period which type of respiratory failure is comment?
    a. Type I
    b. Type II
    c. Type III
    d. Type IV

52. Which of the following drugs does not cause delirium in ICU?
    a. Morphine
    b. Lidocaine
    c. Penicillin
    d. Omeprazole

53. In FFP is indicated in all of the following except:
    a. Warferin induced bleeding
    b. DIC
    c. Factor IX deficiency
    d. IgA deficiency

54. Intra aortic balloon counterpulsation is contraindicated in:
    a. Unstable angina
    b. Immediate postoperative period
    c. AR
    d. MR

55. A patient is being transferred to the recovery room from the OT. At the time of arrival become pulsless but his ECG is normal, which of the following is not the cause:
    a. Pericardial tampnade
    b. Tension pnemothorax
    c. Hypoxia
    d. Myocardial infarction

44. d 45. a 46. a 47. a 48. c 49. b 50. b 51. c
52. d 53. d 54. c 55. d

56. In postcardiac surgical recovery patient blood sugar should be kept between:
    a. 150-200 mg/dL
    b. 12-175 mg/dL
    c. 80-110 mg/dL
    d. 175 –225 mg/dL

57. In recovery a post CABG patient is having hypotension. His hemodynamic data following P –120/mt, BP – 80/55 mm Hg, PCWP – 7 mm Hg, CI – 1.8 L/m^2, SVR – 1800. Which of the following is an appropriate treatment?
    a. Dobutamine infusion
    b. Dopamine infusion
    c. Norepinephrine infusion
    d. Saline infusion

58. Which of the following has high mixvenous saturation:
    a. Anemia
    b. Cardiogenic shock
    c. Early sepsis
    d. Late sepsis

59. Which of the following does not increase the mortality in CABG?
    a. Diabetes
    b. Hypertension
    c. Low EF
    d. Elderly

60. Pulses alter is found in:
    a. Pericardial tamponade
    b. Hypertrophic cardiomyopathy
    c. Constrictive pericarditis
    d. Left ventricular failure

61. Regarding the blood supply of the heart:
    a. The right coronary artery runs in the anterior atrio-ventricular groove
    b. The coronary sinus is in the anterior atrio-ventricular groove
    c. There are no anastomoses between the right and left coronary circulations
    d. The atrio-ventricular node is supplied by the left coronary artery

62. Pheochromocytoma:
    a. Is bilateral in 30% of cases
    b. Metastases, if they occur, will commonly be to the brain
    c. Is usually associated with hypoglycemia
    d. May be associated with carcinoma of the thyroid

63. An amniotic fluid embolus is associated with all except:
    a. Respiratory depression
    b. Permanent neurological sequelae
    c. A Coagulopathy
    d. Considerable mortality

64. Which of the following statement is false - Intrathecal opioids:
    a. Act on kappa receptors
    b. Have a lower incidence of nausea and vomiting than systemic opioids
    c. Cause delayed respiratory depression
    d. Can have all their side-effects reversed with nalxone

65. The elderly have:
    a. Decreased GFR
    b. Higher MAC requirement
    c. Reduced FRC
    d. A greater volume of distribution for water-soluble drugs

56. c 57. d 58. c 59. b 60. d 61. a 62. d 63. a
64. b 65. a

66. Sickle cell trait:
    a. Is a homozygous condition
    b. Is commoner in males
    c. Cannot occur simultaneously with thalassemia trait
    d. Is sometimes associated with a negative sickling test

67. The Valsalva maneuver:
    a. Assess baroreceptor reflexes
    b. Involves inspiration against a closed glottis
    c. Results in an initial fall in heart rate
    d. Blood pressure (BP) initially decreases

68. Side-effects of amiodarone include all except:
    a. Photosensitivity
    b. Hypothyroidism
    c. Pulsus bigemini
    d. Corneal microdeposits

69. Exracorporeal membrane oxygenation (ECMO) all are true except:
    a. Is not suitable for use in adults
    b. Can cause systemic hypertension
    c. Is suitable for use in a neonate with a diaphragmatic hernia
    d. Requires anticoagulation

70. Myocardial infarction (MI) during the perioperative period:
    a. Is most likely to occur 3-5 days postoperatively
    b. Is less common with regional anesthesia
    c. Is more common in upper abdominal surgical procedures
    d. Is more common after prolonged procedures

71. Lasers:
    a. Produce ionizing radiation
    b. Always require gas as a medium
    c. Produce energy of variable wavelengths
    d. Can be used to debulk tumors

72. About ACE inhibitors all are true except:
    a. Are the first-line of treatment for hypertension caused by unilateral renal artery stenosis
    b. Have a diuretic action
    c. Improve survival after myocardial infarction
    d. Are contraindicated in pregnancy

73. On an ECG the following suggest a tachycardia to be of ventricular in origin:
    a. Absence of P waves
    b. QRS duration greater than 0.14 s
    c. Left axis deviation
    d. Presence of a fusion beat

74. Brainstem death criteria require:
    a. P_aCO_2 to be greater than 6.7 kPa
    b. 'Dolls eyes' movement when rotating the head
    c. A flat EEG
    d. Absence of spinal reflexes (e.g. knee)

75. Paroxysmal supraventricular tachycardia can be treated by all except:
    a. Pressure on the carotid sinus
    b. Intravenous lignocaine
    c. Verapamil
    d. Adenosine

66. d 67. a 68. c 69. b 70. c 71. d 72. b 73. d
74. a 75. b

76. A raised CVP in hypotensive patient may be due to all except:
    a. A tension pneumothorax
    b. A large pulmonary embolus
    c. Adrenocortical insufficiency
    d. A venous air embolus

77. Cardiac catheterization in a 55-year-old man revealed:
    Right atrial (RA) pressure - 5 mm Hg
    Right ventricular (RV) pressure - 80/30 mm Hg
    Pulmonary artery (PA) pressure - 80/40 mm Hg
    Pulmonary capillary wedge pressure (PCWP) - 9 mm Hg
    Left ventricular (LV) pressure - 100/70 mm Hg
    The values are consistent with:
    a. Mitral stenosis
    b. Mitral regurgitation
    c. Primary pulmonary hypertension (PPH)
    d. Aortic stenosis

78. Hypomagnesemia causes all except:
    a. Can cause tetany
    b. Increase myocardial contractility
    c. Causes muscle weakness
    d. Increase susceptibility to cardiac arrhythmias

79. In myasthenia which drug should not be given:
    a. Digoxin
    b. ACE inhibitor
    c. Ciprofloxacin
    d. Aminoglycosides

80. Pulmonary artery occlusion pressure (PAOP) is a good indicator of left ventricular (LV) end diastolic pressure:
    a. In aortic regurgitation
    b. With left atrial myxoma
    c. Following a myocardial infarction
    d. In MS

81. When investigating a patient with a hemorrhagic disease:
    a. An increased prothrombin time (PT) is found with hemophilia A
    b. An increased PT occurs with factor Van Willebrands disease
    c. A decreased PT indicates increased plasma fibrinogen
    d. An increased PTT indicates factor VIII deficiency

82. Following have association except:
    a. Lowenstein and high dose morphine anesthesia
    b. J Kaplan and pulmonary artery catheter
    c. D Mangano and aspirin
    d. C Mangano and persantin

83. All of the following agents have shown beneficial effects on mortality if used in the setting of an acute myocardial infarction except:
    a. β-blockers
    b. ACE inhibitors
    c. Magnesium
    d. Aspirin

84. A 19-year-old male who presents to the emergency department with a sudden onset of right-sided weakness and dysarthria. He has no significant past medical history. He last saw a physician for a broken arm 4 years ago. He denies using illicit drugs, denies smoking, and is a social drinker.

76. c 77. c 78. b 79. d 80. c 81. d 82. d 83. c

His physical examination and laboratory data are normal, despite the neurologic deficit. His ECG reveals a normal sinus rhythm with a normal QRS, ST, and T wave. A magnetic resonance imaging (MRI) scan is obtained and is positive for an embolic event:

a. No cardiac workup is necessary because this condition is most likely related to drugs
b. Obtain a serial ECG and cardiac enzymes to detect a silent MI
c. Obtain an echocardiogram focusing on the atria and intra-atrial septum
d. Obtain a carotid duplex scan to rule out a carotid stenosis

85. All of the following conditions are associated with mitral valve prolapse except:
a. Sudden death
b. Endocarditis
c. Congestive heart failure (CHF)
d. Mitral stenosis

86. All of the following statements concerning cardiac murmurs are true except:
a. All diastolic murmurs are pathologic
b. Continuous murmurs always indicate organic disease
c. Late systolic murmurs are pathologic
d. Pansystolic murmurs are rarely innocent in nature

87. In the treatment of left ventricular failure all have shown to increase the survival except:
a. ACE inhibitor
b. Beta-blocker
c. Aldactone
d. Lasix

88. Each of the following is an indication for surgical intervention in those patients who present with endocarditis except:
a. Large vegetation
b. Organism isolated
c. CHF despite medical therapy
d. Fungal endocarditis

89. All of the following antiarrhythmic agents act predominantly with the fast sodium channels except:
a. Procainamide
b. Flecainide
c. Beta blocker
d. Lidocaine

90. You are consulted about a 34-year-old pregnant women who complains of increasing dyspnea and lower-extremity edema. Her examination reveals that she is hypertensive and in mild heart failure. The echocardiogram shows LV dysfunction. You start all of the following except:
a. ACE inhibitor
b. Digoxin
c. Furosemide
d. Verapamil

91. All of the following statements concerning a left anterior divisional block (LADB) are true except:
a. The QRS axis is between –30° and –90°
b. It always signifies underlying heart disease
c. It may inscribe a small R wave followed by a dominant S wave in leads II, III, and aVF
d. QRS duration is between 80 ms and 100 ms

92. The most common valvular lesion seen in carcinoid is:
a. Mitral regurgitation (MR) and aortic stenosis (AS)
b. Pulmonary stenosis (PS) and tricuspid regurgitation (TR)
c. Pulmonary stenosis and aortic stenosis
d. Mitral stenosis (MS) and aortic stenosis

93. The most common primary tumor of the heart is:
a. Rhabdomyosarcoma
b. Angiosarcoma
c. Fibroma
d. Myxoma

84. c 85. d 86. d 87. d 88. b 89. c 90. d 91. d
92. b 93. d

94. The presence of which of the following condition has the poorest long-term prognosis in patients with aortic stenosis?:
    a. Angina
    b. Syncope
    c. Valve area of less than 0.5 cm^2
    d. CHF

95. In patients with rheumatic heart disease, the most common valve affected is:
    a. Mitral
    b. Aortic
    c. Pulmonary
    d. Tricuspid

96. For those asymptomatic patients diagnosed with an accessory pathway on a surface ECG, you would suggest to:
    a. Perform immediate electrophysiologic studies to determine the location of the pathway and consider ablation
    b. Initiate a prophylatic calcium channel blocker
    c. Clinical follow up
    d. Administer a β-blocker

97. You are asked to provide physical examinations for a high-school football team. You would allow all of the students diagnosed with the following anatomy to participate in competitive sports, except:
    a. Small patent ductus arteriosus (PDA) with normal pulmonary pressures
    b. Small ventricular septal defect (VSD) with normal pulmonary pressures
    c. Obstructive hypertrophic cardiomyopathy with normal systemic pressures
    d. A surgically corrected ostium secundum atrial septal defect (ASD) with normal pulmonary pressure and normal electrical activation

98. You are seeing a 64-year-old woman admitted for a cardiac catheterization for angina. She has a history of hypertension. Her physical examination is unremarkable, but you notice a baseline serum creatinine of 2.4 mg/dL. Other than the routine precatheterization order, you would:
    a. Start renal dose dopamine precatheterization and continue for 12 hrs following the procedure
    b. Hydrate with 0.45% normal saline solution 12 hours precatheterization and continue for 12 hrs following the procedure
    c. Hydrate as in choice b; add furosemide 40 mg IV as the first dye injection is given
    d. Do a dialysis preprocedure to a normal creatinine, then proceed as for a routine catheterization

99. A 64-year-old man presents with increasing chest discomfort. His cardiac workup culminates with a cardiac catheterization, which reveals a significant stenosis in the proximal left anterior descending coronary artery at the first septal perforator of 80%. The expected rate of restenosis for a balloon angioplasty in this patient would be:
    a. 15 to 20%
    b. 20 to 30%
    c. 30 to 40%
    d. 40 to 50%

100. The urgent need for bypass surgery in the above patient would be directly related to all the following, except:
    a. Lesion location
    b. Lesion length
    c. Thrombus present in the area
    d. Severity of stenosis

101. All of the following suggest that a wide complex tachycardia originates from above the ventricle (supraventricular tachycardia), except:

94. d 95. a 96. c 97. c 98. b 99. c 100. d

a. Onset with a premature P wave
b. RSR configuration in VI
c. Atrioventricualr (AV) dissociation
d. Slowing or terminating with an increase in vagal tone

102. You see a 68-year-old male for his annual check-up. He denies any symptoms, and he is active without any complaints. Upon reviewing the records you see that it has been 5 years since his last examination. At that time a soft carotid bruit on the left side was documented. Your examination confirms the bruit and an ultrasound quantifies the stenosis of 80% based on Doppler flow measurements. The remainder of your examination is essentially unremarkable, without evidence of neurological pathology. You tell him the following:
a. His stroke risk is low (<5%) because the bruit was noted 5 years ago and has remained stable. Aspirin would be your only recommendation
b. His stroke risk is about 21%. Therefore he should consider endarterectomy, which carries an 8% stroke rate
c. His stroke risk is >75% and therefore should undergo emergency endarterectomy, which carries only at 15% stroke rate
d. Follow-up in 5 years; if the stenosis is worse at that time, consider an endarterectomy

103. ECG findings in hypocalcemia is:
a. U wave
b. Short QT interval
c. Peaked T waves
d. Prolongation of the ST segment

104. In long term which of the inotropes does not increase mortality:
a. Amrinone
b. Milrinone
c. Xamoterol
d. Digoxin

105. Which of the following pathophysiologic changes may be most useful in documenting, within less than 6 hours, that a patient had a myocardial infarction?
a. ST elevation on an electrocardiogram
b. Elevated serum levels of creatinine kinase
c. Elevated serum levels of myocardial lactate dehydrogenase
d. Maximal indices of coagulative necrosis

106. A 63-year-old man has experienced episodes of angina, syncope, and dyspnea on exertion for 'quite some time'. On auscultation, his physician notices a late-peaking systolic ejection mumur that increases in intensity with longer cardiac cycle lengths, a gallop in the fourth heart sound (S_4), and a soft aortic valve component in the second heart sound (A_2). An electrocardiogram (ECG) shows abnormally high R waves in lead AVL. Which one of the following is the most likely diagnosis?
a. Mitral stenosis caused by rheumatic fever
b. Aortic stenosis caused by a congenital bicuspid aortic valve
c. Mitral regurgitation caused by infective endocarditis
d. Aortic regurgitation caused by aortic root dilation

107. All of the following descriptions of cardiac conduction abnormalities are correct, except:
a. Complete heart block – no relationship between P waves and QRS complexes
b. First-degree atrioventricular (AV) block-prolonged PR interval, but normal QRS complex
c. High grade AV block-PR interval is prolonged when a beat occurs, and there is a wide QRS complex
d. Left bundle branch block – long QRS complex with a tall R wave in V_6 and a deep S wave in V_1

101. c 102. b 103. b 104. d 105. a 106. b 107. c

108. All of the following statements concerning the mechanism of clot formation are correct, except:
   a. Activation of thrombin by factor V is the final common pathway in converting soluble fibrinogen to insoluble fibrin
   b. The extrinsic pathway is activated by a lipoprotein called tissue factor, whereas the intrinsic pathway is activated by contact with foreign surfaces
   c. Thrombin and several other cascade proteins are serine proteases that activate the next molecule in the pathway
   d. Antithrombin III is an important regulator of the clotting cascade and acts by covalently cross-linking fibrin monomers into large meshworks in which platelets become lodged

109. A rational approach for the treatment of unstable ventricular tachycardia associated with myocardial ischemia in a hospitalized patient includes:
   a. Amiodarone
   b. DC shock
   c. Lidocaine
   d. Propranolol

110. The phase 1 of the ventricular action potential is primarily due to which one of the following actions?
   a. An inward flux of Ca^{2+}
   b. An inward K^{+}current
   c. An outward K^{+} current
   d. An outward Na^{+} current

111. All of the following statements about the influence of cardiovascular disease on sexuality are true, except:
   a. Some patients have impaired sexual functioning following a myocardial infarction
   b. Myocardial infarctions that occur during intercourse are often associated with unusual and stressful circumstances
   c. The most common reason for decreased frequency of intercourse after a myocardial infarction is anginal pain associated with intercourse
   d. There is a higher incidence of return to normal sexual activity by patients who receive exercise training and education than by those who are not involved in such programs

112. Regarding the blood supply of the heart, the following is correct?
   a. The right coronary artery runs in the anterior atrioventricular groove
   b. The coronary sinus is in the anterior atrioventricular groove
   c. There are no anastomoses between the right and left coronary circulations
   d. The atrioventricular node is supplied by the left coronary artery

113. The Mallampati test for difficult intubation:
   a. Is extremely reliable
   b. Requires the tongue to be inside the mouth
   c. Takes into account head and neck movement
   d. Is superior to the Wilson criteria
   e. Has considerable interobserver variability

114. Selection of patients for randomized trials may be done: what is incorrect?
   a. By tossing a coin
   b. By random number tables
   c. As they arrive
   d. By Bartlett's test

115. A small pulse pressure may be found in:
   a. Aortic stenosis
   b. Patent ductus arteriosus
   c. Beriberi
   d. Cor pulmonale

108. d 109. b 110. a 111. c 112. a 113. e 114. d 115. a

116. Hypokalemia occuring during anesthesia and surgery can be due to:
    a. Mannitol administration
    b. Hypocapnia due to intermittent positive-pressure ventilation (IPPV)
    c. Intravenous digoxin
    d. Presence of a metabolic acidosis

117. High Frequency Jet Ventilation (HFJV):
    a. Uses a frequency greater than 1 Hz
    b. Needs an I:E ratio of at least 1:3
    c. Can be beneficial for a severe asthmatic requiring ventilation
    d. Allows for humidification

118. Pheochromocytoma:
    a. Is bilateral in 30% of cases
    b. Metastases, if they occur, will commonly be to the liver
    c. Is usually associated with hypoglycemia
    d. Increase urinary excretion of 5-hydroxyindoleacetic acid (5-HIAA)

119. Propofol:
    a. Has no effect on intraocular pressure
    b. Has no cardiovascular depressant effects
    c. Can turn urine green
    d. Occurs as a 10% solution

120. Complications within 24 hours of having a tracheostomy include all, except:
    a. Subcutaneous emphysema
    b. Innominate artery erosion
    c. Apnea
    d. Tracheal stenosis
    e. Occult hemorrhage

121. Regarding an exponential function: the incorrect statement is:
    a. After three time constants, the event is 95% complete
    b. After one time constant, 37% of the event is complete
    c. Half-life is the time taken for 50% decay
    d. There is a constant proportional rate of change

122. Perfluorocarbons: what is false?
    a. Can be used as a blood substitute
    b. Are antigenic
    c. Have a long elimination half-life
    d. Can be used for gas exchange in the lungs

123. As regards hepatitis C:
    a. It is known cause of post transfusion hepatitis
    b. It frequently results in fulminant hepatic failure
    c. Vertical transmission is common
    d. It is frequently associated with hepatitis E

124. High output cardiac failure can occur with all, except:
    a. An arteriovenous (AV) fistula
    b. Paget's disease
    c. Aortic regurgitation
    d. Acute pulmonary embolus
    e. Iron deficiency anemia

116. b 117. a 118. b 119. c 120. b 121. c 122. d 123. a 124. d

125. After birth:
    a. The foramen ovale closes due to reversal of the pressure gradient between the right and left atria
    b. The ductus arteriosus normally closes within 24 hours
    c. Lung compliance decreases
    d. Umbilical artery cannulation is possible only up to 1 hour following delivery

126. In a normal distribution: what is incorrect?
    a. The mean, median and mode are the same
    b. 99% of observations lie within 2 standard deviations
    c. The standard deviation is the square root of the variance
    d. Calculation of the variance gives a measure of dispersion

127. Acute pulmonary edema may be a feature of all, except:
    a. Left atrial myxoma
    b. A severe head injury
    c. Naloxone administration
    d. Constrictive pericarditis
    e. Myocardial infarction

128. Lasers:
    a. Produce ionizing radiation
    b. Always require gas as a medium
    c. Produce energy of variable wavelengths
    d. Can be used to debulk tumors

129. Malignant hypertension can cause all, except:
    a. Papilledema
    b. Cerebrovascular accident (CVA)
    c. Left ventricular hypertension
    d. Pulmonary hypertension
    e. Renal failure

130. Intubation is more difficult in a neonate because the:
    a. Epiglottis is vestigial
    b. Head is small in relation to the body
    c. Tongue is large in relation to the size of the oral cavity
    d. Larynx is more caudal
    e. Narrowest part of the upper airway is infraglottic

131. Patients with Down's syndrome are at risk from anesthesia because of:
    a. A high incidence of atlantoaxial instability
    b. A low resistance to infection
    c. Associated congenital cardiac defects
    d. Increased incidence of (MH)

132. ACE inhibitors:
    a. Are the first-line treatment for hypertension caused by renal artery stenosis
    b. Have a diuretic action
    c. Improve survival after myocardial infarction
    d. Can be associated with loss of taste

133. Sympathectomy is indicated in the treatment of all, except:
    a. Raynaud's disease
    b. Intermittent claudication
    c. Diabetic neuropathy
    d. Hyperhidrosis
    e. Chronic regional pain syndrome (CRPS) type II

125. a 126. b 127. d 128. d 129. d 130. c 131. a 132. d 133. c

134. On an ECG the following suggest a tachycardia to be ventricular in origin:
   a. Absence of P waves
   b. QRS duration greater than 0.14 s
   c. Left axis deviation
   d. Presence of a fusion beat

135. Reflex pulmonary vasoconstriction may be abolished by:
   a. Hypoxia
   b. Tolazoline
   c. Adrenaline
   d. Nitrous oxide

136. Pulmonary artery enlargement occurs in all, except:
   a. Fallot's tetralogy
   b. Atrial septal defect (ASD)
   c. Mitral stenosis
   d. Pulmonary stenosis
   e. Cor pulmonale

137. Myasthenic syndrome: all are true, except:
   a. Produces marked post-tetanic facilitation
   b. Responds to anticholinesterase medication
   c. Shows sensitivity to non-depolarizing muscle relaxants
   d. Shows sensitivity to depolarizing muscle relaxants
   e. Improves with exercise

138. Stroma-free hemoglobins:
   a. Have a half-life greater than 24 hours
   b. Strongly activate complement
   c. Are scavenged by the reticuloendothelial system
   d. Can cause intravascular coagulation

139. In tetralogy of Fallot:
   a. There is an overriding aorta
   b. Palliative surgery is all that is available
   c. Cyanotic spells are worsened by squatting
   d. Pulmonary plethora is present radiographically

140. Pulmonary artery occlusion pressure (PAOP) is a good indicator of left ventricular (LV) end diastolic pressure in all, except:
   a. After a pneumonectomy
   b. With constrictive pericarditis
   c. Following a myocardial infarction
   d. In pulmonary hypertension

141. Complications of central venous line insertion include:
   a. Cardiac tamponade
   b. Pneumothorax
   c. Horner's syndrome
   d. Phrenic nerve palsy
   e. Thrombosis

142. When investigating a patient with a hemorrhagic disease:
   a. An increased prothrombin time (PT) is found with hemophilia A
   b. An increased PT occurs with factor V deficiency
   c. A decreased PT indicates increased plasma fibrinogen
   d. An increased bleeding time indicates factor VIII deficiency
   e. A low platelet count occurs in von Willebrand's disease

134. a 135. b 136. a 137. b 138. c 139. a 140. a 141. e 142. b

143. The following are true of the T wave of the ECG:
   a. It represents ventricular depolarization
   b. It is normally more than 2 mV in the standard leads
   c. The amplitude is increased in hyperkalemia
   d. The amplitude is increased in digoxin toxicity
   e. It is normal in atrial fibrillation

144. Blood, platelets are important in hemostasis as they all, except:
   a. Adhere to collagen
   b. Help to initiate the coagulation cascade
   c. Stimulate local vasoconstriction
   d. Encourage fibrinolysis
   e. Play a part in clot retraction

145. The following are true of acute cardiac tamponade, except:
   a. It can be associated with aortic dissection
   b. The JVP is low and falls further on inspiration
   c. The radial artery blood pressure falls on expiration
   d. Diuretics are preferred to paracentesis as first-line treatment
   e. The presence of hepatomegaly would suggest right heart failure rather than tamponade

146. In Hyperkalemia:
   a. There is a tall, peaked T wave
   b. There is a U wave
   c. There is a deep S wave
   d. Ventricular fibrillation may occur

147. P waves are absent in:
   a. Atrial fibrillation
   b. Atrial flutter
   c. Nodal tachycardia
   d. Ventricular tachycardia
   e. First degree heart block

148. The pulmonary artery wedge pressure:
   a. Measures the right atrial pressure
   b. Reflects the left atrial pressure
   c. Is named from the wedge-shaped end of the catheter
   d. Is normally greater than 10 mm Hg
   e. Is raised in tricuspid stenosis

149. TEE – all are true, except:
   a. Is the most senstitive monitor of myocardial ischemia
   b. Requires specific training and certification
   c. Is not very expensive
   d. Is required in port access surgery
   e. Is useful in TMLR

150. Following have association:
   a. S Reiz and coronary steal
   b. Lowenstein and high dose morphine anesthesia
   c. J Kaplan and pulmonary artery catheter
   d. D Mangano and aspirin
   e. C Mangano and persantin

143. c 144. d 145. d 146. a 147. a 148. b 149. c 150. e

151. All the following conditions will increase the A_2 to opening snap interval in mitral stenosis except:
   a. Systemic hypertension
   b. Aortic stenosis
   c. Left ventricular dysfunction
   d. Tachycardia
   e. Calcified mitral valve

152. All of the following conditions are associated with mitral valve prolapse as a serious complication, except:
   a. Sudden death
   b. Endocarditis
   c. Congestive heart failure (CHF)
   d. Embolic phenomena
   e. Myxomatous degeneration

153. Pulsus paradoxus is best defined as:
   a. An alternating intensity in a beat-to-beat rhythm following the release of a prolonged Valsalva maneuver
   b. A marked and exaggerated inspiratory fall in the systolic BP in which the Korotkoff's sounds disappear during inspiration
   c. A normal physiologic response to tachycardia
   d. A condition seen only in a patient with tamponade who has diastolic dysfunction
   e. A marked and exaggerated expiratory fall in the systolic BP in which the Korotkoff's sounds disappear during expiration

154. All of the following statements concerning cardiac murmurs are true, except:
   a. All diastolic murmurs are pathologic
   b. Continuous murmurs always indicate organic disease
   c. Late systolic murmurs are pathologic
   d. Pansystolic murmurs are rarely innocent in nature
   e. Grade 5-6 murmurs are rarely innocent in origin.

155. All of the following are frequently associated complications of coarctation of the aorta, except:
   a. Congestive heart failure
   b. Gastrointestinal angiodysplasia
   c. Endocarditis
   d. Cerebral hemorrhage
   e. Aortic dissection

156. Characteristics that would portend a poor prognosis and an increased likelihood for severe coronary artery disease include all of the following, except:
   a. Failure to complete stage II of a Bruce protocol
   b. The onset of chest pain prior to the completion of the second stage of any of the currently available protocols
   c. Postexercise ECG change (ST depression) greater than 6 minutes to recovery
   d. A flat BP response of less than 130 mm Hg with continued exercise (off β-blockers)
   e. Greater than 2 mm ST depression in multiple leads

157. Each of the following is an indication for surgical intervention in those patients who present with endocarditis, except:
   a. Organism isolated
   b. Recurrent embolism
   c. Extravalvular infection
   d. Aortic regurgitation
   e. CHF despite medical therapy

151. d 152. e 153. e 154. d 155. c 156. b 157. b

158. Thallium 201 (^{201}TI) is used as a myocardial imaging agent because:
    a. It acts as a calcium analog that will perfuse only actively metabolizing tissue.
    b. It has a short half-life (75 seconds)
    c. Its extraction by the myocardium is dependent on blood flow
    d. It can also be used for a first-pass study, which will provide an ejection fraction
    e. Following its initial extraction by the myocardium, there is virtually no diffusion out of the myocyte

159. All of the following antiarrhythmic agents interact predominantly with the fast sodium channels, except:
    a. Procainamide
    b. Flecainide
    c. N-acetylprocainamide (NAPA)
    d. Lidocaine
    e. Phenytoin

160. You are consulted about a 34-year-old pregnant women who complains of increasing dyspnea and lower-extremity edema. Her examination reveals that she is hypertensive and in mild heart failure. The laboratory data and echocardiogram are commensurate with peripartum cardiomyopathy with left ventricular dysfunction. You start all of the following, except:
    a. ACE inhibitor
    b. Digoxin
    c. Furosemide
    d. Hydralazine
    e. Oxygen

161. You are asked urgently to examine a 57-year-old woman in the coronary care unit who presented to the emergency 3 hours previously with an acute inferior wall MI. You notice that she presented to the emergency 40 minutes after the onset of symptoms and received thrombolytic therapy shortly thereafter. She now is markedly diaphoretic and has mild tachypnea without chest pain.
    Examination reveales BP 80/44, elevated JVP to 7 cm. Her precordium is quiet, and there are bibasilar rales. Following your assessment, you note all of the following, except:
    a. This complication occurs in approximately one-third of inferior wall infarctions and needs no treatment
    b. Fluid challenge increases the central venous pressure
    c. Emergency surgery is the treatment of choice
    d. Balloon-tip flow-directed catheterization will help confirm the diagnosis
    e. An intraaortic balloon pump will help unload the left ventricle, which can improve hemodynamics

162. All of the following statements concerning a left anterior divisional block (LADB) are true, except:
    a. The QRS axis is between –30° and –90°
    b. It always signifies underlying heart disease
    c. It may inscribe a small R wave followed by a dominant S wave in leads II, III, and a VF
    d. QRS duration is between 80 ms and 100 ms
    e. In the elderly, it is seen more commonly than a left posterior divisional block (LPDB)

158. d 159. c 160. c 161. c 162. d

163. When comparing a non-Q-wave myocardial infarction with a Q-wave infarction, which of the following statements is true?
    a. Non-Q-wave infarctions have a much better 1 year survival profile
    b. Because non-Q-wave infarctions are considered a small infarction, they have a much lower chance of a reinfarction
    c. Non-Q-wave infarctions occur predominantly in the inferior wall; Q-wave infarctions occur predominantly in the anterior wall
    d. Because non-Q-wave infarctions tend to be smaller infarctions, left ventricular function plays no role in prognosis
    e. The mortality associated with non-Q-wave infarctions occurs later when compared to patients with Q-wave infarctions

164. The most common valvular lesion seen in carcinoid is:
    a. Mitral regurgitation (MR) and aortic stenosis (AS)
    b. Pulmonary stenosis (PS) and tricuspid regurgitation (TR)
    c. Pulmonary stenosis and aortic stenosis
    d. Mitral stenosis (MS) and aortic stenosis
    e. Aortic regurgitation (AR) and mitral stenosis (MS)

165. The most common primary tumor of the heart is:
    a. Rhabdomyosarcoma
    b. Angiosarcoma
    c. Fibroma
    d. Myxoma
    e. Thymoma

166. The presence of which of the following conditions protends the poorest long-term prognosis in patients with aortic stenosis?
    a. Angina
    b. Syncope
    c. Calcification of the valve
    d. Valve area of less than 0.5 cm^2
    e. CHF

167. In patients with rheumatic heart disease, the most common valve affected is:
    a. Mitral
    b. Aortic
    c. Pulmonary
    d. Tricuspid
    e. Rheumatic heart disease does not affect valvular structures

168. For those asymptomatic patients diagnosed with an accessory pathway on a surface ECG, you would suggest:
    a. Perform immediate electrophysiologic studies to determine the location of the pathway and consider ablation
    b. Initiate a prophylatic calcium channel blocker
    c. Obtain a single average ECG to look for late potentials
    d. Administer a β-blocker
    e. None of the above

163. b 164. d 165. e 166. a 167. a 168. e

169. You are asked to provide physical examinations for a high-school football team. You would allow all of the students diagnosed with the following anatomy to participate in competitive sports, except:
    a. Small patent ductus arteriosus (PDA) with normal pulmonary pressures
    b. Small ventricular septal defect (VSD) with normal pulmonary pressures
    c. Obstructive hypertrophic cardiomyopathy with normal systemic pressures
    d. A surgically corrected ostium secundum atrial septal defect (ASD) with normal pulmonary pressure and normal electrical activation
    e. None of the above would be allowed to participate in competitive athletics

170. Constrictive pericarditis is associated with each of the following, except:
    a. Rheumatic heart disease
    b. Radiation therapy for Hodgkin's disease
    c. Tuberculosis
    d. Bacterial (purulent) pericarditis
    e. Hypothyroidism

171. Following an extensive workup of a 47-year-old man for severe CHF, you determine that the best treatment strategy includes a cardiac transplant. You inform this patient that the 5-year survival is:
    a. Less than 50%
    b. 50 to 60%
    c. 60 to 70%
    d. 70 to 80%
    e. 90 to 95%

172. You are seeing a 64-year-old woman admitted for a cardiac catheterization for angina. She has a history of hypertension. Her physical examination is unremarkable, but you notice a baseline serum creatinine of 2.4 mg/dL. Other than the routine precatheterization order, you would:
    a. Start renal dose dopamine precatheterization and continue for 12 hrs following the procedure
    b. Hydrate with 0.45% normal saline solution 12 hours precatheterization and continue for 12 hrs following the procedure
    c. Hydrate as in choice b; add furosemide 40 mg IV as the first dye injection is given
    d. Do a dialysis preprocedure to a normal creatinine, then proceed as for a routine catheterization
    e. Follow normal catheterization procedures

173. Indications for electrophysiologic study include all of the following, except:
    a. A 37-year-old woman; history of palpitation and documented supraventricular tachycardia
    b. A 42-year-old male pilot; history of syncope and a delta wave on his surface ECG
    c. A 24-year-old woman; delta wave on ECG, suggestive of a septal accessory pathway
    d. A 66-year-old man; history of an inferior wall MI presents with syncope
    e. A 75-year-old man; documented monomorphic ventricular tachycardia patient was placed on a combination of quinidine and mexiletine

174. The urgent need for bypass surgery in the above patient would be directly related to all the following, except:
    a. Lesion location
    b. Lesion length
    c. Thrombus present in the area
    d. Severity of stenosis
    e. Calcification in the lesion

169. c 170. e 171. d 172. b 173. c 174. d

175. All of the following statements concerning a cardiac rupture following a myocardial infarction are true, except:
    a. It occurs more frequently in men as compared to women
    b. It is more likely to occur following the first myocardial infarction
    c. The patient frequently has pre-existing hypertension
    d. It usually occurs within the first 5 days after the infarction
    e. It is usually seen in patients over age 65

176. All of the following are typical features of mitral stenosis found on physical examination, except:
    a. Presystolic murmur
    b. Loud S1
    c. Soft S3
    d. Opening snap
    e. Mid-to late diastolic murmur

177. All of the following cardiac abnormalities should receive endocarditis prophylaxis for the appropriate indication, except:
    a. Mitral valve prolapse with a regurgitation murmur
    b. Hypertrophic cardiomyopathy
    c. Isolated secundum atrial defect
    d. Prosthetic cardiac valve
    e. History of previous endocarditis

178. Out of the following lesions which procedure listed below does not require antibiotic prophylaxis?
    Mitral valve prolapse with a regurgitation murmur
    Hypertrophic cardiomyopathy
    Isolated secundum atrial defect
    Prosthetic cardiac valve
    History of previous endocarditis
    a. Tonsillectomy and/or adenodectomy
    b. Gallbladder surgery
    c. Endoscopy with a planned biopsy
    d. Cystoscopy
    e. Vaginal hysterectomy

179. A 64-year-old man presents to the emergency department with the complaint of severe pain in his right leg. He states that the pain was of sudden onset and that it occurred while he was resting. He denies palpitations, syncope, or dizziness and has no history of valvular heart disease. His past medical history is remarkable for an anterior wall myocardial infarction 4 weeks prior to this incident, for which he has had an uncomplicated course. Examination reveals a cool slightly mottled right leg from the knee down. Femoral pulses are normal, and the distal prothrombin time (PT) and deep pulse (DP) are absent in the right leg and diminished in the left leg. Following the arteriogram and embolectomy, the patient noted a significant improvement.
    Which of the following tests would be most important to complete the workup of this patient?
    a. Echocardiogram
    b. Ventilation and perfusion scan
    c. Liver profile
    d. PT
    e. Abdominal aortogram

175. a 176. c 177. c 178. c 179. a

180. All of the following suggest that a wide complex tachycardia originates from above the ventricle (supraventricular tachycardia), except:
   a. Onset with a premature P wave
   b. RSR configuration in VI
   c. Atrial-ventricualr (AV) dissociation
   d. Slowing or terminating with an increase in vagal tone
   e. RP interval 100 ms

181. A 28-year-old woman presents to your clinic with an atypical type of chest pain. Following a complete history and physical, you diagnosis mitral valve prolapse (MVP). You can explain to the patient that although MVP tends to be benign, complications can occur. These complications include all of the following, except:
   a. Sudden cardiac death
   b. Chordal rupture and flail mitral leaflet
   c. Infective endocarditis
   d. Embolic phenomena
   e. Angiodysplasia

182. When considering the need for warfarin or aspirin in patients with nonrheumatic atrial fibrillation (NRAF) for the prevention of a primary event (emboli), which statement is true?
   a. Warfarin offers to benefit in preventing a primary event in those patients over age 75
   b. In a 57-year-old hypertensive man with NRAF, the risk of a primary event while taking aspirin is over 5%
   c. In a 68-year-old woman without a history of an embolic event, hypertension, or CHF, warfarin is the drug of choice
   d. For patients over age 75, the total stroke rate (ischemic plus hemorrhagic) was similar when treated with aspirin or warfarin
   e. The combination of aspirin and warfarin has a surprisingly low intracarnial bleeding rate with a very low primary event rate

183. All of the following are indications for the insertion of a permanent pacemaker, except:
   a. Symptomatic type I 2º AV block
   b. 1º AV block with symptoms of fatigue or weakness
   c. Bifascicular block with intermittent type II 2º AV block without symptoms attributable to heart block
   d. 1º AV block with a left anterior or posterior hemiblock
   e. Symptomatic atrial fibrillation with a fixed ventricular response, off medications

184. You see a 68-year-old male for his annual check-up. He denies any symptoms, and he is active without any complaints. Upon reviewing the records you see that it has been 5 years since his last examination. At that time a soft carotid bruit on the left side was documented. Your examination confirms the bruit and an ultrasound quantifies the stenosis of 60 to 80% based on Doppler flow measurements. The remainder of your examination is essentially unremarkable, without evidence of neurological pathology. You tell him the following:
   a. His stroke risk is low (<5%) because the bruit was noted 5 years ago and has remained stable. Aspirin would be your only recommendation
   b. His stroke risk is about 21%. Therefore he should consider endarterectomy, which carries an 8% stroke rate
   c. His stroke risk is >75% and therefore should undergo emergency endarterectomy, which carries only at 15% stroke rate
   d. Follow-up in 5 years; if the stenosis is worse at that time, consider an endarterectomy
   e. His stroke risk is 50%, and the risk of surgery is also 50%. Refer to a center that performs carotid stenting

180. c 181. c 182. d 183. d 184. b

185. ECG findings in Hypokalemia associated with:
   a. U wave
   b. Short QT interval
   c. Peaked T waves
   d. Prolongation of the ST segment
   e. RSR pattern

186. ECG findings in Hypocalcemia associated with:
   a. U wave
   b. Short QT interval
   c. Peaked T waves
   d. Prolongation of the ST segment
   e. RSR pattern

187. ECG findings in Hyperkalemia associated with:
   a. U wave
   b. Short QT interval
   c. Peaked T waves
   d. Prolongation of the ST segment
   e. RSR pattern

188. ECG findings in Hypercalcemia associated with:
   a. U wave
   b. Short QT interval
   c. Peaked T waves
   d. Prolongation of the ST segment
   e. RSR pattern

189. True statements concerning mycotic aneurysms include which of the following?
   a. They have a low incidence of rupture
   b. They are usually fusiform in appearance
   c. They tend to be caused by a fungal infection
   d. They are restricted to the smaller arteries of the body
   e. First described by William Osler

190. True statements concerning evaluation of CAD include which of the following?
   a. A normal 201T uptake excludes CAD
   b. A 2-mm or larger depression of the ST segment is a marker of left main artery disease
   c. A fixed defect seen on a stress thallium test represents a scar
   d. The lead that shows the greatest amount of depression is very specific for the vessel territory involved
   e. Dobutamine stress Echo is a useful screening test

191. The more common adverse effects of amiodarone include which of the following?
   a. Skin discoloration
   b. Renal failure
   c. Hepatitis
   d. Hyperthyroidism
   e. Hypothyroidism

192. True statements concerning the treatment modalities in patients with hypertrophic obstructive cardiomyopathy include which of the following?
   a. DDD pacing
   b. Septal myomyectomy
   c. Digoxin
   d. Calcium channel blockers
   e. Dipyridamole

193. Side effect of quinidine:
   a. Hypotension
   b. Skin discoloration
   c. Pyridostigmine will reduce its adverse effects
   d. Exercise can precipitate a proarrhythmic response
   e. Class II/III action

185. a 186. b 187. c 188. b 189. e 190. e 191. a 192. c 193. e

194. Side effect of sotalol:
   a. Hypotension
   b. Skin discoloration
   c. Pyridostigmine will reduce its adverse effects
   d. Exercise can precipitate a proarrhythmic response
   e. Class II/III action

195. Which of the following statements about ACh release and deactivation is true?
   a. ACh release is blocked by the toxin associated with *Clostridium tetani*
   b. Uptake of ACh into the presynaptic receptor is the most important mechanism in terminating the ACh signal
   c. Acetylcholinesterase (AChE) inhibitors, such as physostigmine, are not effective in the treatment of myasthenia gravis, because patients with myasthenia have no cholinergic nerve terminals to release ACh
   d. The influx of Ca^{2+} into the depolarized axon terminal is a prerequisite for the release of stored ACh
   e. Inhibitors of the enzyme monoamine oxidase (MAO) are important in the treatment of depression because they inhibit the breakdown of ACh into its constituents, acetic acid and choline

196. All of the following are anaerobes that can be found in the normal human body, except:
   a. Propionibacter organisms
   b. Bacteroides
   c. Pseudomonas
   d. Fusobacteriu organisms
   e. Clostridia

197. A 21-year-old man dies suddenly during his track workout. The man had a history of occasional fainting, as does his brother. On autopsy, his heart showed a hypertrophic interventricular septum out of proportion with the rest of the heart. Which one of the following is the most likely diagnosis?
   a. Sarcoidosis
   b. Amyloidosis
   c. Idiopathic hypertrophic cardiomyopathy
   d. Hemochromatosis
   e. Hypertensive heart disease

198. All of the following statements about mitral valve prolapse are correct, except:
   a. Diagnosis of mitral valve prolapse rarely can be made before symptoms occur
   b. Mitral valve prolapse is seen in approximately 7% of the population
   c. Mitral valve prolapse usually causes a mid systolice click
   d. Ehlers-Danlos syndrome and other connective tissue diseases are associated with mitral valve prolapse
   e. Infective endocurditis is an infrequent, yet possible, complication of mitral valve prolapse

199. All of the following statements about rheumatic heart disease are correct, except:
   a. It usually follows pharyngitis due to group A β-hemolytic streptococci
   b. All three layers of the heart – endocardium, myocardium, and pericardium – may be affected
   c. Rheumatic heart disease cannot be distinguished from other forms of carditis on the basis of microscopic analysis of biopsies alone.
   d. The five major criteria for diagnosis of acute rheumatic fever are carditis, polyarthritis, chorea, erythema marginatum, and subcutaneous nodules
   e. The mitral valve is the most commonly affected valve in chronic rheumatic heart disease

194. a 195. d 196. c 197. c 198. a 199. c

200. Which of the following pathophysiologic changes may be most useful in documenting, within less than 6 hours, that a patient had a myocardial infarction?
   a. Inverted or biphasic T wave on an electrocardiogram
   b. Eelevated serum levels of creatinine kinase
   c. Elevated serum levels of myocardial lactate dehydrogenase
   d. Maximal indices of coagulative necrosis
   e. Peak tissue infiltration of neutrophils

201. Which of the following statements correctly pairs a commonly used anticogulant with its mechanism of action?
   a. Heparin to cleave the covalent linkage between fibrin monomers
   b. Tissue plasminogen activator acts by irreversibly inhibiting thrombin
   c. Dicumarol (warfarin) is a natural product which competitively inhibits the vitamin K dependent γ-carboxylation of several cascade proteins
   d. Aspirin irreversibly binds fibrinogen, which decreases the pool of available fibrin monomers that can participate in clot formation
   e. Streptokinase is a bacterial product that causes platelet lysis, therefore inhibiting platelet aggregation

202. A 57-year-old man complains of having episodes of chest pain. His blood pressure is 160/100 mm Hg, he has been smoking 1 pack of cigarettes every day for the past 40 years,and both his legs are amputated at the knee. Which one of the following actions are most appropriate?
   a. Because of the patient's amputations, a coronary angiogram should be performed in lieu of an exercise test
   b. The patient does not need an exercise test because his potential coronary artery disease can easily be assessed at rest
   c. The patient should immediately be rushed to the operating room for emergent bypass surgery
   d. Administration of dipyramidole should be used as a substitute for exercise in assessing the extent of the patient's potential coronary artery disease
   e. The patient is advised to quit smoking and to take one aspirin per day; he can safely return to work

203. Based on the above history and physical examination, the patient is most likely to have:
   a. Atrial fibrillation
   b. Ventricular paroxysmal tachycardia
   c. Congestive heart failure
   d. Adult respiratory distress syndrome
   e. Rebound hypertensive crisis

204. A rational approach for the treatment of ventricular tachycardia associated with myocardial ischemia in a hospitalized patient includes:
   a. Digitalis
   b. Diltiazem
   c. Lidocaine
   d. Propranolol
   e. Verapamil

205. A 39-year-old-man presents for his regularly scheduled physical examination.During the cardiac portion of the examination, a palpable pre-systolic apical impulse is noted, and an S_4 is heard on auscultation. Which one of the following statements is most likely correct?
   a. The patient may have hypertrophic left ventricle secondary to aortic stenosis
   b. The patient likely has some form of underlying heart disease (e.g. myocardial infarction, mitral regurgitation)
   c. The patient has increased ventricular compliance
   d. The patient has aggravated hypotension
   e. The patient is undergoing atrial fibrillation

200. a 201. c 202. d 203. c 204. c 205. a

206. The upstroke of the ventricular action potential is primarily due to which one of the following actions?
a. An inward flux of Ca^{2+}
b. An inward K^+current
c. An outward K^+ current
d. An outward Na^+ current
e. An inward Na^+current

207. A 62-year-old man experiences crushing substernal chest pain. After 4 days of circulatory support in the intensive care unit, he dies. Histologic study of his heart would show all of the following findings, except:
a. Coagulative necrosis
b. Liquefactive necrosis
c. Hypereosinophilic wavy fibers
d. Neutrophilic infiltrate
e. Thrombus in coronary artery

208. Each of the following statements concerning intercostal nerves is true, except:
a. They are the anterior rami of the 12 thoracic spinal nerves
b. They are connected to the sympathetic trunk by rami communicans
c. The first intercostal nerve is joined to the brachial plexus
d. They supply the anterior abdominal muscles
e. They supply the parietal pleuras

209. Serious complications in a patient who has just suffered an acute myocardial infarction include all of the following, except:
a. Cardiac tamponade
b. Peripheral embolism
c. Mitral valve incompetence
d. Aortic aneurysm
e. Rupture of the ventricular septum

210. All of the following organization are cardiac related, except:
a. AHA
b. AATS
c. IACTA
d. SCA
e. SAMBA

211. IABP is useful in all, except:
a. Cardiogenic shock
b. Cardiac arrest
c. Unstable angina
d. Post MI, mitral regurgitation
e. Post CPB, low pressing

212. Beating heart surgery compared to CABG on CPB produce all the following, except:
a. Has less stroke rate
b. Has less inflammatory response
c. Has shorter ICU stay
d. Saves cost
e. Produces less surgical bleeding

213. The cardiac output thermodilution curve shown below can be produced by which of the following conditions:

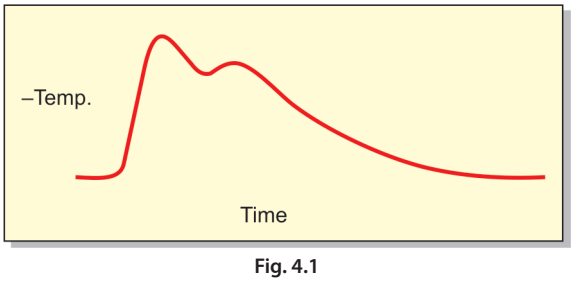


Fig. 4.1

206. e 207. b 208. a 209. d 210. e 211. b 212. a

a. Left-to-right intracardiac shunt
b. Tricuspid regurgitation
c. Slow indicator injection
d. Pulmonary arteriovenous malformation

214. In a preoperative patient with tetralogy of Fallot, the best indicator of the magnitude of the average, chronic R->L shunt is the:
a. Color of the tongue
b. Arterial pO_2
c. Hematocrit
d. Pulmonary blood flow at catheterization

215. Ketamine is relatively contraindicated except one, for induction of anesthesia in an infant with:
a. Anomalous left coronary artery
b. Critical aortic stenosis
c. Hypoplastic left heart syndrome
d. Tetralogy of Fallot

216. The newborn ductus arteriosus is likely to be constricted by except:
a. Oxygen
b. Acetylcholine
c. Indomethacin
d. PGE_1

217. Who first used cardiopulmonary bypass (CPB) successfully in clinical practice?
a. C Walton Lillehei
b. Gibbon
c. Dennis and colleagues
d. DeWall-Lillehei

218. A pulmonary capillary wedge pressure is being recorded continuously in a paralyzed patient on positive pressure ventilation with an I:E ratio of 1:2. The pressure is seen to rise and fall in time with the respiratory cycle.
Which one of the following statements regarding the wedge pressure is correct?
a. The mean of the highest and lowest value should be recorded
b. The transmural pressure (pressure inside minus pressure outside) of the left atrium rises during inspiration
c. The pressure should be read at its highest point
d. The pressure should be read at its lowest point

219. A blood transfusion may lawfully be administered in all situations, except:
a. An adult patient in an emergency whose Jehovah's Witness status is uncertain
b. An unconscious adult patient who is carrying an advance directive indicating his Jehovah's Witness status and refusing transfusion of blood products
c. A child of Jehovah's Witness parents for whom a specific issue order has been obtained
d. A child of Jehovah's Witness parents in an emergency

220. False about the serum troponins:
a. Have a greater sensitivity than CK-MB in diagnosis of MI
b. May be detected in serum 5 days after infarction
c. When detected in serum invariably reflect irreparable myocardial damage
d. Have a prognostic role in critical illness

221. Correct statement about assessing the severity of aortic stenosis:
a. The pressure gradient across the valve is the most accurate method
b. Angiography is not always required
c. Exercise tolerance is a good measure of severity
d. The pressure gradient measured at angiography will be higher than that found on the echocardiogram

213. a 214. c 215. d 216. d 217. b 218. d 219. b 220. c 221. b

222. In the fetal circulation:
   a. The stroke volume of the left ventricle is the same as the stroke volume of the right ventricle
   b. Deoxygenated blood arrives at the placenta via the umbilical vein
   c. Cardiac output is defined as the volume of blood ejected by the left ventricle in one minute
   d. Only 12% of the right ventricular output enters the pulmonary circulation

223. The following situations are associated with an increase in the risk of awareness, except:
   a. Thyrotoxicosis
   b. β-blockade
   c. Cardiac surgery on CPB
   d. Off pump CABG

224. The potential metabolic problems from massive blood transfusion are all, except:
   a. Increased 2,3-DPG levels
   b. Hyperkalemia
   c. Citrate toxicity
   d. Hypomagnesemia

225. American Heart Association (AHA) recommended drug therapy for pulseless VT/VF in adult:
   a. IV Lidocaine 10 mg
   b. IV Amiodarone 300 mg
   c. IV Metoprolol 5 mg
   d. IV Diltiazem 15 mg

226. Regarding Neuromuscular Junction (NMJ) in neonates, all are true, except:
   a. NMJ is immature with lesser ACh than adults
   b. Shows myasthenic response - fade even in absence of muscle relaxants
   c. Sensitive to suxamethonium and myalgia seen from 9 days of age
   d. Resistance to suxamethonium and sensitive to nondepolarizers

227. Isoprenaline:
   a. Acts at beta 1 adrenoreceptors
   b. Increases total peripheral vascular resistance
   c. Is excreted unchanged in the urine
   d. Increases systemic blood pressure

228. Which of the following ECG changes is not seen in pulmonary hypertension?
   a. Right axis deviation
   b. Right ventricular hypertrophy/strain
   c. Incomplete/complete left bundle branch block
   d. RS ratio > 1 in lead V1

229. Important factors in the intraoperative care of the patient with aortic stenosis include all, except:
   a. Avoiding hypotension
   b. Maintaining systemic vascular resistance
   c. Avoiding tachycardias
   d. Never using regional anesthesia

230. About dopexamine all are true, except:
   a. Causes arterial vasoconstriction
   b. Increases the force of myocardial contraction
   c. Increases renal blood flow
   d. Causes arrhythmias

231. Severe V/Q abnormalities are associated with all, except:
   a. A small decrease in tidal volume
   b. A rise in the (A-a) O_2 difference
   c. A major pulmonary embolus
   d. An increase in the alveolar dead-space

222. d 223. d 224. a 225. b 226. c 227. a 228. c 229. d
230. a 231. a

232. The magnitude of shunting across a simple nonrestrictive VSD depends on:
   a. Location of the VSD
   b. Left ventricle to right ventricle pressure gradient
   c. Size of the VSD
   d. Pulmonary and systemic vascular resistances

233. Which of the following is an adverse consequence of the use of "designer drugs"?
   a. Stroke
   b. Toxic consequences of drug adulteration
   c. Diabetes
   d. Heart disease
   e. Lung cancer

234. Early change in the brain during exposure to addictive drugs involves the insertion of _____ receptors into neuron membranes located within the _____:
   a. GABA; hippocampus
   b. D2; nucleus accumbens
   c. AMPA; VTA
   d. Glycine; VTA
   e. AMPA; amygdale

235. Which of the following illustrates the concept of negative reinforcement?
   a. A woman injects heroin into her veins to obtain a "rush"
   b. A hungry rat presses a lever to obtain a food pellet
   c. A rat presses a lever that results in delivery of a shock through the floor of the chamber
   d. A man ingests an aspirin to rid himself of a strong headache
   e. A child is sent to his room after screaming at the dinner table

236. Which of the following illustrates the concept of craving?
   a. A man ingests an aspirin to rid himself of a strong headache
   b. A hungry rat presses a lever to obtain a food pellet
   c. A rat presses a lever that results in delivery of a shock through the floor of the chamber
   d. A woman injects heroin into her veins to obtain a "rush"
   e. An injection of cocaine reinstates responding for intravenous cocaine in a rat that underwent extinction of cocaine responding

237. Many NSAIDs can lead to gastrointestinal disturbances and they are considered to be a main factor in the etiology of peptic ulcers. What is the main cause of most peptic ulcers?
   a. Helicobacter pylori
   b. Alcohol
   c. NSAIDs
   d. Nicotine

238. Which NSAID should not be used for long-term treatment of inflammatory conditions?
   a. Aspirin
   b. Diclofenac
   c. Mefenamic acid
   d. Indimethacin

239. Local anesthetics are often given together with adrenaline. Why?
   a. To lessen the pain of injection
   b. To act as a potentiator
   c. To dilate blood vessels
   d. To constrict blood vessels

240. What is the equivalent dose of fentanyl when compared with 10 mg of morphine?
   a. 200-250 mcg of fentanyl
   b. 150-200 mcg of fentanyl
   c. 50-100 mcg of fentanyl
   d. 100-150 mcg of fentanyl

232. d 233. b 234. c 235. d 236. e 237. a 238. c 239. d 240. b

241. Levosimendan is a:
   a. ATP binder
   b. cGMP agonist
   c. NaKAT Pase channel opener
   d. cAMP agonist

242. For clients receiving naltrexone, the _____ should be mentioned before starting treatment and monthly for the first three months:
   a. Renal function
   b. Clotting function
   c. Liver function
   d. Visual acuity

Mitral Valve

243. The following are consistent with severe MR, except:
   a. Dominant diastolic flow in the left upper pulmonary vein
   b. Vena contracta width 8 mm
   c. Effective regurgitant orifice area 0.2 cm^2
   d. Regurgitant fraction 60%

244. Using the Carpentier nomenclature the following are true:
   a. P1 is closer to the left atrial appendage than P3
   b. P3 and A3 are on the surgeons right
   c. A1 and P1 are nearest the anterolateral part of the commissure
   d. P2 corresponds to the middle scallop of the posterior leaflet
   e. P3 receives chordae tendinae from the anterolateral papillary muscle

245. The following are true of mitral valve prolapsed:
   a. A2 scallop is most frequently involved
   b. Classic mitral valve prolapse affects 5% of the population
   c. An eccentric MR jet is directed towards the side of the affected leaflet
   d. P2 prolapse can be repaired using the technique of triangular resection

246. The following are true of standard TEE views:
   a. At 90°, the A1/P1 coaptation is visualized
   b. In the bicommissural view from left to right P3 A2 P1 scallops are visualized
   c. At zero degree, withdrawal and flexion of the probe moves towards the posteromedial commissure
   d. The vena contracta is most reliably measured in the bicommissural view

247. The following is true of mitral stenosis:
   a. The most common cause is not rheumatic fever
   b. The Wilkins score includes commissural assessment
   c. Mitral valve area 1.5 cm^2 indicates severe stenosis
   d. Moderate or severe MR contraindicates balloon valvuloplasty

248. The ACC/AHA guidelines for valvular heart disease give class I recommendations for all, except:
   a. Mitral valve repair in patients with acute symptomatic MR where repair is likely
   b. Mitral valve repair in asymptomatic patients with severe MR, LVES diameter >45 mm and ejection fraction <60%
   c. Balloon mitral valvotomy in asymptomatic patients with MVA 1.5-2 cm^2
   d. Intraoperative TEE to guide mitral valve repair

241. c 242. a 243. c 244. e 245. d 246. b 247. d 248. c

249. The following is true of the subvalvular apparatus, except:
   a. Chordae from the anterolateral papillary attach only to the anterior mitral leaflet
   b. The posteromedial papillary muscle is usually supplied by both the right coronary and circumflex coronary arteries
   c. Third order chordae attach to both the anterior and posterior leaflets
   d. Torn chordae are the usual cause of flail mitral leaflet

250. In the Carpentier classification of leaflet abnormality, the incorrect statement is:
   a. Type III abnormality of the posterior leaflet usually causes an anteriorly directed jet of MR
   b. Type I abnormality is associated with normal leaflet motion
   c. Type III abnormality in dilated cardiomyopathy is usually associated with a central jet of MR
   d. Type II abnormality with flail anterior leaflet gives a posteriorly directed jet of MR

251. In mitral valve repair all are true, except:
   a. Isolated P2 prolapse has the best success rate
   b. SAM can be successfully treated by increasing the afterload
   c. MR severity should be assessed in the awake state
   d. A2 leaflet prolapse is usually amenable to triangular resection

252. The following are true of the St Jude mechanical prosthesis, except:
   a. It is the most commonly implanted prosthetic valve
   b. It is a tilting disc valve
   c. Small convergent closure jets are normal
   d. Can be implanted in the mitral, aortic and tricuspid position

Cardiovascular Anesthesia

253. Which of the following statements regarding atropine is incorrect?
   a. Has no effect on acetylcholine production or destruction
   b. Dilates cutaneous blood vessels
   c. Is a parasympathetic depressant
   d. Stimulates the respiratory center

254. The following is true of alpha-adrenoceptor blocking agents:
   a. They increase blood flow in normal skin and muscle
   b. They cause drowsiness
   c. The clinically useful drugs are competitive antagonists
   d. They have only alpha 1- blocking activity

255. Captropril: Choose FTTFT the correct statement:
   a. Increases the rate of breakdown of angiotensin II
   b. Inhibits the breakdown of bradykinin
   c. May cause an increase in plasma potassium
   d. Can safely be given in large doses in hypertensive crisis

256. The following are important in physiological limitation of blood clotting, except:
   a. Removal of activated clotting factors by the liver
   b. Prostacyclin
   c. Protein C
   d. A factor released from the endothelial cells

249. d 250. a 251. d 252. a 253. d 254. a 255. b 256. a

257. Heart rate is slowed by:
a. Amphetamine
b. Atropine
c. Propranolol
d. Dobutamine

258. In using propranolol to treat hypertension: What is not true?
a. May exacerbate asthma
b. Often produces postural hypotension
c. May precipitate cardiac failure in susceptible patients
d. Should be avoided in a patient with Raynaud's phenomenon

259. Cardiac output may be measured by all, except:
a. Thermodilution
b. Electromagnetic flow meter
c. Doppler ultrasound
d. Limb plethysmography

260. In pulse oximetry:
a. The theoretical basis is Stefan's law
b. Carboxyhemoglobin does not affect readings
c. Accuracy at readings above 90% saturation is to within 0.1%
d. Pulse amplitude is a good indicator of cardiac output

261. One of the following statements, regarding coronary blood flow is incorrect?
a. Is about 500 mL/min at rest
b. Supplies muscle that takes up 40 mL oxygen per minute at rest
c. Is altered directly by vagal activity
d. Is autoregulated

262. Which of the following is a sign of respiratory distress in a 13-month-old child?
a. Femur fracture
b. Knee dislocation
c. Lumbar spine fracture
d. Skull fracture

263. Which of the following is considered normal for newborn to 3-month-old infant?
a. Respiratory rate of 40 bpm
b. Pulse of 80 bpm
c. Sunken fontanel
d. Respiratory retractions

264. Which of the following statements is most important in the field management of the hypothermic submersion?
a. Keep the patient in the water until you are ready to transport
b. Apply warm, moist towels to the body surface
c. Initiate warmed humidified oxygen
d. Remove wet clothing and dry the patient

265. Which of the following is TRUE regarding flail chest in a child?
a. Diagnosed by tracheal deviation
b. Often associated with severe lung injury
c. Treated with needle decompression
d. Usually not very serious

266. A 3-year-old requires bag-value-mask ventilation which of the following suggests proper ventilation?
a. Bradycardia
b. Cyanosis
c. Gastric distention
d. Symmetric rise and fall of the chest

267. A 3-year-old is injured in a motor vehicle collision. Vital signs are: respiratory rate, 40 bpm; pulse rate, 130 bpm; and BP, 70/40. The child's skin is cool and pale. Which of the following is the most likely condition?
a. Cardiogenic shock
b. Hypovolemic shock
c. Neurogenic shock
d. Tension pneumothorax

257. c 258. b 259. d 260. d 261. a 262. d 263. a 264. d
265. b 266. d 267. b

5

Congestive Heart Failure and Congenital Heart Disease

1. Most important acute factor in changing the position of the force-velocity and ventricular function curves:
   a. Circulating catecholamines—adrenal medullary release
   b. Reduced parasympathetic tone
   c. Increased adenosine release
   d. Increased cardiac adrenergic nerve activity

2. Drug used in treating CHF—associated with a reversible thrombocytopenia:
   a. Dopamine (Intropin)
   b. Hydralazine (Apresoline)
   c. Methyldopa (Aldomet)
   d. Amrinone (Inocor)
   e. Digoxin (Lanoxin, Lanoxicaps)

3. First-line agents used in treating congestive heart failure:
   a. Hydralazine (Apresoline)
   b. Dobutamine (Dobutrex)
   c. ACE inhibitors
   d. Thiazide diuretics
   e. Calcium channel blockers

4. Left ventricular stroke volume—relationship to afterload
   a. Direct
   b. Inverse

5. Most important digitalis-mediated cardiac effect:
   a. Tachycardia
   b. Improved real perfusion
   c. Decreased AV transmission
   d. Shift of the force-velocity relationship upward

6. Short-term inotropic support of the failing myocardium:
   a. Furosemide (Lasix)
   b. Diltiazem (Cardiazem)
   c. Dobutamine (Dobutrex)
   d. Milrinone (Primacor)
   e. Dopamine (Intropin)

7. Exogenous agents that improve ventricular performance:
   a. Isoproterenol (Isuprel)
   b. Theophylline
   c. Diltiazem (Cardiazem)
   d. Nifedipine (Procardia, Adalat)
   e. Caffeine

1. d 2. d 3. c 4. b 5. d 6. d, e 7. a, b, e

8. Appropriate interventions in the management of cardiogenic shock:
   a. Supplemental oxygen
   b. Surgery to repair valve pathologies or to revascularize
   c. Intra-aortic balloon pump
   d. IV nitroglycerin
   e. All of the above

9. Perhaps more useful in a CHF patient with marginal GFR due to poor renal perfusion:
   a. Dopamine (Intropin)
   b. Dobutamine (Dobutrex)
   c. Methoxamine (Vasoxyl)

10. Less arrhythmogenic; less tachycardia:
   a. Dopamine (Intropin)
   b. Dobutamine (Dobutrex)

11. Drugs used in the management of congestive heart failure:
   a. Torsemide (Demadex)
   b. Dobutamine (Dobutrex)
   c. Milrinone (Primacor)
   d. Ramipril (Altace)
   e. Digoxin (Lanoxin, Lanoxicaps)
   f. All of the above

12. Vasoconstrictors:
   a. Endothelin I
   b. Angiotensin II
   c. Both
   d. Neither

13. Mechanism by which vasodilators improve myocardial performance in CHF:
   a. Increase heart rate
   b. Promote diuresis
   c. Reduce afterload
   d. Reduce pulmonary blood flow

14. Physiological effects associated with acute pulmonary edema:
   a. Elevation of pulmonary capillary pressures
   b. Alveolar edema
   c. Rales
   d. Expectoration of blood-tinged fluid
   e. Pretibial edema

15. Agent of choice among phosphodiesterase inhibitors for short-term parenteral support in severe heart failure patients:
   a. Dopamine (Intropin)
   b. Milrinone (Primacor)
   c. Dobutamine (Dobutrex)
   d. IV isoproterenol (Isuprel)
   e. IV epinephrine

16. Agents which depress ventricular performance:
   a. Dopamine (Intropin)
   b. General anesthetics
   c. Disopyramide (Norpace)
   d. Procainamide (Procan SR, Pronestyl-SR)

17. Inhibitors and Na/K ATPase—used in management of CHF:
   a. Enalapril (Vasotec)
   b. Amrinone (Inocor)
   c. Dobutamine (Dobutrex)
   d. Digoxin (Lanoxin, Lanoxicaps)
   e. Minoxidil (Loniten)

18. Effective exercise on intrathoracic blood volume:
   a. Increased
   b. Decreased
   c. No effect

19. State of neurohumoral activation in CHF:
   a. Highly activated
   b. Generally suppressed

8. e	9. a	10. b	11. f	12. c	13. c	14. a, b, c, d
15. b	16. b, c, d	17. d	18. a	19. a		

20. Primarily excreted in the urine; digitalis glycosides with half-life of 1.6 days:
    a. Digoxin (Lanoxin, Lanoxicaps)
    b. Digitoxin
    c. Both
    d. Neither

21. Most significant factor in blood flow resistance:
    a. Vessel length
    b. Blood viscosity
    c. Vessel radius

22. Consequences of renin-angiotensin system activation:
    a. Reduced circulating angiotensin II
    b. Reduced aldosterone
    c. Reduced vasoconstriction
    d. None of the above

23. Physiological depressants of left ventricular function (depression of myocardial force-velocity curves):
    a. Hypercapnea
    b. Hypoxia
    c. Ischemia
    d. Acidosis
    e. Increased adrenal medullary epinephrine

24. Clinical efficacy of digitalis glycosides is based on:
    a. Decreased transmission through the AV node
    b. Increased myocardial contractility
    c. Both
    d. Neither

25. Tissue perfusion dependencies:
    a. Cardiac
    b. Vascular
    c. Microcirculatory
    d. Humoral
    e. All of the above

26. Factors that can cause congestive heart failure:
    a. Systemic hypertension
    b. Arrhythmias
    c. Pulmonary emboli
    d. Myocardial infarction
    e. All of the above

27. Associated with cardiac cachexia:
    a. Impairment of intestinal absorption
    b. Anorexia
    c. Vomiting
    d. Hepatomegaly
    e. Increased tumor necrosis factor (circulating)
    f. All of the above

28. Atrial contraction (atrophic) is more likely to be important in:
    a. The normal ventricle
    b. The hypertrophic ventricle
    c. No difference

29. Most common symptom of heart failure:
    a. Tachycardia
    b. Oliguria
    c. Splenomegaly
    d. Hepatomegaly
    e. Dyspnea

30. Component of digitalis responsible for Na/K ATPase binding:
    a. Genin or aglycone moiety
    b. Sugar residues
    c. Steroid component

20. a	21. c	22. d	23. a, b, c, d	24. c	25. e	26. e
27. f	28. b	29. e	30. a			

31. Increase respiratory muscle work of breathing in CHF due to:
    a. Interstitial pulmonary edema
    b. Vessel enlargement
    c. Both
    d. Neither

32. Even in low doses does not increase renal blood flow:
    a. Dopamine (Intropin)
    b. Dobutamine (Dobutrex)

33. Has vasodilator properties—causes a decrease in afterload as well as positive inotropism:
    a. Dopamine (Intropin)
    b. Dobutamine (Dobutrex)
    c. Phenylephrine (Neo-Synephrine)

34. Beta-receptor number and congestive heart failure:
    a. Increased
    b. Decreased
    c. No change

35. Factors that promote movement of fluid into extravascular spaces:
    a. Hypoxic states—precapillary arteriolar vasodilatation; postcapillary venule vasoconstriction
    b. Circulating toxins
    c. Reduced intravascular plasma protein
    d. All of the above

36. Sudden-onset of severe shortness-of-breath and coughing—awakening the patient:
    a. Orthopnea
    b. Paroxysmal dyspnea (Nocturnal)

37. Fundamental abnormality and heart failure—embodied in:
    a. Depression of the myocardial force-glossy relationship
    b. Abnormality in length-active muscle tension curves
    c. Both
    d. Neither

38. Precipitating causes of congestive heart failure:
    a. AV dissociation
    b. Severe bradycardia
    c. Reduce synchrony of ventricular contraction
    d. Tachyarrhythmias
    e. All of the above

39. Factors influencing end-diastolic volumes:
    a. Volume depletion
    b. Body position
    c. Venous tone
    d. Skeletal muscle activity
    e. Uterine contraction
    f. All of the above

40. Factor(s) affecting microvascular blood flow:
    a. Colloid forces
    b. Capillary hydrostatic pressures
    c. Both
    d. Neither

41. Bipyridines phosphodiesterase inhibitors used in CHF:
    a. Dobutamine (Dobutrex)
    b. Amrinone (Inocor)
    c. Hydralazine (Apresoline)
    d. Minoxidil (Loniten)
    e. Furosemide (Lasix)

31. c 32. b 33. b 34. b 35. d 36. b 37. c 38. e
39. f 40. c 41. b

42. Cardiac output is directly dependent upon:
    a. Peripheral vascular resistance
    b. Intravascular blood volume
    c. Heart rate alone
    d. Heart rate and stroke volume
    e. Stroke volume and peripheral vascular systems

Drugs used for Treatment of Heart Failure

43. All of the following are normally involved in the pathogenesis of heart failure, except:
    a. A cardiac lesion that impairs cardiac output
    b. An increase in peripheral vascular resistance
    c. A decrease in preload
    d. An increase in sodium and water retention

44. All of the following are compensatory mechanisms that occur during the pathogenesis of congestive heart failure, except:
    a. An increase in ventricular end-diastolic volume
    b. An increase in the concentration of plasma catecholamines
    c. An increase in vagal tone
    d. Increased activity of the renin-angiotensin-aldosterone system

45. All of the following are recommended at the initial stages of treating patients with heart failure, except:
    a. Reduced salt intake
    b. Verapamil
    c. ACE inhibitors
    d. Diuretics

46. All of the following agents belong to cardiac glycosides, except:
    a. Digoxin
    b. Strophantin K
    c. Amrinone
    d. Digitoxin

47. The nonglycoside positive inotropic drug is:
    a. Digoxin
    b. Strophantin K
    c. Dobutamine
    d. Digitoxin

48. Sugar molecules in the structure of glycosides influence:
    a. Cardiotonic action
    b. Pharmacokinetic properties
    c. Toxic properties
    d. All of the above

49. A glycone is essential for:
    a. Plasma protein binding
    b. Half-life
    c. Cardiotonic action
    d. Metabolism

50. Choose the derivative of the plant Foxglove (Digitalis):
    a. Digoxin
    b. Strophantin K
    c. Dobutamine
    d. Amrinone

51. All of the following statements regarding cardiac glycosides are true, except:
    a. They inhibit the Na^+/K^+-ATPase and thereby increase intracellular Ca^{++} in myocardial cells
    b. They cause a decrease in vagal tone
    c. Children tolerate higher doses of digitalis than do adults
    d. The most frequent cause of digitalis intoxication is concurrent administration of diuretics that deplete K^+

42. d 43. c 44. c 45. b 46. c 47. c 48. b 49. c
50. a 51. b

52. An important action of digitalis is to increase vagal tone. It is:
    a. True
    b. False

53. Digoxin is thought to increase intracellular concentrations of calcium in myocardial cells by indirectly slowing the action of the sodium-calcium exchanger. This consideration is:
    a. True
    b. False

54. Compare the half-life of digoxin and the half-life of digitoxin:
    a. Digoxin is greater than digitoxin
    b. Digitoxin is greater than digoxin

55. All of the following statements regarding cardiac glycosides are true, except:
    a. They inhibit the activity of the Na^+/K^+-ATPase
    b. They decrease intracellular concentrations of calcium in myocytes
    c. They increase vagal tone
    d. They have a very low therapeutic index

56. All of the following statements regarding cardiac glycosides are true, except:
    a. Digoxin is a mild inotrope
    b. Digoxin increases vagal tone
    c. Digoxin has a longer half-life than digitoxin
    d. Digoxin acts by inhibiting the Na^+/K^+ ATPase

57. The most cardiac manifestation of glycosides intoxication is:
    a. Atrioventricular junctional rhythm
    b. Second-degree atrioventricular blockade
    c. Ventricular tachycardia
    d. All of the above

58. The manifestations of glycosides intoxication are:
    a. Visual changes
    b. Ventricular tachyarrhythmias
    c. Gastrointestinal disturbances
    d. All of the above

59. For digitalis-induced arrhythmias the following drug is favored:
    a. Verapamil
    b. Amiodarone
    c. Lidocaine
    d. Propanolol

60. In very severe digitalis intoxication the best choice is to use:
    a. Lidocaine
    b. Digibind (Digoxin immune fab)
    c. Oral potassium supplementation
    d. Reducing the dose of the drug

61. All of the following statements regarding cardiac glycoside-induced ventricular tachyarrhythmias are true, except:
    a. Lidocaine is a drug of choice in treatment
    b. Digibind should be used in life-threatening cases
    c. They occur more frequently in patients with hyperkalemia than in those with hypokalemia
    d. They are more likely to occur in patients with a severely damaged heart

62. This drug is a selective beta-1 agonist:
    a. Digoxin
    b. Dobutamine
    c. Amrinone
    d. Dopamine

52. a 53. a 54. b 55. b 56. c 57. d 58. d 59. c
60. b 61. c 62. b

63. Tolerance to this inotropic drug develops after a few days:
    a. Amrinone
    b. Amiodarone
    c. Dobutamine
    d. Adenosine

64. This drug inhibits breakdown of cAMP in vascular smooth muscle:
    a. Digoxin
    b. Dobutamine
    c. Amrinone
    d. Dopamine

65. This drug is useful for treating heart failure because it increases the inotropic state and reduces afterload:
    a. Amiodarone
    b. Amrinone
    c. Propanolol
    d. Enalapril

66. This drug acts by inhibiting type III cyclic nucleotide phosphodiesterase:
    a. Amiodarone
    b. Milrinone
    c. Propanolol
    d. Enalapril

67. All of the following statements regarding inhibitors of type III phosphodiesterase are true, except:
    a. They raise cAMP concentrations in cardiac myocytes
    b. They reduce afterload
    c. They show significant cross-tolerance with beta-receptor agonists
    d. They are associated with a significant risk for cardiac arrhythmias

68. All of the following drugs are used in the treatment of severe congestive heart failure, except:
    a. Verapamil
    b. Digoxin
    c. Dobutamine
    d. Dopamine

69. Drugs most commonly used in chronic heart failure are:
    a. Cardiac glycosides
    b. Diuretics
    c. Angiotensin-converting enzyme inhibitors
    d. All of the above

70. All of the following statements concerning angiotensin converting enzyme (ACE) inhibitors are true, except:
    a. They act by inhibiting the ability of renin to convert angiotensinogen to angiotensin I.
    b. Enalapril is a prodrug that is converted to an active metabolite
    c. They reduce secretion of aldosterone
    d. They can produce hyperkalemia in combination with a potassium-sparing diuretic

71. All of the following effects of ACE inhibitors may be useful in treating heart failure, except:
    a. They decrease afterload
    b. They increase circulating catecholamine levels
    c. They reduce reactive myocardial hypertrophy
    d. They increase myocardial beta-1 adrenergic receptor density

72. All of the following statements concerning the use of angiotensin-converting enzyme (ACE) inhibitors in the treatment of heart failure are true, except:
    a. They improve hemodynamics by decreasing afterload
    b. They can increase plasma cholesterol levels
    c. They may slow the progression of heart failure by preventing myocardial and vascular remodeling
    d. They are effective first-line agents in the treatment of chronic heart failure

63. c 64. c 65. b 66. b 67. c 68. a 69. d 70. a
71. b 72. b

73. Characteristics of Class IA antiarrhythmic include a moderate action on Phase 0 depolarization and a vagal stimulatory action:
    a. True
    b. False

74. Variant (Prinzmetal) angina is characterized by a fixed myocardial O_2 supply and an increase in O_2 demand:
    a. True
    b. False

75. A 54-year-old man is admitted to the emergency department. He has taken more than 50 digoxin tablets (0.25 mg each), ingesting them about 2 hours before admission. His pulse is 54 b/min, and the ECG shows third-degree heart block. Which of the following is the most important therapy to initiate in this patient?
    a. SC cardioversion
    b. Digoxin immune Fab
    c. Lidocaine
    d. Phenytoin
    e. Potassium salts

76. Adverse effects associated with the use of amiodarone include all of the following except:
    a. Cardiac depression
    b. Pulmonary fibrosis
    c. Thyroid dysfunction
    d. Increased QT interval
    e. All of the above can occur

77. Which of the following drug combinations has been found to be very effective as a pharmacotherapy for heart failure in Afro-Americans?
    a. Clonidine
    b. Atenolol
    c. Prazosin
    d. Phenoxybenzamine
    e. Lisinopril

78. Which of the following is an undesired effect associated with the use of Cholestyramine?
    a. Increased VLDL
    b. Increased LDL
    c. Decreased HDL
    d. Decreased triglycerides (TGs)
    e. Decreased cholesterol absorption

79. Which of the following drug combinations has been found to be very effective as a pharmacotherapy for heart failure in Afro-Americans?
    a. Hydralazine and Lisinopril
    b. Isosorbide dinitrate and Hydralazine
    c. Metoprolol and Lisinopril
    d. Metoprolol and Hydralazine
    e. Lisinopril and Isosorbide dinitrate

80. The major effect of which of the following on the action potential is a marked prolongation of repolarization and duration of the action potential?
    a. Class IB (lidocaine, Xylocaine)
    b. Class IC (flecainide, Tambocor)
    c. Class II (propranolol, Inderal)
    d. Class III (amiodarone, Cordarone)
    e. Class IV (verapamil, Isoptin)

81. A 53-year-old woman is being treated for atrial flutter subsequent to a myocardial infarction. After commencing treatment she experiences prolonged depression, bradycardia and wheezing. Which of the following agents was the patient prescribed?
    a. Propranolol (Inderal)
    b. Phenytoin (Dilantin)
    c. Quinidine (Cardioquin)
    d. Flecainide (Tambocor)
    e. Verapamil (Isoptin, Calan)

73. b 74. b 75. b 76. e 77. b 78. a 79. b 80. d 81. a

82. With respect to the treatment of angina, all members of this drug class would cause reflex tachycardia?
    a. Calcium blockers
    b. Beta blockers
    c. Nitrates
    d. A and C
    e. All of the above

MCQs on Congenital Heart Disease

83. Congenital heart disease is the most common cardiac condition in childhood and most frequently results from:
    a. Maternal medications
    b. Mutant genes
    c. Rubella virus
    d. Fetal distress
    e. Genetic and environmental factors

84. Incomplete fusion of the endocardial cushions is usually associated with which of the following types of atrial septal defect (ASD)?
    a. Secundum type ASD
    b. Primum type ASD
    c. Common atrium
    d. Probe patent ASD
    e. Sinus venous type ASD

85. The most common type of defect of the cardiac septa is:
    a. Secundum ASD
    b. Muscular ventricular septal defect (VSD)
    c. Primum ASD
    d. Membranous VSD
    e. Sinus venosus ASD

86. The most common congenital malformation of the heart and great vessels associated with the congenital rubella syndrome is:
    a. Coarctation of the aorta
    b. Tetralogy of Fallot
    c. Patent ductus arteriosus
    d. Atrial septal defect
    e. Ventricular septal defect

87. Which of the following combinations correctly pairs a fetal atrial septum with the opening(s) found in it?

	Septum	*Openings*
a.	Septum	Primum foramen ovale
b.	Septum secundum	Ostium primum and ostium secundum
c.	Septum primum	Ostium primum and ostium secundum
d.	Septum secundum	Ostium secundum
e.	Septum primum	Ostium secundum and foramen ovale

88. Which of the following conditions would be observed in a case of complete dextrocardia?
    a. The apex of the heart pointing toward the individual's left side
    b. The pulmonary trunk draining the ventricle on the left side
    c. The bicuspid valve positioned between the atrium on the left side and the ventricle on the left side
    d. The septum secundum forming part of the wall of the atrial chamber on the right side
    e. The ostium secundum located in the septum forming part of the wall of the atrial chamber on the left side

82. c 83. e 84. b 85. d 86. c 87. c 88. b

89. Typically, the abnormal flow of blood in a congenital atrial septal defect results from overlapping of the:
    a. Ostium primum and ostium secundum
    b. Septum primum and septum secundum
    c. Foramen ovale and septum primum
    d. Septum primum and septum spurium
    e. Ostium secundum and foramen ovale

90. The tetralogy of Fallot is an association of anomalies that arises through a pathogenic cascade of malformations in the heart. Which of the following anomalies would be considered to be the final defect in this pathogenic cascade?
    a. Constricted subpulmonary orifice
    b. Pulmonary stenosis
    c. Rightward displacement of the aorta (overriding aorta)
    d. Ventricular septal defect
    e. Enlarged right ventricle

91. In a normal fetus shortly before birth, which of the following vessels or heart chambers would contain the most highly oxygenated blood?
    a. Right ventricle of the heart
    b. Ductus arteriosus
    c. Umbilical arteries
    d. Pulmonary trunk
    e. Common carotid arteries

92. In a particular newborn infant, a substantial volume of blood takes the following route from the left ventricle to the lower limbs: ascending aorta to brachiocephalic artery to right subclavian artery to right internal thoracic artery to right anterior intercostal artery to right posterior intercostal artery to descending aorta. Which of the following conditions does this infant probably have?
    a. Double aortic arch
    b. Coarctation of the aorta proximal to the ductus arteriosus
    c. Coarctation of the aorta distal to the ductus arteriosus
    d. Situs inversus
    e. Abnormal right subclavian artery passing posterior to the esophagus and trachea

93. A female infant with congestive heart failure and a continuous systolic and diastolic murmur was diagnosed as having a patent ductus arteriosus. Which of the following statements is correct?
    a. The ductus arteriosus is a remnant of the left fourth aortic arch
    b. The ductus arteriosus is closed during fetal development
    c. The ductus arteriosus shunts blood from the umbilical vein to the inferior vena cava
    d. The ductus arteriosus closes just before birth
    e. In the fetus, most of the blood from the pulmonary trunk flows into the aorta

94. Normally the ductus arteriosus closes/constricts:
    a. During the fetal period
    b. Just before birth
    c. At birth
    d. During puberty
    e. It does not constrict

95. On routine examination a loud murmur was detected at the lower left sternal border of an infant who has failed to thrive and has poor weight. A diagnosis of VSD (ventricular septal defect) was made, and subsequently, the absence of the membranous part of the septum was confirmed by two-dimensional echocardiography. Membranous VSD _____ .

89. e 90. e 91. e 92. c 93. e 94. c

a. Arises from the failure of subendocardial tissue of the endocardial cushions to fuse with the aorticopulmonary septum and muscular part of the interventricular septum
b. Results from excessive resorption of myocardial tissue
c. Causes shunting of blood from the right ventricle to the left ventricle
d. Is found only in association with an ASD (atrial septal defect)
e. Is a rare condition and the less common type of VSD

96. In membranous VSD there is a shunting of blood:
a. From the left atrium to the right atrium
b. From the left ventricle to the right ventricle
c. From the right ventricle to the right atrium
d. From the left ventricle to the left atrium
e. From the left ventricle to the right atrium

97. Transposition of the great (arteries) vessels was diagnosed in a male infant with obvious cyanosis and mild tachypnea. This condition results from which of the following?
a. Abnormal resorption of the septum primum
b. Failure of the endocardial cushions to fuse
c. Faulty partitioning of the bulbous cordis and truncus arteriosus
d. Involution of the ductus arteriosus
e. Abnormal transformation of the sixth aortic arches

98. Congenital heart disease most frequently results from:
a. Maternal medications
b. Rubella virus
c. Mutant genes
d. Fetal distress
e. Genetic and environmental factors

99. How many shunts are there in the fetal cardiovascular system which cause blood to bypass the liver and the lungs?
a. 1
b. 2
c. 3
d. 4
e. 5

100. All of the following are true with respect to congenital malformations of the heart and great vessels, except:
a. Interventricular septal defects are the least common congenital heart defect
b. Ventricular septal defects (VSDs) are usually found in the membranous part of the interventricular septum
c. Anomalous formation of the aorticopulmonary septum can result in tetralogy of Fallot
d. Tetralogy of Fallot may include pulmonary valve stenosis and an overriding aorta
e. Tetralogy of Fallot may include a ventricular septal defect and hypertrophy of the right ventricle

101. An 18-year-old female died in a car accident on the way to the hospital for open heart surgery to correct a septal defect. Autopsy of her heart revealed a patent foramen ovale. There was abnormal resorption of the septum primum, showing fenestrations with a netlike appearance. Which of the following best accounts for her anomaly?
a. Atrioventricular defect
b. Common atrium
c. Membranous ventricular septal defect
d. Muscular ventricular septal defect
e. Secundum atrial septal defect

Note: Synthesis. Answers A, C, D are concerned with defects in the ventricles and therefore unrelated to atrial defects. Answer B concerns absence of the atrial septum (primum and secundum). Answer E is the correct response.

95. a 96. b 97. c 98. e 99. c 100. a 101. e

102. An autopsy of an infant demonstrated absence of thymus gland, absence of parathyroid glands, fish-mouth deformity, low-set notched ears, nasal clefts, thyroid hypoplasia, and cardiac abnormalities. These anomalies are consistent with abnormal migration of neural crest cells. Which of the following cardiac structures might also be affected in this infant?
    a. The bundle of His and Purkinje fibers of the heart
    b. The moderator band and septomarginal trabecula of the right ventricle
    c. The pulmonary veins of the left atrium
    d. The sinus venarum, ostium of the coronary sinus, and right atrium
    e. The tricuspid valve, mitral valve, and interventricular membranous septum

    Note: Analysis. Explanation—Answers A–D are all derivatives of cardiogenic lateral plate splanchnic mesoderm. Answer E, the valves and the interventricular membranous septum are all portions of the cardiac skeleton, which is neural crest derived.

103. An autopsy of a newborn showed absence of the left subclavian artery. This absent left subclavian artery probably resulted from abnormal development of which of the following structures?
    a. The left fourth aortic arch
    b. The left fifth aortic arch
    c. The left sixth aortic arch
    d. The left seventh intersegmental artery
    e. The left eighth intersegmental artery

    Note: Analysis A—the left fourth aortic arch forms arch of aorta; B—the left fifth aortic arch degenerates; C—the left sixth aortic arch: distal portion forms ductus arteriosus and the proximal portion forms left pulmonary artery; D—the left seventh intersegmental artery forms the left subclavian artery; E—the left eighth intersegmental artery forms superior thoracic artery. D is the correct response.

104. Membranous VSD:
    a. Arises from the failure of subendocardial tissue of the endocardial cushions to fuse with the aorticopulmonary septum and the membranous part of the interventricular septum
    b. In the infant initially causes shunting of blood from the right ventricle to the left ventricle
    c. Is a rare condition and the least common type of VSD
    d. Is found only in association with an ASD (atrial septal defect), such as patent foramen ovale
    e. Results from excessive resorption of myocardial tissue of the muscular part of the interventricular septum

    Note: Analysis. Explanation A—membranous VSD arises from the failure of subendocardial tissue of the endocardial cushions to fuse with the aorticopulmonary septum and the membranous part of the interventricular septum is the correct response; B—membranous VSD in the infant initially causes shunting of blood from the right ventricle to the left ventricle is false, initial shunting of blood would be from left ventricle (higher pressure) to right ventricle (lower pressure); C—membranous VSD is a rare condition and the least common type of VSD, false, most common type of VSD, and is the most prominent in males; D—membranous VSD is found only in association with an ASD (atrial septal defect), such as patent foramen ovale, false, can occur without an atrial septal defect; E—membranous VSD results from excessive resorption of myocardial tissue of the muscular part of the interventricular septum false, resorption of myocardial tissue of the muscular part of the interventricular septum would give rise to a muscular VSD.

105. In a normal fetus shortly before birth, which of the following vessel(s) or heart chamber would contain the most highly-oxygenated blood?
    a. Common carotid arteries
    b. Ductus arteriosus
    c. Pulmonary trunk
    d. Right ventricle of the heart
    e. Superior vena cava

102. e 103. d 104. a 105. a

Note: Synthesis. Explanation A—of the five choices, the common carotid arteries contain the most highly oxygenated blood, and therefore is the correct response; B—within the ductus arteriosus deoxygenated blood is coming from right ventricle; C—within pulmonary trunk deoxygenated blood coming from lungs to heart; D—within the right ventricle of the heart there is mixing of deoxygenated blood from superior vena cava with residual deoxygenated remaining in the right ventricle; E—within the superior vena cava deoxygenated blood comes from the cranial end of fetus.

106. An MRI of an infant shows transposition of the viscera, e.g. situs inversus with dextrocardia: the liver on the left and the heart on the right. Which of the following conditions would be observed in this case?
   a. The apex of the heart pointing toward the individual's left side
   b. The bicuspid valve positioned between the atrium on the left side and the ventricle on the left side
   c. The ostium secundum located in the septum forming part of the wall of the ventricular chamber on the left side
   d. The pulmonary trunk draining the ventricle on the left side
   e. The septum secundum forming part of the wall of the ventricular chamber on the right side

   Note: Synthesis. Explanation A—the apex of the heart pointing toward the individual's left side is the normal position for the apex of heart; B—the bicuspid valve positioned between the atrium on the left side and the ventricle on the left side is the normal position for bicuspid valve; C—the ostium secundum located in the septum forming part of the wall of the ventricular chamber on the left side is a wrong answer, the ostium secundum (atrial structure) never forms the ventricular foramen; D—the pulmonary trunk draining the ventricle on the left side is the correct response, under normal circumstances the pulmonary trunk would drain the ventricle on the right side; E—the septum secundum forming part of the wall of the ventricular chamber on the right side is a wrong answer, the septum secundum (atrial structure) does not form the ventricular septum.

107. Transposition of the great vessels was diagnosed in a male infant with obvious cyanosis and mild tachypnea. This condition results from which of the following?
   a. Abnormal resorption of the septum secundum
   b. Abnormal transformation of the sixth pair of aortic arches
   c. Failure of the endocardial cushions to fuse
   d. Faulty partitioning of the bulbus cordis and the truncus arteriosus
   e. Involution of the ductus arteriosus

   Note: Analysis. Transposition of the great vessels occurs with an abnormal partitioning of the outflow tract of the heart (i.e. bulbous cordis and truncus arteriosus becoming the future aorta and pulmonary trunk). Answers A, B, C, and E have nothing to do with partitioning of the outflow tract; D—correct response.

108. In a particular newborn infant, a substantial volume of blood takes the following route from the left ventricle to the lower limbs: ascending aorta to brachiocephalic artery to right subclavian artery to right internal thoracic artery to right 3–12 anterior intercostal arteries to right posterior 3–12 intercostal arteries to descending aorta. Which of the following conditions does this infant probably have?
   a. Abnormal right subclavian artery passing posterior to the esophagus and trachea
   b. Coarctation of the aorta distal to the ductus arteriosus
   c. Double aortic arch
   d. Situs inversus
   e. Transposition of the great vessels

106. d 107. d 108. b

Note: Synthesis. Postductal coarctation with collateral circulation to dorsal aorta: A, C, D, & E are not associated with problem. Postductal coarctation during development of the embryo/fetus allows collateral circulation to develop in the individual so that structures caudal to the upper extremities can develop normally and continue to receive blood flow postpartution, B is the correct response.

109. Which of the following best describes ductus arteriosus?
   a. In the fetus, most of the blood from the pulmonary trunk flows into the aorta
   b. The ductus arteriosus closes just before birth
   c. The ductus arteriosus is a remnant of the left fourth aortic arch
   d. The ductus arteriosus is closed during fetal development
   e. The ductus arteriosus shunts blood from the umbilical vein to the inferior vena cava

Note: Comprehension. Explanation A—in the fetus, most of the blood from the pulmonary trunk flows into the aorta is the correct response; B—the ductus arteriosus closes just before birth is false, the ductus arteriosus closes just after birth, not before; C—the ductus arteriosus is a remnant of the left fourth aortic arch is false, the ductus arteriosus is a remnant of the left sixth distal aortic arch; D—the ductus arteriosus is closed during fetal development is false, the ductus arteriosus is open during fetal development, to allow blood to by-pass the lungs thereby allowing their development under a low pressure system; E—the ductus arteriosus shunts blood from the umbilical vein to the inferior vena cava is false, the ductus venosus shunts blood from the umbilical vein to the inferior vena cava.

110. Tetralogy of Fallot is a common grouping of four cardiac defects, which consist of the following:
   a. Common atrium, common ventricle, patent ductus arteriosus, dextrocardia
   b. Common outflow tract, membranous ventricular septal defect, patent ductus arteriosus, patent foramen ovale
   c. Hypertrophy of the right ventricle, aortic stenosis, ventricular septal defect, overriding pulmonary trunk
   d. Hypertrophy of the right ventricle, pulmonary stenosis, ventricular septal defect, overriding aorta
   e. Persistent truncus arteriosus, patent ductus arteriosus, hypoplastic left heart syndrome, common atrium

Note: Comprehension. This problem relates to a case in the phase dealing with Tetralogy of Fallot. The problem initially starts as abnormal partitioning of the outflow track leading to a larger than normal size aorta and a smaller than normal size pulmonary trunk, reflected in the "over riding aorta and pulmonary stenosis." Since the septum between the future aorta and pulmonary trunk is not in the middle, the interventricular membranous septum fails to form (midline fusion of left and right bulbar ridges with endocardial cushions), leading to the (high [membranous] VSD) ventricular septal defect. This, in turn, leads to a left to right shunt of blood causing the right ventricle to hypertrophy. D is the correct response.

109. a 110. d

6

Antiarrhythmic Drugs

1. Least likely to cause cardiac failure:
   a. Propranolol (inderal)
   b. Pindolol (visken)
   c. Metoprolol (lopressor)

2. Major adverse effects of verapamil (Isoptin, Calan) or diltiazem (Cardiazem) IV administration:
   a. Diarrhea
   b. Hypertension
   c. Positive inotropism
   d. Stroke

3. Same antiarrhythmic classification: disopyramide (Norpace) and
   a. Propranolol (inderal)
   b. Triamterene (Dyrenium)
   c. Procainamide (Procan SR, Pronestyl-SR)
   d. Bretylium (Bretylol)
   e. Diltiazem (Cardiazem)

4. Most likely effective in treating supraventricular tachyarrhythmias:
   a. Flecainide (Tambocor)
   b. Esmolol (Brevibloc)
   c. Lidocaine (Xylocaine)
   d. Hydroxyzine (Atarax, Vistaril)
   e. Atropine

5. A reversible lupus erythematous-like syndrome is most likely associated with this antiarrhythmic drug:
   a. Quinidine gluconate (Quinaglute, Quinalan)
   b. Adenosine (Adenocard)
   c. Carbamazepine (Tegretol)
   d. Procainamide (Procan SR, Pronestyl-SR)
   e. Lidocaine (Xylocaine)

6. Antiarrhythmic drug most likely to cause seizures (at high concentrations) by direct CNS actions:
   a. Quinidine gluconate (Quinaglute, Quinalan)
   b. Amiodarone (Cordarone)
   c. Lidocaine (Xylocaine)
   d. Phenytoin (Dilantin)
   e. Propranolol (Inderal)

1. b 2. b 3. c 4. b 5. d 6. c

7. Antiarrhythmic drug, acting at potassium channels:
   a. Adenosine (Adenocard)
   b. Sotalol (Betapace)
   c. Diltiazem (Cardiazem)
   d. Esmolol (Brevibloc)
   e. Quinidine gluconate (Quinaglute, Quinalan)

8. Cinchonism: adverse effect associated with this antiarrhythmic drug:
   a. Procainamide (Procan SR, Pronestyl-SR)
   b. Verapamil (Isoptin, Calan)
   c. Quinidine gluconate (Quinaglute, Quinalan)
   d. Flecainide (Tambocor)
   e. Adenosine (Adenocard)

9. Antiarrhythmic drug, administered IV, typically used to suppress ventricular arrhythmias associated with acute myocardial infarction:
   a. Amiodarone (Cordarone)
   b. Metoprolol (Lopressor)
   c. Lidocaine (Xylocaine)
   d. Phenytoin (Dilantin)
   e. Esmolol (Brevibloc)

10. Despite being a myocardial depressant, this antiarrhythmic drug's anticholinergic properties facilitate AV nodal transmission:
   a. Phenytoin (Dilantin)
   b. Amiodarone (Cordarone)
   c. Adenosine (Adenocard)
   d. Quinidine gluconate (Quinaglute, Quinalan)
   e. Diltiazem (Cardiazem)

11. Changes in cardiac automaticity is most directly associated with changes in which slope of the myocardial action potential?
   a. Phase 0
   b. Phase 1
   c. Phase 2
   d. Phase 3
   e. Phase 4

12. Contraindicated in asthmatic patients, this antiarrhythmic drug blocks beta-1 receptors:
   a. Adenosine (Adenocard)
   b. Lidocaine (Xylocaine)
   c. Procainamide (Procan SR, Pronestyl-SR)
   d. Propranolol (Inderal)
   e. None of the above

13. Class II antiarrhythmic drug:
   a. Adenosine (Adenocard)
   b. Atropine
   c. Esmolol (Brevibloc)
   d. Lidocaine (Xylocaine)
   e. Mexiletine (Mexitil)

14. Muscarinic receptor antagonist, this antiarrhythmic drug may be effective in managing bradycardia:
   a. Esmolol (Brevibloc)
   b. Adenosine (Adenocard)
   c. Lidocaine (Xylocaine)
   d. Atropine
   e. Mexiletine (Mexitil)

7. b 8. c 9. c 10. d 11. e 12. d 13. c 14. d

15. Calcium channel blocker—effective in treating supraventricular arrhythmias:
    a. Tocainide (Tonocard)
    b. Verapamil (Isoptin, Calan)
    c. Quinidine gluconate (Quinaglute, Quinalan)
    d. Procainamide (Procan SR, Pronestyl-SR)
    e. Heparin

16. Class III antiarrhythmic drug may be effective in treating ventricular arrhythmias; prolongs phase 3 (repolarization); potassium channel blocker:
    a. Esmolol (Brevibloc)
    b. Amiodarone (Cordarone)
    c. Lidocaine (Xylocaine)
    d. Propafenone (Rythmol)
    e. Moricizine (Ethmozine)

17. Naturally occurring metabolites, given by IV administration, this antiarrhythmic agent slows conduction through the AV node:
    a. Esmolol (Brevibloc)
    b. Adenosine (Adenocard)
    c. Lidocaine (Xylocaine)
    d. Procainamide (Procan SR, Pronestyl-SR)
    e. Bretylium (Bretylol)

18. Digoxin (Lanoxin, Lanoxicaps) is useful in treating high ventricular rates in patients with atrial fibrillation because:
    a. Digoxin (Lanoxin, Lanoxicaps) is a good drug for stopping atrial fibrillation
    b. Digoxin (Lanoxin, Lanoxicaps) increases cardiac contractility
    c. Digoxin (Lanoxin, Lanoxicaps) slows conduction through the AV node; therefore it reduces heart rate
    d. Digoxin (Lanoxin, Lanoxicaps) is metabolized in the liver
    e. Digoxin (Lanoxin, Lanoxicaps) is inexpensive

19. Antiarrhythmic drug likely to increase heart rate:
    a. Tocainide (Tonocard)
    b. Verapamil (Isoptin, Calan)
    c. Quinidine gluconate (Quinaglute, Quinalan)
    d. Propranolol (Inderal)
    e. Esmolol (Brevibloc)

20. Always administered by IV because of significant first-pass effect, this anti-rhythmic drug suppresses ventricular arrhythmias associated with acute myocardial infarction; CNS side effects are prominent in overdosage:
    a. Verapamil (Isoptin, Calan)
    b. Propranolol (Inderal)
    c. Lidocaine (Xylocaine)
    d. Amiodarone (Cordarone)
    e. Quinidine gluconate (Quinaglute, Quinalan)

21. This drug is a Class IA antiarrhythmic drug:
    a. Sotalol
    b. Propranolol
    c. Verapamil
    d. Quinidine

15. b 16. b 17. b 18. c 19. c 20. c 21. d

22. This drug is a Class IC antiarrhythmic drug:
    a. Flecainide
    b. Sotalol
    c. Lidocaine
    d. Verapamil

23. This drug is a Class II antiarrhythmic drug:
    a. Flecainide
    b. Propranolol
    c. Lidocaine
    d. Verapamil

24. This drug is a Class III antiarrhythmic drug:
    a. Flecainide
    b. Sotalol
    c. Lidocaine
    d. Verapamil

25. This drug prolongs repolarization:
    a. Flecainide
    b. Sotalol
    c. Lidocaine
    d. Verapamil

26. This drug is a Class IV antiarrhythmic drug:
    a. Flecainide
    b. Sotalol
    c. Lidocaine
    d. Verapamil

27. This drug is used in treating supraventricular tachycardias:
    a. Digoxin
    b. Dobutamine
    c. Amrinone
    d. Dopamine

28. This drug is associated with Torsades de pointes.
    a. Flecainide
    b. Sotalol
    c. Lidocaine
    d. Verapamil

29. This drug has beta-adrenergic blocking activity:
    a. Flecainide
    b. Sotalol
    c. Lidocaine
    d. Verapamil

30. This drug is useful in terminating atrial but not ventricular tachycardias:
    a. Flecainide
    b. Sotalol
    c. Lidocaine
    d. Verapamil

31. This is a drug of choice for acute treatment of ventricular tachycardias:
    a. Flecainide
    b. Sotalol
    c. Lidocaine
    d. Verapamil

32. The calcium channel blockers have direct negative inotropic effects because they reduce the inward movement of calcium during the action potential. Thick consideration is:
    a. True
    b. False

33. Common unwanted effects of the dihydropyridines are due to vasodilation. It's:
    a. True
    b. False

34. Verapamil is a more potent vasodilator than nifedipine. This statement is:
    a. True
    b. False

35. This drug is contraindicated in patients with moderate to severe heart failure:
    a. Nifedipine
    b. Verapamil
    c. Both of the above
    d. None of the above

22. c	23. b	24. b	25. b	26. d	27. a	28. b	29. b
30. d	31. c	32. a	33. a	34. b	35. b		

36. This drug is an effective bronchodilator:
    a. Nifedipine
    b. Verapamil
    c. Both of the above
    d. None of the above

37. This drug is used intravenously to terminate supraventricular tachycardias:
    a. Nifedipine
    b. Verapamil
    c. Both of the above
    d. None of the above

38. This drug has a little or no direct effect on chronotropy and dromotropy at normal doses:
    a. Nifedipine
    b. Diltiazem
    c. Verapamil
    d. All of the above

39. Verapamil has a significant effect on automaticity in the SA node. It's:
    a. True
    b. False

40. This drug acts by inhibiting slow calcium channels in the SA and AV nodes:
    a. Quinidine
    b. Adenosine
    c. Flecainide
    d. Diltiazem

41. All of the following statements regarding verapamil are true, except:
    a. It blocks L-type calcium channels
    b. It increases heart rate
    c. It relaxes coronary artery smooth muscle
    d. It depresses cardiac contractility

42. All of the following calcium channel blockers are useful in the treatment of cardiac arrhythmias, except:
    a. Bepridil
    b. Diltiazem
    c. Verapamil
    d. Nifedipine

43. All of the following are common adverse effects of calcium channel blockers, except:
    a. Skeletal muscle weakness
    b. Dizziness
    c. Headache
    d. Flushing

44. Tick the adverse reactions characteristic for lidocaine:
    a. Agranulocytosis, leukopenia
    b. Extrapyramidal disorders
    c. Hypotension, paresthesias, convulsions
    d. Bronchospasm, dyspepsia

36. d 37. b 38. a 39. a 40. d 41. b 42. d 43. a 44. c

7

Narcotic Analgesics

1. Narcotic analgesics should:
   a. Relieve severe pain
   b. Induce loss of sensation
   c. Reduce anxiety and exert a calming effect
   d. Induce a stupor or somnolent state

2. Second-order pain is:
   a. Sharp, well-localized pain
   b. Dull, burning pain
   c. Associated with fine myelinated A-delta fibers
   d. Effectively reduced by non-narcotic analgesics

3. Chemical mediators in the nociceptive pathway are all of the following, except:
   a. Enkephalins
   b. Kinins
   c. Prostaglandins
   d. Substance P

4. Indicate the chemical mediator in the antinociceptive descending pathways:
   a. BETA-endorphin
   b. Met- and leu-enkephalin
   c. Dynorphin
   d. All of the above

5. Which of the following mediators is found mainly in long descending pathways from the midbrain to the dorsal horn?
   a. Prostaglandin E
   b. Dynorphin
   c. Enkephalin
   d. Glutamate

6. Select the brain and spinal cord regions, which are involved in the transmission of pain?
   a. The limbic system, including the amygdaloidal nucleus and the hypothalamus
   b. The ventral and medial parts of the thalamus
   c. The substantia gelatinosa
   d. All of the above

1. a 2. b 3. a 4. d 5. c 6. d

7. Mu (μ) receptors are associated with:
   a. Analgesia, euphoria, respiratory depression, physical dependence
   b. Spinal analgesia, mydriasis, sedation, physical dependence
   c. Dysphoria, hallucinations, respiratory and vasomotor stimulation
   d. Analgesia, euphoria, respiratory stimulation, physical dependence

8. Which of the following opioid receptor types is responsible for euphoria and respiratory depression?
   a. Kappa-receptors
   b. Delta-receptors
   c. Mu-receptors
   d. All of the above

9. Indicate the opioid receptor type, which is responsible for dysphoria and vasomotor stimulation:
   a. Kappa-receptors
   b. Delta-receptors
   c. Mu-receptors
   d. All of the above

10. Kappa and delta agonists:
   a. Inhibit postsynaptic neurons by opening K^+ channels
   b. Close a voltage-gated Ca^{2+} channels on presynaptic nerve terminals
   c. Both a and b
   d. Inhibit of arachidonate cyclooxygenase in CNS

11. Which of the following supraspinal structures is implicated in pain-modulating descending pathways?
   a. The midbrain periaqueductal gray
   b. The hypothalamus
   c. The aria postrema
   d. The limbic cortex

12. Indicate the neurons, which are located in the locus ceruleus or the lateral tegmental area of the reticular formation:
   a. Dopaminergic
   b. Serotoninergic
   c. Nonadrenergic
   d. Gabaergic

13. Which of the following analgesics is a phenanthrene derivative?
   a. Fentanyl
   b. Morphine
   c. Methadone
   d. Pentazocine

14. Tick narcotic analgesic, which is a phenylpiperidine derivative:
   a. Codeine
   b. Dezocine
   c. Fentanyl
   d. Buprenorphine

15. Which of the following opioid analgesics is a strong mu receptor agonist?
   a. Naloxone
   b. Morphine
   c. Pentazocine
   d. Buprenorphine

16. Indicate the narcotic analgesic, which is a natural agonist:
   a. Meperidine
   b. Fentanyl
   c. Morphine
   d. Naloxone

17. Select the narcotic analgesic, which is an antagonist or partial mu receptor agonist:
   a. Fentanyl
   b. Pentazocine
   c. Codeine
   d. Methadone

7. a 8. c 9. a 10. b 11. a 12. c 13. b 14. c
15. b 16. c 17. b

18. Which of the following agents is a full antagonist of opioid receptors?
    a. Meperidine
    b. Buprenorphine
    c. Naloxone
    d. Butorphanol

19. The principal central nervous system effect of the opioid analgesics with affinity for a mu receptor is:
    a. Analgesia
    b. Respiratory depression
    c. Euphoria
    d. All of the above

20. Which of the following opioid analgesics can produce dysphoria, anxiety and hallucinations?
    a. Morphine
    b. Fentanyl
    c. Pentazocine
    d. Methadone

21. Indicate the opioid analgesic, which has 80 times analgesic potency and respiratory depressant properties of morphine, and is more effective than morphine in maintaining hemodynamic stability?
    a. Fentanyl
    b. Pentazocine
    c. Meperidine
    d. Nalmefene

22. Which of the following opioid analgesics is used in combination with droperidol in neuroleptanalgesia?
    a. Morphine
    b. Buprenorphine
    c. Fentanyl
    d. Morphine

23. Fentanyl can produce significant respiratory depression by:
    a. Inhibiting brain stem respiratory mechanisms
    b. Suppression of the cough reflex leading to airway obstruction
    c. Development of truncal rigidity
    d. Both a and c

24. Most strong mu receptor agonists cause:
    a. Hypertension
    b. Increasing the pulmonary arterial pressure and myocardial work
    c. Cerebral vasodilatation, causing an increase in intracranial pressure
    d. All of the above

25. Which of the following opioid analgesics can produce an increase in the pulmonary arterial pressure and myocardial work?
    a. Morphine
    b. Pentazocine
    c. Meperidine
    d. Methadone

26. Morphine causes the following effects, except:
    a. Constipation
    b. Dilatation of the biliary duct
    c. Urinary retention
    d. Bronchiolar constriction

27. Therapeutic doses of the opioid analgesics:
    a. Decrease body temperature
    b. Increase body temperature
    c. Decrease body heat loss
    d. Do not affect body temperature

28. Which of the following opioid analgesics is used in obstetric labor?
    a. Fentanyl
    b. Pentazocine
    c. Meperidine
    d. Buprenorphine

18. c 19. d 20. c 21. a 22. c 23. d 24. c 25. b
26. b 27. a 28. c

29. Indicate the opioid analgesic, which is used for relieving the acute, severe pain of renal colic:
    a. Morphine
    b. Naloxone
    c. Methadone
    d. Meperidine

30. Which of the following opioid analgesics is used in the treatment of acute pulmonary edema?
    a. Morphine
    b. Codeine
    c. Fentanyl
    d. Loperamide

31. The relief produced by intravenous morphine in dyspnea from pulmonary edema is associated with reduced:
    a. Perception of shortness of breath
    b. Patient anxiety
    c. Cardiac preload (reduced venous tone) and afterload (decreased peripheral resistance)
    d. All of the above

32. Rhinorrhea, lacrimation, chills, gooseflesh, hyperventilation, hyperthermia, mydriasis, muscular aches, vomiting, diarrhea, anxiety, and hostility are effects of:
    a. Tolerance
    b. Opioid overdosage
    c. Drug interactions between opioid analgesics and sedative-hypnotics
    d. Abstinence syndrome

33. The diagnostic triad of opioid overdosage is:
    a. Mydriasis, coma and hyperventilation
    b. Coma, depressed respiration and miosis
    c. Mydriasis, chills and abdominal cramps
    d. Miosis, tremor and vomiting

34. Which of the following opioid agents is used in the treatment of acute opioid overdose?
    a. Pentazocine
    b. Methadone
    c. Naloxone
    d. Remifentanyl

35. Indicate the pure opioid antagonist, which has a half-life of 10 hours:
    a. Naloxone
    b. Naltrexone
    c. Tramadol
    d. Pentazocine

36. In contrast to morphine, methadone:
    a. Causes tolerance and physical dependence more slowly
    b. Is more effective orally
    c. Withdrawal is less severe, although more prolonged
    d. All of the above

37. Which of the following opioid analgesics is a partial mu receptor agonist?
    a. Morphine
    b. Methadone
    c. Buprenorphine
    d. Sufentanyl

38. Indicate a partial mu receptor agonist, which has 20-60 times analgesic potency of morphine, and a longer duration of action:
    a. Pentazocine
    b. Buprenorphine
    c. Nalbuphine
    d. Naltrexone

29. d 30. a 31. d 32. d 33. b 34. c 35. b 36. d
37. c 38. b

39. Which of the following opioid analgesics is a strong kappa receptor agonist and a mu receptor antagonist?
    a. Naltrexone
    b. Methadone
    c. Nalbuphine
    d. Buprenorphine

40. Which of the following drugs has weak mu agonist effects and inhibitory action on norepinephrine and serotonin reuptake in the CNS?
    a. Loperamide
    b. Tramadol
    c. Fluoxetine
    d. Butorphanol

39. c 40. b

8

Non-narcotic Analgesics

1. Non-narcotic analgesics are mainly effective against pain associated with:
   a. Inflammation or tissue damage
   b. Trauma
   c. Myocardial infarction
   d. Surgery

2. Non-narcotic agents cause:
   a. Respiratory depression
   b. Antipyretic effect
   c. Euphoria
   d. Physical dependence

3. Non-narcotic analgesics are all of the following drugs, except:
   a. Paracetamol
   b. Acetylsalicylic acid
   c. Butorphanol
   d. Ketorolac

4. Select the non-narcotic drug, which is a para-aminophenol derivative:
   a. Analgin
   b. Aspirin
   c. Baclofen
   d. Paracetamol

5. Which of the following non-narcotic agents is salicylic acid derivative?
   a. Phenylbutazone
   b. Ketamine
   c. Aspirin
   d. Tramadol

6. Tick pirazolone derivative:
   a. Methyl salicylate
   b. Analgin
   c. Paracetamol
   d. Ketorolac

7. Which one of the following non-narcotic agents inhibits mainly cyclooxygenase (COX) in CNS?
   a. Paracetamol
   b. Ketorolac
   c. Acetylsalicylic acid
   d. Ibuprofen

8. Most of non-narcotic analgetics have:
   a. Anti-inflammatory effect
   b. Analgesic effect
   c. Antipyretic effect
   d. All of the above

9. Indicate the non-narcotic analgesic, which lacks an anti-inflammatory effect:
   a. Naloxone
   b. Paracetamol
   c. Metamizole
   d. Aspirin

1. a 2. b 3. c 4. d 5. c 6. b 7. a 8. d 9. b

10. Correct statements concerning aspirin include all of the following, except:
    a. It inhibits mainly peripheral COX
    b. It does not have an anti-inflammatory effect
    c. It inhibits platelet aggregation
    d. It stimulates respiration by a direct action on the respiratory center

11. For which of the following conditions could aspirin be used prophylactically?
    a. Noncardiogenic pulmonary edema
    b. Peptic ulcers
    c. Thromboembolism
    d. Metabolic acidosis

12. All of the following are undesirable effects of aspirin, except:
    a. Gastritis with focal erosions
    b. Tolerance and physical addiction
    c. Bleeding due to a decrease of platelet aggregation
    d. Reversible renal insufficiency

13. Characteristic findings of salicylism include:
    a. Headache, mental confusion and drowsiness
    b. Tinnitus and difficulty in hearing
    c. Hyperthermia, sweating, thirst, hyperventilation, vomiting and diarrhea
    d. All of the above

14. Analgin usefulness is limited by:
    a. Agranulocytosis
    b. Erosions and gastric bleeding
    c. Methemoglobinemia
    d. Hearing impairment

15. Methemoglobinemia is possible adverse effect of:
    a. Aspirin
    b. Paracetamol
    c. Analgin
    d. Ketorolac

16. Correct the statements concerning ketorolac include all of the following, except:
    a. It inhibits COX
    b. It is as effective as morphine for a short-term relief from moderate to severe pain
    c. It has a high potential for physical dependence and abuse
    d. It does not produce respiratory depression

17. Indicate the nonopioid agent of central effect with analgesic activity:
    a. Reserpine
    b. Propranolol
    c. Clopheline
    d. Prazosin

18. Select the anti seizure drug with an analgesic component of effect:
    a. Carbamazepine
    b. Ethosuximide
    c. Phenytoin
    d. Clonazepam

19. Which of the following nonopioid agents is an antidepressant with analgesic activity?
    a. Fluoxetine
    b. Moclobemide
    c. Tranylcypromine
    d. Amitriptyline

20. Tick mixed (opioid/nonopioid) agent:
    a. Paracetamol
    b. Tramadol
    c. Sodium valproate
    d. Butorphanol

10. d 11. c 12. b 13. d 14. a 15. b 16. c 17. c
18. a 19. b 20. d

9

General Anesthetics

1. The state of "general anesthesia" usually includes:
   a. Analgesia
   b. Loss of consciousness, inhibition of sensory and autonomic reflexes
   c. Amnesia
   d. All of the above

2. Inhaled anesthetics and intravenous agents having general anesthetic properties:
   a. Directly activate GABAA receptors
   b. Facilitate GABA action but have no direct action on GABAA receptors
   c. Reduce the excitatory glutamatergic neurotransmission
   d. Increase the duration of opening of nicotine-activated potassium channels

3. Indicate the anesthetic, which is an inhibitor of NMDA glutamate receptors:
   a. Thiopental
   b. Halothane
   c. Ketamine
   d. Sevoflurane

4. An ideal anesthetic drug would:
   a. Induces anesthesia smoothly and rapidly and secure rapid recovery
   b. Posses a wide margin of safety
   c. Be devoid of adverse effects
   d. All of the above

5. Which of the following general anesthetics belongs to inhalants?
   a. Thiopental
   b. Desflurane
   c. Ketamine
   d. Propofol

6. Indicate the anesthetic, which is used intravenously:
   a. Propofol
   b. Halothane
   c. Desflurane
   d. Nitrous oxide

7. Which of the following inhalants is a gas anesthetic?
   a. Halothane
   b. Isoflurane
   c. Nitrous oxide
   d. Desflurane

1. d 2. a 3. c 4. d 5. b 6. a 7. c

8. Sevoflurane has largely replaced halothane and isoflurane as an inhalation anesthetic of choice because:
   a. Induction of anesthesia is achieved more rapidly and smoothly
   b. Recovery is more rapid
   c. It has low post-anesthetic organ toxicity
   d. All of the above

9. The limitation of sevoflurane is:
   a. High incidence of coughing and laryngospasm
   b. Chemically unstable
   c. Centrally mediated sympathetic activation leading to a rise of BP and HR
   d. Hepatotoxicity

10. Which of the following inhalants lacks sufficient potency to produce surgical anesthesia by itself and therefore is commonly used with another inhaled or intravenous anesthetic?
   a. Halothane
   b. Sevoflurane
   c. Nitrous oxide
   d. Desflurane

11. Which of the following inhaled anesthetics has rapid onset and recovery?
   a. Nitrous oxide
   b. Desflurane
   c. Sevoflurane
   d. All of the above

12. Indicate the inhaled anesthetic, which reduces arterial pressure and heart rate:
   a. Isoflurane
   b. Halothane
   c. Desflurane
   d. Nitrous oxide

13. Which of the following inhaled anesthetics causes centrally mediated sympathetic activation leading to a rise in blood pressure and heart rate?
   a. Desflurane
   b. Sevoflurane
   c. Nitrous oxide
   d. Isofurane

14. Indicated the inhaled anesthetic, which decreases the ventilatory response to hypoxia:
   a. Sevoflurane
   b. Nitrous oxide
   c. Desflurane
   d. Halothane

15. Which of the following inhaled anesthetics is an induction agent of choice in patient with airway problems?
   a. Desflurane
   b. Nitrous oxide
   c. Halothane
   d. None of the above

16. Indicate the inhaled anesthetic, which causes the airway irritation:
   a. Nitrous oxide
   b. Sevoflurane
   c. Halothane
   d. Desflurane

17. Which of the following inhaled anesthetics increases cerebral blood flow least of all?
   a. Sevoflurane
   b. Nitrous oxide
   c. Isoflurane
   d. Desflurane

18. Indicate the inhaled anesthetic, which should be avoided in patients with a history of seizure disorders:
   a. Enflurane
   b. Nitrous oxide
   c. Sevoflurane
   d. Desflurane

8. d 9. b 10. c 11. d 12. b 13. a 14. b 15. c
16. d 17. b 18. a

19. Which of the following inhaled anesthetics can produce hepatic necrosis?
    a. Sevoflurane
    b. Desflurane
    c. Halothane
    d. Nitrous oxide

20. Indicated the inhaled anesthetic, which may cause nephrotoxicity:
    a. Halothane
    b. Sevoflurane
    c. Nitrous oxide
    d. Diethyl ether

21. Which of the following inhaled anesthetics decreases metheonine synthase activity and causes megaloblastic anemia?
    a. Desflurane
    b. Halothane
    c. Nitrous oxide
    d. Sevoflurane

22. Unlike inhaled anesthetics, intravenous agents such as thiopental, etomidate, and propofol:
    a. Have a faster onset and rate of recovery
    b. Provide a state of conscious sedation
    c. Are commonly used for induction of anesthesia
    d. All of the above

23. Indicate the intravenous anesthetic, which is an ultra-short-acting barbiturate:
    a. Fentanyl
    b. Thiopental
    c. Midazolam
    d. Ketamine

24. Indicate the intravenous anesthetic, which is a benzodiazepine derivative:
    a. Midazolam
    b. Thiopental
    c. Ketamin
    d. Propofol

25. Which of the following agents is used to accelerate recovery from the sedative actions of intravenous benzodiazepines?
    a. Naloxone
    b. Flumazenil
    c. Ketamine
    d. Fomepizole

26. Neuroleptanalgesia has all of the following properties, except:
    a. Droperidol and fentanyl are commonly used
    b. It can be used with nitrous oxide to provide neuroleptanesthesia
    c. Hypertension is a common consequence
    d. Confusion and mental depression can occur as adverse effects

27. Which of the following intravenous anesthetics has antiemetic actions?
    a. Thiopental
    b. Propofol
    c. Ketamine
    d. Fentanyl

28. Indicate the intravenous anesthetic, which causes minimal cardiovascular and respiratory depressant effects:
    a. Propofol
    b. Thiopental
    c. Etomidate
    d. Midazolam

29. Indicate the intravenous anesthetic, which produces dissociative anesthesia:
    a. Midazolam
    b. Ketamine
    c. Fentanyl
    d. Thiopental

19. c 20. b 21. c 22. d 23. b 24. a 25. b 26. c
27. b 28. c 29. b

30. Ketamine anesthesia is associated with:
    a. Cardiovascular stimulation
    b. Increased cerebral blood flow, oxygen consumption and intracranial pressure
    c. Disorientation, sensory and perceptual illusions, and vivid dreams following anesthesia
    d. All of the above

31. According to Laplace's law:
    a. Wall tension = P × R/2h
    b. Wall tension = p × h/2R
    c. Wall tension = P × R/h
    d. Wall tension = P × 2R/h

32. Factor 8 levels in stored blood at 14 days:
    a. 95%
    b. 80%
    c. 75%
    d. 30%

33. The phenomenon of positive ionotropic effect that occurs with abrupt increases in systolic pressure is called as:
    a. Creep
    b. Bowditch
    c. Anrep
    d. None of the above

34. Features of hyperkalemia includes all except:
    a. Prolonged PR interval
    b. Increase in P wave amplitude
    c. Peaking of T wave
    d. Decreased QRS amplitude

35. Allen's test is said to be normal when the hand regains its normal color within:
    a. 7 sec
    b. 5 sec
    c. 10 sec
    d. 15 sec

36. Conditions in which PCWP > LVEDP includes all except:
    a. PEEP
    b. AR
    c. Mitral valve disease
    d. Increased pulmonary vascular resistance

37. In a normal TEG, α angle is:
    a. An index of clot strength, the normal value being 35 to 45°
    b. An index of clot strength, the normal value being 45 to 55°
    c. An index of speed of clot formation, the normal value being 45 to 55°
    d. An index of fibrin formation, the normal value being 35 to 45°

38. The pressure volume loop in MS shows:
    a. ↓ LVEDV, ↓ LVEDP, ↓ SV
    b. ↑ LVEDV, ↓ LVEDP, ↓ SV
    c. ↓ LVEDV, ↑ LVEDP, ↓ SV
    d. ↑LVEDV, ↑ LVEDP, ↓ SV

39. Load independent indices of contractility of heart includes all except:
    a. Endsystolic pressure volume relation (ESPVR)
    b. Preload recruitable stroke work
    c. Isovolumic myocardial acceleration
    d. Ejection fraction

30. d 31. a 32. c 33. c 34. d 35. d 36. b 37. c
38. a 39. d

40. In TOE, which of the following statements is true:
    a. Pulsed wave Doppler is useful in measurement of high velocities
    b. Continuous wave Doppler has spatial specificity
    c. Continuous wave Doppler is able to measure high flow velocities
    d. Pulse wave Doppler has spatial ambiguity

41. Mol wt of heparin is:
    a. 10,000-30,000 daltons
    b. 50,000-70,000 daltons
    c. 30,000-50,000 daltons
    d. 70,000-90,000 daltons

42. According to Gorlin's formula:
    a. Valve area = trans valvular flow rate/$\sqrt{PG}$
    b. Valve area = trans valvular flow rate/PG^2
    c. Valve area = trans valvular flow $rate^2/PG$
    d. Valve area = trans valvular flow rate/PG

43. In a patient with sever MR LV dysfunction is said to exist when LVEF is:
    a. 40%-50%
    b. 60%-70%
    c. 30%-40%
    d. 50%-60%

44. Risk factors for sudden death after repair of TOF included all except:
    a. Ventriculotomy
    b. Residual RVOTO
    c. Severe PR
    d. Repair in infant age group

45. Absolute contraindications to balloon mitral valvuloplasty includes all except:
    a. Known LA thrombus
    b. Significant MR
    c. Severe cardiothoracic deformity
    d. Recent embolic event of <2 months duration

46. Systemic hypothermia results in:
    a. ↓ in cerebral oxygen consumption of 13% for each 1°C ↓ in body temperature
    b. ↓ in cerebral oxygen consumption of 10% for each 1°C ↓ in body temperature
    c. ↓ in cerebral oxygen consumption of 7% for each 1°C ↓ in body temperature
    d. ↓ in cerebral oxygen consumption of 4% for each 1°C ↓ in body temperature

47. Regarding HIT-II all are true except:
    a. Formation of white clots
    b. Occur after about 5 days of heparin administration
    c. Immune mediated reaction
    d. Due to pro aggregatory effects of heparin on platelets

40. c 41. a 42. a 43. d 44. d 45. c 46. c 47. d

48. Potential advantages of distal perfusion techniques for thoracic and thoraco abdominal aortic reconstruction includes all except:
    a. Control of proximal hypertension
    b. ↓ in LV afterload
    c. ↓ in duration of mesenteric ischemia
    d. ↓ in risk of thromboembolic events

49. Regarding classification of aortic dissections, which of the following is false:
    a. Standford A—involvement of asc aorta and arch, and possibly descending aorta
    b. De Bakey Type II—originates and confined to ascending aorta
    c. De Bakey Type III—originates in aortic arch
    d. Stanford B—confined to descending thoracic aorta

50. Strategies to decrease the risk of paraplegia from spinal cord ischemia after thoracoabdominal aortic procedures includes all, except:
    a. Lumbar CSF drainage to maintain CSF pressure 10-12 Hg
    b. MAP to be maintained > 80 mm Hg
    c. Selective spinal cord hypothermia
    d. Pharmacological neuro protection with opioids

51. Beneficial effects of MUF includes all, except:
    a. Improves LV compliance
    b. Increase in A-a O_2 gradient
    c. Decreased in total body water
    d. Increase in arterial blood pressure

52. Goals of anesthesia in ALCAPA surgery includes all except:
    a. Maintain a fast HR
    b. Maintain normal to slightly high PVR
    c. Optimize cardiac output
    d. Maintain systemic arterial oxygen saturation

53. The full CPB flow rate in children weighing 3-10 kg is around:
    a. 150 to 200 ml/kg/min
    b. 125 to 175 ml/kg/min
    c. 100 to 120 ml/kg/min
    d. 75 to 100 ml/kg/min

54. Transmitral flow on pulsed wave Doppler in a patient with normal mitral valve and normal left ventricular function shows:
    a. Early systolic filling characterized by 'E' wave and late systolic filling characterized by 'A' wave
    b. Early diastolic filling characterized by 'E' wave and late diastolic filling characterized by 'A' wave
    c. Systolic or 'S' waveform and diastolic or 'D' waveform
    d. None of the above

55. Area of normal mitral valve is:
    a. 2–3 cm^2
    b. 4-5 cm^2
    c. 3-4 cm^2
    d. 4-6 cm^2

48. d 49. c 50. d 51. b 52. a 53. b 54. b 55. d

56. The following statements related to pulmonary venous flow patterns are not correct:
    a. It is used to quantify the degree of mitral regurgitation
    b. In any given patient with mitral regurgitation there can be no significant disparity between right and left venous patterns
    c. Systolic flow reversal can occur in patients with severe mitral regurgitation
    d. None of the above

57. The ACC/AHA guidelines recommend waiting for the following duration after MI, to perform elective noncardiac surgery:
    a. 1 week
    b. 4-6 weeks
    c. 3 months
    d. 6 months

58. The following statements about QT interval on ECG are correct, except:
    a. QT interval represents interval between beginning of Q wave and end of T wave
    b. The normal value is 0.35 to 0.44 seconds
    c. Amiodarone is the antiarrhythmic of choice in patients with prolonged QT interval
    d. Emotional stress or sympathetic stimulation in patients with prolonged QT can induce ventricular fibrillation

59. Relating to endovascular aortic aneurysm repair (EVAR) which of the following is true?
    a. EVAR should be used in patients unfit for open surgery
    b. There is a 40% absolute reduction in early (30 day) mortality compared to open repair
    c. Secondary procedures after EVAR are rare
    d. Anticoagulation is not required for EVAR as the aorta is not cross clamped

60. Which of the following statement regarding video assisted thoracoscopic surgery is false?
    a. CO_2 may be insuffalated in to pleural cavity
    b. Continuous positive airway pressure will not interfere with surgery
    c. The need for one lung ventilaton is greater for VATS than for open thoracotomy
    d. VATS is the procedure of choice for resection of nonmalignant pulmonary lesions (blebs, bullae, granulomas)

61. The coagulation factors are glycoproteins synthesized in the liver, which circulate as inactive molecules termed as:
    a. Serine proteases
    b. Peptidans
    c. Zymogens
    d. Serpins

62. Myocardial O_2 consumption at HR of 70/min is:
    a. 4 ml/100 mg/min
    b. 8 ml/100 mg/min
    c. 16 ml/100 mg/min
    d. 12 ml/100 mg/min

63. Which is not mandatory in management of a mediastinal tumors with airway obstruction:
    a. DLT
    b. LMA
    c. Fiberoptic bronchoscopy
    d. Adequate availability of blood

64. Normal LA pressure is:
    a. 0-4 mm Hg
    b. 4-8 mm Hg
    c. 4-12 mm Hg
    d. 8-16 mm Hg

56. b 57. b 58. c 59. b 60. b 61. c 62. b 63. b 64. c

65. C wave in CVP waveform is due to:
    a. Systolic ventricular contraction
    b. Isovolumetric contraction
    c. Isovolumetric relaxation
    d. Atual contraction

66. On CPB venous saturation should be:
    a. 50%
    b. 30%
    c. 70%
    d. 90%

67. "Egg on side" appearance on CxR is classically seen in:
    a. TGA
    b. TOF
    c. Truncus arteries
    d. TAPVC

68. Anesthesia for first BT shunt was given by:
    a. Maude Abbot
    b. Helen Taussig
    c. Austin Lamont
    d. Alfred Blalock

69. Target PO_2 after PA Banding are:
    a. 70-75%
    b. 75-80%
    c. 80-85%
    d. 85-90%

70. Arterial filter in adult CPB circuit is usually of:
    a. 10 micron
    b. 40 micron
    c. 70 micron
    d. 100 micron

65. b 66. c 67. a 68. c 69. d 70. b

10

Vitamins, Vitamin-like Compounds, Antivitamins, Enzymes and Antienzymes

1. Vitamins are:
   a. Inorganic nutrients needed in small quantities in the body
   b. Organic substances needed in very large quantities in the body
   c. Any of various fat-soluble or water-soluble organic substances essential in minute amounts for normal growth and activity of the body and obtained naturally from plant and animal foods
   d. Products of endocrine gland secretion

2. Vitamin-like compounds are:
   a. A number of compounds, whose nutritional requirements exist at specific periods of development, particularly neonatal development, and periods of rapid growth
   b. Inorganic nutrients needed in small quantities in body
   c. Organic substances needed in very large quantities in body
   d. Products of endocrine gland secretion

3. Antivitamins are:
   a. Any of various fat-soluble or water-soluble organic substances essential in minute amounts for normal growth and activity of the body and obtained naturally from plant and animal foods
   b. Substances that prevent vitamins from exerting their typical metabolic effects
   c. Any of numerous proteins or conjugated proteins produced by living organisms and functioning as specialized catalysts for biochemical reactions
   d. Nonprotein organic substances that usually contain a vitamin or mineral and combine with a specific apoenzyme to form an active enzyme system

1. c 2. a 3. b

4. Coenzymes are:
   a. Any of various fat-soluble or water-soluble organic substances essential in minute amounts for normal growth and activity of the body and obtained naturally from plant and animal foods
   b. Substances that prevent vitamins from exerting their typical metabolic effects
   c. Any of numerous proteins or conjugated proteins produced by living organisms and functioning as specialized catalysts for biochemical reactions
   d. Nonprotein organic substances that usually contain a vitamin or mineral and combines with a specific apoenzyme to form an active enzyme system

5. Antienzymes are:
   a. Agents, especially inhibitory enzymes or antibodies to enzymes, that retard, inhibit, or destroy enzymic activity
   b. Substances that prevent vitamins from exerting their typical metabolic effects
   c. Any of numerous proteins or conjugated proteins produced by living organisms and functioning as specialized catalysts for biochemical reactions
   d. Nonprotein organic substances that usually contain a vitamin or mineral and combines with a specific apoenzyme to form an active enzyme system

6. Hypovitaminosis is an insufficiency of one or more essential vitamins. This consideration is:
   a. True
   b. False

7. Hypervitaminosis is any of various abnormal conditions in which the physiological effect of a vitamin is produced to a pathological degree by excessive intake of the vitamin. This consideration is:
   a. True
   b. False

8. Select a fat-soluble vitamin:
   a. Ascorbic acid
   b. Tocopherol
   c. Thiamine
   d. Riboflavin

9. Select a water-soluble vitamin:
   a. Vitamin A
   b. Vitamin E
   c. Vitamin D
   d. Vitamin B_1

10. Which of the following vitamins can be also synthesized from a dietary precursor?
   a. Vitamin C
   b. Vitamin A
   c. Vitamin B_1
   d. Vitamin B_6

11. Which of the following vitamins resembles with hormone?
   a. Vitamin K
   b. Vitamin A
   c. Vitamin D
   d. Vitamin E

12. Beri-beri is caused by the deficiency of:
   a. Riboflavin
   b. Ascorbic acid
   c. Nicotinic acid
   d. Thiamine

4. d 5. a 6. a 7. a 8. b 9. d 10. b 11. c 12. d

13. Beri-beri is:
    a. Disease caused by a deficiency of thiamine, endemic in eastern and southern Asia, and characterized by neurological symptoms, cardiovascular abnormalities, and edema. It is also called endemic neuritis
    b. Inflammation at the corners of the mouth caused by a deficiency of riboflavin, associated with a wrinkled or fissured epithelium that does not involve the mucosa
    c. A disorder of the lips often due to riboflavin deficiency and other B-complex vitamin deficiencies and characterized by fissures, especially in the corners of the mouth
    d. All of the above

14. Deficiency symptom of riboflavin is:
    a. Cheilitis—inflammation of the lips or of a lip, with redness and the production of fissures radiating from the angles of the mouth
    b. Cheilosis—a disorder of the lips characterized by fissures, especially in the corners of the mouth
    c. Angular stomatitis, associated with a wrinkled or fissured epithelium that does not involve the mucosa
    d. All of the above

15. All of the following statements concerning vitamin A functions are true, except:
    a. Transmission of light stimuli to the brain, via combination with a specific protein, opsin, to form a visual pigment, rhodopsin, in the retina of the eye
    b. Regulation of cell growth and differentiation in epithelium, connective tissues (including bone and cartilage) and hematopoietic tissues by retinoic acid, a highly bioactive metabolite of retinol
    c. Retinoic acid is especially important during embryogenesis
    d. Acts as a hormone involved in regulation of calcium and phosphorus homeostasis

16. Deficiency symptom of vitamin A is:
    a. Night blindness—lessened ability to see in dim light
    b. Xerophthalmia and keratomalacia
    c. Various epithelial tissue defects, leading to decreased resistance to infective diseases, male and female infertility
    d. All of the above

17. Xerophthalmia is:
    a. Extreme dryness of the conjunctiva resulting from a disease localized in the eye or from systemic deficiency of vitamin A
    b. A condition, usually in children with vitamin A deficiency, characterized by softening and subsequent ulceration and perforation of the cornea
    c. A condition of the eyes in which vision is normal in daylight or other strong light but is abnormally weak or completely lost at night or in dim light and that results from vitamin A deficiency
    d. All of the above

13. a 14. d 15. d 16. d 17. a

18. Keratomalacia is:
    a. Extreme dryness of the conjunctiva resulting from a disease localized in the eye or from systemic deficiency of vitamin A
    b. A condition, usually in children with vitamin A deficiency, characterized by softening and subsequent ulceration and perforation of the cornea
    c. A visual defect marked by the inability to see as clearly in bright light as in dim light
    d. All of the above

19. Night blindness (Hemeralopia, Nyctalopia) is:
    a. Extreme dryness of the conjunctiva resulting from a disease localized in the eye or from systemic deficiency of vitamin A
    b. A condition, usually in children with vitamin A deficiency, characterized by softening and subsequent ulceration and perforation of the cornea
    c. A condition of the eyes in which vision is normal in daylight or other strong light but is abnormally weak or completely lost at night or in dim light and those results from vitamin A deficiency
    d. All of the above

20. All of the following statements concerning vitamin E functions are true, except:
    a. An extremely important antioxidant, which protects cell membrane lipids from peroxidation by breaking the chain reaction of free radical formation to which polyunsaturated fatty acids are particularly vulnerable
    b. Antisterility and antiabortion factor
    c. Specifically required for synthesis of prothrombin and several other clotting factors
    d. An essential for oxidative processes regulation

21. Which of the following statements concerning vitamin B_1 functions are true?
    a. An extremely important antioxidant, which protects cell membrane lipids from peroxidation by breaking the chain reaction of free radical formation to which polyunsaturated fatty acids are particularly vulnerable
    b. An essential coenzyme for oxidative decarboxylate of alpha-keto acids, most important being conversion of pyruvate to acetyl coenzyme A
    c. Specifically required for synthesis of prothrombin and several other clotting factors
    d. Essential constituent of the flavoproteins, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD)

22. All of the following statements concerning vitamin B_2 functions are true, except:
    a. Essential constituent of flavoproteins, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD)
    b. Plays key roles in hydrogen transfer reactions associated with glycolysis, TCA cycle and oxidative phosphorylation
    c. An essential coenzyme for oxidative decarboxylate of alpha-keto acids, most important being conversion of pyruvate to acetyl coenzyme A
    d. Deficiency symptoms are cheilitis, cheilosis and angular stomatitis

18. b 19. c 20. c 21. b 22. c

23. Which of the following statements concerning vitamin PP (B_3, niacin) functions are true?
    a. Active group of the coenzymes nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP)
    b. An essential coenzyme for oxidative decarboxylate of alpha-keto acids, most important being conversion of pyruvate to acetyl coenzyme A
    c. Specifically required for synthesis of prothrombin and several other clotting factors
    d. Essential constituent of flavoproteins, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD)

24. Which of the following statements concerning pyridoxine (vitamin B_6) functions are true?
    a. Active functional form is pyridoxal phosphate, which is an essential coenzyme for transamination and decarboxylation of amino acids in more than 50 different enzyme systems
    b. Active group of the coenzymes nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP)
    c. Essential constituent of flavoproteins, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD)
    d. An extremely important antioxidant, which protects cell membrane lipids from peroxidation by breaking the chain reaction of free radical formation to which polyunsaturated fatty acids are particularly vulnerable

25. Which of the following statements concerning pantothinic acid functions are true?
    a. Active functional form is pyridoxal phosphate, which is an essential coenzyme for transamination and decarboxylation of amino acids in more than 50 different enzyme systems
    b. Essential constituent of coenzyme A, the important coenzyme for acyl transfer in the TCA cycle and *de novo* fatty acid synthesis
    c. An extremely important antioxidant, which protects cell membrane lipids from peroxidation by breaking the chain reaction of free radical formation to which polyunsaturated fatty acids are particularly vulnerable
    d. Coenzyme for several reactions involving CO_2 fixation into various compounds, e.g. acetyl CoA to malonyl CoA (acetyl CoA carboxylase)—initial step in *de novo* fatty acid synthesis; propionyl-CoA to methylmalonyl- CoA (propionyl-CoA Carboxylase), pyruvate to oxaloacetate (pyruvate carboxylase)

26. Which of the following statements concerning biotin functions are true?
    a. Active functional form is pyridoxal phosphate, which is an essential coenzyme for transamination and decarboxylation of amino acids in more than 50 different enzyme systems
    b. Essential constituent of coenzyme A, the important coenzyme for acyl transfer in the TCA cycle and *de novo* fatty acid synthesis
    c. An extremely important antioxidant, which protects cell membrane lipids from peroxidation by breaking the chain reaction of free radical formation to which polyunsaturated fatty acids are particularly vulnerable
    d. Coenzyme for several reactions involving CO_2 fixation into various compounds, e.g. acetyl-CoA to malonyl-CoA (acetyl-CoA carboxylase)—initial step in *de novo* fatty acid synthesis; propionyl-CoA to methylmalonyl-CoA (propionyl-CoA Carboxylase), pyruvate to oxaloacetate (pyruvate carboxylase)

23. a 24. a 25. b 26. d

27. Which of the following statements concerning vitamin B_{12} (cyanocobalamin) functions are true?
    a. Active functional form is pyridoxal phosphate, which is an essential coenzyme for transamination and decarboxylation of amino acids in more than 50 different enzyme systems
    b. Essential constituent of coenzyme A, the important coenzyme for acyl transfer in the TCA cycle and *de novo* fatty acid synthesis
    c. Coenzyme for numerous metabolic reactions, including transformation of methylmalonyl-CoA to succinyl CoA in the metabolism of propionate; DNA synthesis (acts in concert with folic acid); transmethylation e.g. methionine synthesis from homocysteine
    d. An extremely important antioxidant, which protects cell membrane lipids from peroxidation by breaking the chain reaction of free radical formation to which polyunsaturated fatty acids are particularly vulnerable

28. Which of the following statements concerning folic acid (folacin) functions are true?
    a. Active functional form is pyridoxal phosphate, which is an essential coenzyme for transamination and decarboxylation of amino acids in more than 50 different enzyme systems
    b. Essential constituent of coenzyme A, the important coenzyme for acyl transfer in the TCA cycle and *de novo* fatty acid synthesis
    c. Carrier of one-carbon (e.g. methyl) groups that are added to, or removed from, metabolites such as histidine, serine, methionine, and purines
    d. An extremely important antioxidant, which protects cell membrane lipids from peroxidation by breaking the chain reaction of free radical formation to which polyunsaturated fatty acids are particularly vulnerable

29. Which of the following statements concerning vitamin C functions are true?
    a. Active functional form is pyridoxal phosphate, which is an essential coenzyme for transamination and decarboxylation of amino acids in more than 50 different enzyme systems
    b. Essential constituent of coenzyme A, the important coenzyme for acyl transfer in the TCA cycle and *de novo* fatty acid synthesis
    c. Carrier of one-carbon (e.g. methyl) groups that are added to, or removed from, metabolites such as histidine, serine, methionine, and purines
    d. Has antioxidant properties and is required for various hydroxylation reactions, e.g. proline to hydroxypoline for collagen synthesis

30. Dermatitis, diarrhea and dementia are characteristics of:
    a. Dry beriberi
    b. Pyridoxine deficiency
    c. Scurvy
    d. Pellagra

31. Pellagra is:
    a. A disease caused by a deficiency of niacin in the diet and characterized by skin eruptions, digestive and nervous system disturbances, and eventual mental deterioration
    b. Inflammation of several nerves at one time caused by a deficiency of thiamine, marked by paralysis, pain, and muscle wasting. Also called multiple neuritis or polyneuritis
    c. A severe form of anemia most often affecting elderly adults caused by a failure of the stomach to absorb vitamin B_{12} and characterized by abnormally large red blood cells, gastrointestinal disturbances, and lesions of the spinal cord. Also called pernicious anemia, malignant anemia
    d. All of the above

27. c 28. c 29. d 30. d 31. a

32. Pernicious anemia is:
    a. A severe form of anemia most often affecting elderly adults, caused by a failure of the stomach to absorb vitamin B_{12} and characterized by abnormally large red blood cells, gastrointestinal disturbances, and lesions of the spinal cord
    b. A form of anemia in which the capacity of the bone marrow to generate red blood cells is defective, caused by a bone marrow disease or exposure to toxic agents, such as radiation, chemicals, or drugs
    c. Anemia characterized by a decrease in the concentration of corpuscular hemoglobin
    d. All of the above

33. Rickets is:
    a. A deficiency disease resulting from a lack of vitamin D or calcium and from insufficient exposure to sunlight, characterized by defective bone growth and occurring chiefly in children
    b. A disease occurring primarily in adults that results from a deficiency in vitamin D or calcium and is characterized by a softening of the bones with accompanying pain and weakness
    c. A disease characterized by a decrease in bone mass and density, occurring especially in postmenopausal women, resulting in a predisposition to fractures and bone deformities such as a vertebral collapse
    d. All of the above

34. Scurvy is:
    a. A disease caused by deficiency of vitamin C and characterized by spongy bleeding gums, bleeding under the skin, and weakness
    b. Extreme dryness of the conjunctiva resulting from a disease localized in the eye or from systemic deficiency of vitamin A
    c. A disease caused by deficiency of niacin in the diet and characterized by skin eruptions, digestive and nervous system disturbances, and eventual mental deterioration
    d. All of the above

35. Which of the following vitamins is given along with isoniazide in treatment of tuberculosis?
    a. Nicotinic acid
    b. Riboflavin
    c. Pyridoxine
    d. Ascorbic acid

36. Which of the following vitamins is also known as an antisterility factor?
    a. Vitamin E
    b. Vitamin B_6
    c. Vitamin B_1
    d. Vitamin K

37. Mega doses of which vitamin are some time beneficial viral respiratory infections:
    a. Vitamin C
    b. Vitamin A
    c. Vitamin K
    d. Vitamin PP

38. Which of the following vitamins improves megaloblast anemia but does not protect the neurological manifestations of pernicious anemia?
    a. Vitamin B_{12}
    b. Vitamin BC
    c. Vitamin PP
    d. Vitamin D

39. Vitamin K enhances the anticoagulant property of coumarins. This statement is:
    a. True
    b. False

32. a 33. a 34. a 35. c 36. a 37. a 38. a 39. b

40. Loosening of teeth, gingivitis and hemorrhage occur in the deficiency of:
    a. Vitamin K
    b. Vitamin B_1
    c. Vitamin B_6
    d. Vitamin C

41. Ingestion of polar bear liver may cause acute poisoning of:
    a. Vitamin D
    b. Vitamin E
    c. Vitamin A
    d. Vitamin C

42. Which of the following antivitamins prevent a vitamin B_6 from exerting its typical metabolic effects?
    a. Isoniazide
    b. Ethanol
    c. Carbamazepine
    d. All of the above

43. Which of the following antivitamins prevent a vitamin A from exerting its typical metabolic effects?
    a. Lipoxidase
    b. Oral contraceptives
    c. Antibiotics
    d. All of the above

44. Which of the following antivitamins prevent a vitamin K from exerting its typical metabolic effects?
    a. Cholestyramine
    b. Coumarins
    c. Antibiotics
    d. All of the above

45. Which of the following coenzymes is of vitamin origin?
    a. Riboxine
    b. Coenzyme Q10
    c. Pyridoxal-5-phosphate
    d. Lipoic acid

46. Which of the following coenzymes is not of vitamin origin?
    a. Coenzyme Q10
    b. Magnesium
    c. Carnitine
    d. All of the above

47. These substances are vitamin-like compounds, except:
    a. Choline
    b. Vitamin PP
    c. Vitamin U (methylmethioninesulfonyl chloride)
    d. Orotate acid

48. Which of the following substances is a vitamin-like compound?
    a. Ascorbic acid
    b. Taurine
    c. Thiamine
    d. Riboflavin

49. Which of the following antienzymes is a proteolysis inhibitor?
    a. Contrical
    b. Sulbactam
    c. Aminocaproic acid
    d. Disulfiram

50. Which of the following antienzymes is a beta-lactamase inhibitor?
    a. Clavulanic acid
    b. Sulbactam
    c. Tazobactam
    d. All of the above

51. Which of the following antienzymes is a fibrinolysis inhibitor?
    a. Clavulanic acid
    b. Sulbactam
    c. Aminocaproic acid
    d. Disulfiram

52. Which of the following antienzymes is an aldehyde dehydrogenase inhibitor?
    a. Tazobactam
    b. Sulbactam
    c. Aminocaproic acid
    d. Disulfiram

40. c 41. d 42. c 43. a 44. d 45. c 46. d 47. b
48. b 49. a 50. d 51. c 52. d

53. Which of the following antienzymes is a cholinesterase inhibitor?
    a. Physostigmine
    b. Selegiline
    c. Aminocaproic acid
    d. Disulfiram

54. Which of the following antienzymes is a monoamine oxidase (MAO) inhibitor?
    a. Physostigmine
    b. Selegiline
    c. Acetazolamide
    d. Disulfiram

55. Which of the following antienzymes is a carbonic anhydrase inhibitor?
    a. Physostigmine
    b. Selegiline
    c. Aminocaproic acid
    d. Acetazolamide

56. Which of the following antienzymes is a xantine oxidase inhibitor?
    a. Physostigmine
    b. Allopurinol
    c. Aminocaproic acid
    d. Acetazolamide

57. Which of the following antienzymes is an aromatase inhibitor used in cancer therapy?
    a. Physostigmine
    b. Allopurinol
    c. Aminocaproic acid
    d. Aminoglutethimide

58. Which of the following enzymes improves GIT functions (replacement therapy)?
    a. Pepsin
    b. Urokinase
    c. L-asparaginase
    d. Lydaze

59. Which of the following enzymes has fibrinolytic activity?
    a. Pepsin
    b. Urokinase
    c. L-asparaginase
    d. Lydaze

60. Which of the following enzymes is used in cancer therapy?
    a. Pepsin
    b. Urokinase
    c. L-asparaginase
    d. Lydaze

61. Which of the following statements concerning nutritional supplement (dietary supplement) are true?
    a. Nutritional supplements are intended to supplement the diet and bear or contain one or more of the following dietary ingredients: a vitamin, a mineral, an herb or other botanical, an amino acid, a dietary substance for human use to supplement the diet by increasing the total daily intake (e.g. enzymes or tissue from organ or glands), a concentrate, such as a meal replacement or energy bar, a metabolite, constituent, or extract
    b. Nutritional supplements are regulated as foods, and not as drugs
    c. Nutritional supplements are not pre-approved on their safety and efficacy, unlike drugs
    d. All of the above

53. a 54. b 55. d 56. b 57. d 58. a 59. b 60. c 61. d

11

Pediatric Cardiology and Psychometric Disease

1. Benzodiazepines reduce anxiety by acting on which neurotransmitter?
   a. GABA
   b. Sertraline
   c. Noradrenaline
   d. Dopamine
2. Selective serotonin reuptake inhibitors(SSRIs) belong to which group of psychotropic drugs?
   a. Anxiolytics
   b. Mood–stabilizers
   c. Antipsychotics
   d. Antidepressants
3. Schizophrenia can present with positive and negative symptoms. What medication would you utilize to treat these?
   a. Antidepressant
   b. Traditional antipsychotic
   c. Antiparkinsonian
   d. Atypical antipsychotic
4. The pharmacokinetic considerations of medications relate to the:
   a. Physiological effect of the drug
   b. Psychological effect of the drug
   c. A and B
   d. Absorption, distribution and metabolism of the drug in the body
5. The pharmacodynamics of drugs relate to the:
   a. Side effects
   b. Psychological implication of the drug
   c. Physiological effect of the drug on the body
   d. Absorption of the drug
6. Psychotic features include:
   a. Positive symptoms: a distortion or exaggeration of normal functioning
   b. Negative symptoms: these relate to a restricted range and/or intensity of emotional expression
   c. A and B
   d. None of the above
7. Anxiolytic drugs are used to treat:
   a. The symptoms of depression and mood disorder
   b. The symptoms of anxiety and stress
   c. The symptoms of psychosis and schizophrenia
   d. None of above

1. a 2. b 3. d 4. b 5. c 6. c 7. b

8. Antipsychotics do which of the following?
   a. Alleviate major positive symptoms (such as thought disorder and hallucinations)
   b. Alleviate major negative symptoms (such as social withdrawal)
   c. Reducing the burden of institutional care
   d. All of the above

9. Behavior medication is a type of:
   a. Behavior therapy
   b. Cognitive behavioral therapy
   c. Humanistic therapy
   d. Client centered therapy

10. Drugs called benzodiazepines are used to treat:
    a. Depression
    b. Anxiety disorders
    c. Schizophrenia
    d. Mood disorders

11. Meta-analysis is often used to compare the effectiveness of studies that have used:
    a. Different procedures
    b. Different number of participants
    c. Different types of control procedures
    d. All of the above

12. Monoamine oxidase inhibitors (MAOIs) are effective for the treatment of:
    a. Schizophrenia
    b. Major depression
    c. Obsessive compulsive disorder
    d. Generalized anxiety disorder

13. Regarding Ca^{2+}, what is true?
    a. In alkalosis binding of a free Ca^{2+} to albumin is low
    b. Approximately 95% of intracellular Ca^{2+} is in cell organelles like mitochondria and ER
    c. Cell devision need Ca^{2+}
    d. Extracellular Ca^{2+} needed to maintain the plasma membrane potential
    e. Intracellular Ca^{2+} is responsible for bone mineralization

14. Which statement is incorrect?
    a. 40% of Ca^{2+} are bound to albumin
    b. Ionized form is active than other forms
    c. Daily Ca^{2+} requirement for adult is about 400-500 mg/day
    d. None of above

15. Which of the following is correct about Ca^{2+}?
    a. Mediate is hormonal action
    b. Calmodulin complex is important in endocytosis
    c. A 12-year-old child is a recommended 100 mg/day of Ca^{2+} per day
    d. Absorption of Ca^{2+} is increased by gastric juice

16. In the primary hyperparathyroidism, which is not correct?
    a. Increase tubular reabsorption of Ca^{2+}
    b. Decrease the activity of hydroxylase in kidney
    c. Possibility of having hypocalcemic tetany in a neonate whose mother is having the condition
    d. Normal serum alkaline phosphate activity
    e. Increase serum ionized Ca^{2+} level

17. True or False, Serum Ca^{2+} level is 2.5 mmol/L
    a. True
    b. False

8. b 9. a 10. b 11. d 12. b 13. c 14. d 15. b
16. b 17. a

18. Regarding Ca^{2+}, what is incorrect?
    a. Mediate in hormonal action
    b. Calmodulin complexes important in endocytosis
    c. A 12-year-old child is recommended 100 mg/day of Ca^{2+} per day
    d. Absorption of Ca^{2+} is increased by gastric juice

19. Regarding Ca^{2+}, what is true?
    a. Both nonionic and ionic forms are physiologically active
    b. Plasma level is regulated only by PTH
    c. Urinary Ca^{2+} output is reduced by PTH
    d. When calculating serum Ca^{2+} total Ca^{2+} and ionized Ca^{2+} level should be measured

20. Intestinal absorption of Ca^{2+} is not true:
    a. Reduced in renal failure
    b. Reduced in steatorrhea
    c. Increased when given oral phosphate
    d. Increased by 1,25 dihydroxycholecalciferol
    e. Decreased by phytates.

21. Serum Ca^{2+} is increased by all, except:
    a. PTH
    b. Diatery phytates
    c. Increased osteoclast activity
    d. Calcitriol

22. Which of the following conditions can present in the neonatal period with central cyanosis?
    a. Eisenmenger syndrome
    b. Pulmonary atresia
    c. Hypoplastic left heart
    d. Transposition of the great arteries
    e. Critical aortic stenosis

23. With regard to the pediatric ECG:
    a. Neonates have right axis deviation
    b. Congenital complete heart block is associated with maternal systemic lupus erythematosus
    c. Right bundle branch block is seen in coarction of the aorta
    d. Romano-Ward syndrome produces prolongation of the PR interval
    e. A resting heart rate in newborns of 180 is a tachycardia

24. Which of the following chest radiograph findings would support the paired diagnosis?
    a. Atrioseptal defect and Coeur en sabot (heart in a boot)
    b. Patient ductus arteriosus (PDA) and rib notching
    c. Truncus arteriosus and absent thymus
    d. Total anomalous pulmonary venous drainage and cottage loaf appreance
    e. Scimitar syndrome and dextrocardia

25. Which of the following conditions are associated with an increased incidence of heart disease?
    a. Kawasaki disease
    b. Congenital rubella
    c. Marfan syndrome
    d. Turner syndrome
    e. Petit mal epilepsy

18. c 19. c 20. c 21. b 22. FTTTT 23. TTTFT 24. FFTTT 25. TTTTF

26. Concerning the fetal circulation:
    a. The umbilical vein carries deoxygenated blood to the placenta from the fetus
    b. Fetal superior vena cava blood preferentially flows across the foramen ovale into the left atrium
    c. Forty percent of right ventricular outflow enters the lungs via the pulmonary arteries
    d. The descending aorta is connected to the pulmonary artery via the ductus venosus
    e. Gas exchange occurs in the fetal lungs

27. Which of the following cardiac defects and teratogens are correctly paired?
    a. Alcohol and transposition of the great arteries
    b. Sodium valproate and tetralogy of Fallot
    c. Furosemide and PDA
    d. Phenytoin and coarctation of the aorta
    e. Lithium and Ebstein anomaly

28. Which of the following are causes of circulatory failure in the first week of life?
    a. Arrhythmias
    b. Hypoplastic left heart
    c. Birth asphyxia
    d. Severe anemia
    e. Fluid overload

29. With regard to advanced life support and resuscitation in children with cardiac arrest, which of the following statements is most factually correct?
    a. Basic life support with high concentration oxygen should be continued throughout any resuscitation with the minimum of interruptions
    b. Ventricular fibrillation is the most common cardiac arrest rhythm in children
    c. It is important that a child's airway is secured during an arrest situation, so it is acceptable for basic life support to be interrupted for as long as it takes to intubate the child
    d. The resuscitation dose of adrenaline is 0.1 μg/kg and should be administered at 4 minute intervals in asystolic arrest with the third dose being given as a higher dose of 1 mg/kg if no response is seen
    e. In a pediatric arrest associated with PEA a 2 J/kg synchronized DC shock should be given every 2 minute while reversible causes are being sought and treated

30. Which of the following statements about ECG changes associated with electrolyte is most factually correct?
    a. ECG changes associated with hyperkalemia are progressive with the severity of hyperkalemia leading to the absence of P waves, broadening of QRS complexes and VF or VT
    b. Hyperkalemia is associated with increased height of U waves
    c. ECG changes seen in hypocalcemia mimic those seen in hypokalemia
    d. Hypernatremia is associated with reduced QT interval on ECG
    e. Hypercalcemia is associated with a shortened QTc and in severe cases sudden death

31. With regard to aortic stenosis, which of the following statements is most factually correct?
    a. Aortic stenosis is the most common cardiac lesion associated with Down syndrome
    b. Right ventricular hypertrophy is a common finding in a child with aortic stenosis
    c. An ejection click on auscultation suggests that the stenosis is supravalvular
    d. The most common treatment for aortic stenosis in childhood is aortic valve replacement
    e. There is an association with sudden death in patients with aortic stenosis

26. FFFFF 27. TTFTT 28. TTTTT 29. a 30. a 31. e

32. Which of the following statements about Williams syndrome is most factually correct?
    a. The most common cardiac lesion associated with Williams syndrome is an atrioseptal defect
    b. Williams syndrome is caused by a microdeletion on chromosome 11, which encodes for the elastin gene
    c. Diagnosis of Williams syndrome can be confirmed by fluorescence *in situ* hybridization (FISH) studies
    d. Williams syndrome is associated with normal development and IQ
    e. Hypercalcemia is required to make the diagnosis of Williams syndrome in a neonate

33. Which of the following statements about cardiovascular disease associated with down syndrome is most factually correct?
    a. The most common cardiac lesion associated with Down syndrome is an atrial septal defect
    b. Echocardiography is indicated in all cases of Down syndrome for identification of congenital cardiac disease even if a murmur is not present
    c. Up to 20% of all cases of Down syndrome have associated heart defects
    d. Cardiac disease in down syndrome becomes symptomatic earlier than isolated congenital heart disease due to the high prevalence of pulmonary arterial hypertension
    e. The cardiac defects associated with Down syndrome are the sole cause of pulmonary vascular disease in this population

34. Which of the following statements concerning transposition of the great arteries is most factually correct?
    a. Transposition of the great arteries associated with decreased pulmonary blood flow and pulmonary oligemia on chest radiograph
    b. Transposition of the great arteries is the most common cause of cyanotic congenital heart disease in the neonatal period
    c. Transposition of the great arteries is associated with a metabolic alkalosis at presentation
    d. The vast majority of cases of transposition of the great arteries are diagnosed on routine antenatal ultrasonography
    e. Transposition of the great arteries occurs together with a recognized pediatric syndrome in 80% of cases

35. Which of the following statements regarding tetralogy of Fallot is most factually correct?
    a. The murmur heard in a patient with tetralogy of Fallot becomes louder during cyanotic spells
    b. Cyanotic spells associated with tetralogy of Fallot usually begin around 4-6 months of age
    c. An arterial septal defect is one of the four major components of tetralogy of Fallot
    d. Finger clubbing usually develops within the first few months of life
    e. Most patients with tetralogy of Fallot have a left-to-right shunt across the VSD

36. Which of the following statements concerning atrial septal defects is most factually correct?
    a. Ostium primum defects are more common than ostium secundum defects
    b. Atrial fibrillation is a common associated complication in the first decade of life
    c. In a secundum defect the ECG shows right bundle branch block and left axis deviation
    d. In children with ASD's the pulmonary vascular resistance increases in early childhood, leading to pulmonary hypertension typically in the first decade of life
    e. A pulmonary to systemic flow ratio of more than 2:1 is an indication for surgical or more commonly percutaneous transcatheter device closure

32. c 33. e 34. b 35. b 36. e

37. Which of the following statements about childhood hypertension is most appropriate?
    a. A systolic pressure greater than the 75th centile for age and sex is defined as hypertension
    b. Primary hepertension is more common than secondary hypertension in children
    c. In infants, the most common cause of hypertension is renal parenchymal disease
    d. Children with hypertension are usually symptomatic
    e. More than 25% of children with secondary hypertension will have symptoms of headache at presentation

38. Which of the following statements concerning infective endocarditis is most factually correct?
    a. Infective endocarditis is associated with a 13-20% mortality rate
    b. Antibiotic prophylaxis is indicated to cover dental procedures in children with congenital heart disease
    c. Splinter hemorrhages in the nailbeds are an almost universal finding
    d. The diagnosis of infective endocarditis is excluded if echocardiography is normal
    e. The right side of the heart is most commonly affected.

39. Which of the following statements about cardiomyopathy is the most factually correct?
    a. Hypertropic obstructive cardiomyopathy is most commonly inherited as an X-linked disorder
    b. Dilated cardiomyopathy is associated with doxorubicin toxicity in children
    c. Restrictive cardiomyopathy is the most common cardiomyopathy in childhood
    d. Endocardial fibroelastosis is a form of hypertrophic cardiomyopathy
    e. There is an increased incidence of dilated cardiomyopathy in infants of mothers with diabetes

40. Which of the following statements about rheumatic fever is most factually correct?
    a. Rheumatic fever is caused by an infection with group A-hemolytic *Streptococcus* species
    b. The most common cardiac manifestation of rheumatic fever is an isolated endocarditis, occurring in over 50% of cases
    c. The most commonly occurring major criterion for diagnosing rheumatic fever is polyarthritis
    d. PR prolongation on the ECG is one of the major diagnostic criteria
    e. Prophylactic antibiotics should be stopped after 3 months

41. Which of the following statements about the pediatric ECG is most accurate?
    a. The PR interval is prolonged in hyperkalemia
    b. The normal PR interval in infancy is 0.2-0.3 s
    c. It is normal to have upright T wave in lead V1 until approximately 3 months of age
    d. A prolonged QTc is considered to be >0.35 s
    e. The normal range for the axis of a neonatal QRS complex is 160-2100

42. Which of the following statements about prolonged QT syndrome is most factually appropriate?
    a. There is a significant risk of sudden death associated with prolonged QT syndrome but 90% of cases of sudden death will have had symptoms before the fatal event
    b. Erythromycin should be avoided in patients with prolonged QT syndrome
    c. Sixty percent of cases of prolonged QT syndrome will present between 30 and 50 years of age
    d. Romano–Ward syndrome is an autosomally dominant, inherited syndrome associated with prolonged QT and congenital deafness
    e. A normal ECG excludes the diagnosis of prolonged QT syndrome in a patient with a positive family history

37. c 38. a 39. b 40. c 41. a 42. b

43. Which symptom from the following list is the most important when considering a diagnosis of Kawasaki disease?
    a. Gallbladder hydrops
    b. High-grade fever for >5 days
    c. Thrombocytosis
    d. Petechial rash
    e. Bilateral exudative conjunctivitis

44. Which is a sign of subacute bacterial endocarditis (SBE)?
    a. Splinter hemorrhage
    b. Extensor surface nodules
    c. Eosinophilia
    d. Cervical nodes
    e. Renal artery bruit

45. A 3-month-old baby boy is admitted to hospital breathless with poor feeding. On arrival the main findings are: pale with pulse of 240/min, liver enlarged at 3 cm below costal margin and saturation in air of 88%. Which is the most appropriate first action?
    a. Intravenous adenosine
    b. Intravenous β blockers
    c. Application of ice pack over face
    d. Oxygen
    e. Intranasal adenosine

46. A 4-day-old baby girl is admitted from home with increasing cyanosis. On examination, she is deeply cyanosed (saturation in air 78%) and has mild subcostal recession. She is alert and not distressed. What is the most likely diagnosis?
    a. Large ventricular septal defect
    b. Tricuspid atresia
    c. Diaphragmatic hernia
    d. Persistent fetal circulation
    e. Transposition of the great arteries

47. A 4-month-old is referred to the outpatient clinic with stridor since birth and faltering growth. The baby is thin with a soft ejection systolic and diastolic murmur. What is the investigation most likely to yield a unifying diagnosis in this clinical setting?
    a. Sweat test
    b. Barium swallow
    c. Direct laryngoscopy
    d. ECG
    e. Arteriography

48. A 2-year-old, fully immunized boy is referred with suspected measless. He has a weak long history of fever and malaise and has developed a generalized morbilliform rash.
    What is the most appropriate first line management?
    a. Full-infection screen including lumbar puncture and urine and broad spectrum antibiotic cover
    b. Vitamin A
    c. High dose aspirin and parenteral immunoglobulin
    d. Parenteral steroids
    e. High dose aspirin alone

49. Which of the following statements about ventricular septal defects (VSDs) is most factually correct?
    a. VSDs are most commonly located in the muscular part of the ventricular septum
    b. VSDs will cause an audible flow murmur across the defect, usually audible from birth
    c. Infective endocarditis is a complication seen in approximately 10% of all children with VSDs
    d. VSDs are associated with higher oxygen content in the blood of the right ventricle than the right atrium
    e. VSDs are associated with right ventricular volume overload

43. b 44. a 45. d 46. e 47. b 48. c 49. d

50. Which of the following interventions would produce the best clinical outcome for a child at risk of developing Eisenmenger syndrome?
    a. Surgical correction of a VSD when cardiac demonstrates significant pulmonary hypertension
    b. Nocturnal oxygen supplementation
    c. Sildenafil to help control pulmonary hypertension
    d. Correction of the VSD before the development of pulmonary hypertension
    e. Total heart and lung transplantation

51. Which of the following statements about patent ductus arteriosus is most factually?
    a. The incidence of persistent ductus arteriosus is increased in males compared with females
    b. Cardiac catheter coil placement is the treatment of choice for symptomatic infants with persistent ductus arteriosus post-term
    c. PDA can be treated with prostaglandins
    d. PDA usually closes spontaneously in term infants
    e. The incidence of PDA is increased in preterm infants and those with perinatal hypoxia and/or distress

50. d 51. e

12

True and False Questions on Miscellaneous Topics

GIVE THE FOLLOWING STATEMENTS AS TRUE (T) OR FALSE (F) IN EACH QUESTION

Ischemic Heart Disease

1. A 40-year-old executive consult the doctor for a routine medical check. He has no symptoms. He is overweight, blood pressure is 130/70, smokes 5 cigarettes per day, and his serum cholesterol is 250 mg/dL. He is a teetotaler. He has no family history of ischemic heart disease:
   a. He should reduce weight to achieve a body mass index of 24
   b. He should start drinking alcohol in moderation
   c. He should reduce smoking
   d. He should be immediately started on a statin
   e. He should be advised to take regular exercise
2. The following symptoms are suggestive of and need further investigation for suspected angina pectoris:
   a. Chest pain on climbing 2 flights of stairs
   b. Epigastric pain after meals
   c. Chest pain at night during sleep which causes the patient to wake up
   d. Shortness of breath and tiredness on moderate exertion
   e. A tightening sensation in the throat during exertion
3. Regarding the risk factors for ischemic heart disease:
   a. It is commoner in obese people
   b. The risk from smoking declines to almost normal soon after stopping smoking
   c. Moderate consumption of alcohol reduces the risk for ischemic heart disease
   d. Meditation has been proven to reduce the risk of developing ischemic heart disease
   e. Premenopausal diabetic women have almost the same risk as men to develop

1. a. T; b. F; c. F; d. F; e. T
2. a. T; b. T; c. T; d. T; e. T
3. a. T; b. F; c. T; d. F; e. T

4. Regarding the risk factors for ischemic heart disease:
   a. Regular aerobic exercise protects against ischemic heart disease
   b. Elevated serum homocysteine levels is an independent risk factor
   c. Blood pressure lowering reduces the risk of ischemic cardiac events
   d. A patient with ischemic heart disease at the age of 70 years is a risk factor for an individual to develop ischemic heart disease
   e. Women on hormone replacement therapy are protected against ischemic heart disease

5. The following are of proven value in reducing the risk factor of ischemic heart disease:
   a. Treatment with antibiotics
   b. Treatment with low dose aspirin
   c. Weight reduction
   d. Treatment with statins
   e. Acupuncture

6. A 45-year-old man is admitted with central chest pain and sweating. His ECG shows T wave inversions in the anterior leads; a previous ECG which he brought is normal. A troponin T test is negative:
   a. Unstable angina is a likely diagnosis
   b. He should be given streptokinase
   c. Intravenous heparin is indicated
   d. He has a high chance of getting a myocardial infarction within the next few days
   e. A non–ST elevation myocardial infarction is a possible diagnosis

7. A 58-year-old women presents with severe central chest pain and shortness of breath. She is in pulmonary oedema, and her blood pressure is 190/100 mm Hg. ECG shows a left bundle branch block which has not been present before. A troponin T test is positive:
   a. An acute anterior myocardial infarction is a likely diagnosis
   b. Her risk of dying due to this event is greater than 50%
   c. Blood pressure reduction is beneficial
   d. Streptokinase is indicated
   e. Pethidine is suitable for analgesia

8. A 35-year-old woman presents with chest pain on exertion. She has no risk factors:
   a. A normal resting ECG excludes the presence of ischemic heart disease
   b. She should be started on aspirin
   c. The likelihood of an exercise ECG being positive is very low
   d. A coronary angiogram is warrented

9. Differences between the sexes in cardiovascular disease and its treatment include:
   a. Cough caused by ACE inhibitors is commoner in women
   b. Isolated systolic hypertension is commoner in men
   c. Women are likely to live longer than men from the date of onset of angina
   d. Prevalence of coronary artery disease in women with chest pain is less than in men with chest pain
   e. Women presenting with coronary artery disease tend to have more severe disease

10. A 50-year-old man develops acute severe right chest pain. Probable causes include:
   a. Pneumothorax
   b. Acute myocardial infarction
   c. Acute cholecystitis
   d. Pleurisy
   e. Rheumatic fever

4. a. T; b. T; c. T; d. F; e. T
5. a. F; b. T; c. T; d. T; e. F
6. a. T; b. F; c. T; d. T; e. F
7. a. T; b. F; c. T; d. T; e. F
8. a. F; b. F; c. T; d. F; e. F
9. a. T; b. T; c. T; d. T; e. T
10. a. T; b. T; c. T; d. T; e. F

11. Causes of increased oxygen demand of the heart include:
    a. Aortic stenosis
    b. Left ventricular hypertrophy
    c. Pregnancy
    d. Treatment with diltiazem
    e. Treatment with Nifedipine

12. The following are important risk factors of ischemic heart disease:
    a. Obesity
    b. Smoking
    c. High salt intake
    d. High glucose intake
    e. Hyperlipidemia

13. The following are true regarding ischemic heart disease:
    a. A male aged 40 years has nearly a 50% risk of developing ischemic heart disease during his lifetime
    b. The majority of men with ischemic heart disease present with chronic angina rather than myocardial infarction
    c. On third of all deaths over the age of 35 years are due to ischemic heart disease
    d. Post menopausal women are at three times the risk of developing ischemic heart disease than premenopausal women of the same age
    e. The use of hormone replacement therapy in postmenopausal women markedly reduces their risk of developing ischemic heart disease

14. Regarding smoking and ischemic heart disease:
    a. Most smokers are aware that smoking will increase the risk of heart disease
    b. Smoking doubles the risk of developing coronary artery disease
    c. In women, the risk of myocardial infarction is increased six fold if they smoke
    d. Passive smoking increase the risk coronary artery disease by 20%
    e. Cigar smoking does not increase the risk of coronary artery disease

15. T-wave inversions on the ECG are seen in the following conditions:
    a. Myocardial infarction
    b. Mitral valve prolapsed
    c. Hyperkalemia
    d. Subarachnoid hemorrhage
    e. Myocarditis

16. The following factors contribute to the development of myocardial ischemia:
    a. Anemia
    b. Polycythemia
    c. Left ventricular hypertrophy
    d. Aortic valve stenosis
    e. Mitral valve stenosis

17. A possible diagnosis of acute myocardial infarction should be considered in the following situations:
    a. Sudden onset severe central chest pain
    b. Sudden severe left ventricular failure
    c. Sudden death
    d. New onset complete heart block
    e. Severe burning epigastric pain

18. In the presence of chest pain, ECG changes suggestive of an acute myocardial infarction include:
    a. Saddle shaped ST segment elevations in all leads
    b. New left bundle branch block
    c. New complete heart block
    d. Deep T wave inversions in the anterior leads
    e. Ventricular tachycardia

11. a. T; b. T; c. T; d. F; e. F
12. a. T; b. T; c. T; d. F; e. T
13. a. T; b. F; c. T; d. T; e. T
14. a. F; b. T; c. T; d. T; e. F
15. a. T; b. T; c. F; d. T; e. T
16. a. T; b. T; c. T; d. T; e. F
17. a. T; b. T; c. T; d. T; e. T
18. a. F; b. T; c. T; d. T; e. T

19. Regarding events after a acute anterior myocardial infarction:
    a. Ventricular fibrillation occurring within the first 24 hours has a relatively good prognosis
    b. Dresslers syndrome occurs within 48 hours
    c. If complete heart block occurs, pacing is usually required
    d. Multiple ventricular ectopics should be treated with antiarrythmics
    e. Treatment with an ACE inhibitor is indicated

20. Regarding the treatment of myocardial infarction:
    a. Streptokinase is indicated in non-ST elevation myocardial infarction
    b. Heparin is indicated in patients given streptokinase
    c. Tenolol will reduce the risk of sudden death
    d. Aspirin will reduce mortality by 25%
    e. An ACE inhibitor will reduce the risk of developing heart failure later on

21. The following are instances of unstable angina:
    a. Anginal pain occurring for the first time
    b. Anginal pain occurring after meals
    c. A sudden reduction in the distance the patient can walk without chest pain
    d. Chest pain on walking to the toilet on the 4th day after myocardial infarction
    e. Angina at rest

22. A patient who developed an acute inferior myocardial infarction is being discharged. The following are true:
    a. He should have a limited exercise ECG prior to discharge
    b. He should abstain from sex for 3 months
    c. He cannot be drive a car for 6 months
    d. He should be referred for coronary angiography in 6 weeks time
    e. He should be advised to take sublingual glyceryl trinitrate in case he develops angina again

23. In a patient who has had a recent myocardial infarction and whose total cholesterol 5.5–8.0 mmol/L the introduction of HMG CoA reductase inhibitor would:
    a. Decrease the reinfarction rate
    b. Increase incidence non-cardiac deaths
    c. Slows the rate of atherosclerosis
    d. Reduce the risk of sudden death
    e. Is a recognized cause of rhabdomyolysis

24. A 34-year-old woman complains of palpitations, breathlessness and chest pain, radiating to the left arm. She had been well, and developed symptoms six weeks ago when her father died of heart attack. She has no risk factors. She complains of difficulty in falling asleep at night. She has had abdominal pain; backache, headache, and numbness of the limbs for several years, for which she has taken treatment repeatedly. Which of the following diagnosis are likely:
    a. Depression
    b. Factitious disorder
    c. Somatization disorder
    d. Gastric
    e. Attention seeking

19. a. T; b. F; c. T; d. F; e. T
20. a. F; b. T; c. T; d. T; e. T
21. a. T; b. F; c. T; d. T; e. T
22. a. T; b. F; c. F; d. F; e. F
23. a. T; b. F; c. T; d. F; e. T
24. a. T; b. F; c. T; d. F; e. F

25. Which of the following statements concerning the treatment of acute myocardial infarction is correct?
    a. A pansystolic murmur developing within three first 24 hours does not require further investigation
    b. Dipyridamole therapy reduces reinfarction within the first year
    c. Heparin is beneficial if given with streptokinase
    d. Prophylactic lignocaine given in the first 48 years effective in preventing ventricular fibrillation
    e. Treatment with a dihydropyridine calcium antagonist is associated with increased cardiovascular mortality

Heart Failure

26. Regarding heart failure:
    a. The prevalence increases with age
    b. It accounts for about 5% of hospital admissions
    c. About 30% of patients die within 3 months of the onset of heart failure
    d. The majority of patients have systolic heart failure
    e. Valvular heart disease is an important cause in the developing world

27. The following are known to result in chronic heart failure:
    a. Ischemic heart disease
    b. Alcohol abuse
    c. Thyrotoxicosis
    d. Vitamin deficiency
    e. Rhythm disturbances

28. The following are true:
    a. A high systolic blood pressure excludes a diagnosis of heart failure
    b. The heart rate is usually high due to increased adrenergic activity
    c. Production of pink frothy sputum is a common feature
    d. The peripheries are warm

29. The following may be early symptoms of heart failure:
    a. Dyspnea on walking 2 flights of stairs
    b. Nocturnal cough
    c. Waking up in the night with dyspnea
    d. A sense of epigastric fullness
    e. Wheezing on exertion

30. In patients with heart failure:
    a. Coarse basal crackles can be heard in the lungs
    b. The heart sounds may be normal
    c. A palpable tender liver may be present
    d. The presence of a pan systolic murmur usually indicates rheumatic mitral valve disease
    e. A wheeze may be present

31. The following are true regarding the ECG in heart failure:
    a. Old changes of myocardial infarction must be looked for
    b. Left bundle branch block suggests that there is significant ventricular damage
    c. A P-pulmonale indicates the presence of left heart failure
    d. Sinus tachycardia is a feature
    e. The presence of U waves suggests hypokalemia due to treatment

25. a. F; b. F; c. F; d. F; e. T
26. a. T; b. T; c. T; d. T; e. T
27. a. T; b. T; c. T; d. T; e. F
28. a. F; b. T; c. F; d. F; e. F
29. a. T; b. T; c. T; d. T; e. T
30. a. F; b. T; c. T; d. F; e. T
31. a. T; b. T; c. F; d. T; e. T

32. Regarding the chest radiography in heat failure:
    a. A normal size heart excludes heart failure
    b. Upper lobe diversion of blood is seen
    c. A large unilateral pleural effusion suggests a pathology other than heart failure
    d. Pleural effusions are commoner on the left
    e. Calcification of the valves is seen

33. Regarding the echocardiogram in heart failure:
    a. It is an essential investigation prior to commencing treatment
    b. It is a reliable investigation to diagnose left ventricular diastolic dysfunction
    c. An ejection fraction below 40% is compatible with heart failure
    d. In mitral regurgitation, the ejection fraction can be high
    e. Left atrial thrombi can be detected

34. Regarding diastolic heart failure:
    a. It occurs in patients with longstanding hypertension
    b. The ejection fraction can be normal
    c. Pulmonary oedema can occur
    d. ACE inhibitors are useful in treatment
    e. Can be differentiated from systolic failure based on the response to diuretics

35. The following are cause of right heart failure:
    a. Chronic left heart failure
    b. Emphysema
    c. Primary pulmonary hepertension
    d. Atrial septal defect
    e. Pneumothorax

36. High output failure occurs in:
    a. Thyrotoxicosis
    b. Septic shock
    c. Paget's disease
    d. Beri beri
    e. Aortic regurgitation

37. Regarding right heart failure:
    a. It occurs secondary to pulmonary hypertension
    b. Emphysema is a known cause
    c. The prognosis is better than for left heart failure
    d. It may result in tricuspid regurgitation
    e. Sildenafil improves survival in patients with pulmonary hypertension

38. A 65-year-old patient is admitted with severe shortness of breath. His blood pressure is 130/90 mm Hg, heart rate 120 beats per minute, and he has bilateral basal crackles. His ECG is normal. He has a past history of chronic heart failure due to ischemic heart disease:
    a. The patient should be placed in the head low position to improve cerebral perfusion
    b. Morphine is useful in reducing pulmonary oedema
    c. Morphine is useful in reducing pulmonary oedema
    d. Frusemide should be given orally
    e. Intravenous ACE inhibitors are effective in treatment

32. a. F; b. T; c. T; d. F; e. F
33. a. F; b. T; c. T; d. T; e. T
34. a. T; b. T; c. T; d. T; e. F
35. a. T; b. T; c. T; d. T; e. F
36. a. T; b. T; c. T; d. T; e. F
37. a. T; b. T; c. F; d. T; e. F
38. a. F; b. T; c. F; d. T; e. T

39. Regarding cardiogenic shock:
    a. Warm extremities with a bounding pulse is a clinical feature
    b. Confusion and restlessness occurs
    c. Elevated central venous pressure is present
    d. Colloids are used to expand circulatory volume
    e. Intra-arterial blood pressure monitoring is recommended

40. Regarding cardiac failure:
    a. Left ventricular end diastolic volume is increased
    b. Bradycardia is usually present
    c. Syncope is a symptom
    d. Hypertension is a cause
    e. A tender enlarged liver indicates the presence of right heart failure

41. In the management of acute ventricular failure:
    a. The patient is kept supine in the head low position
    b. Thiazide diuretics are indicated
    c. Oxygen is given via a face mask
    d. Morphine is given intramuscularly
    e. Ventilation is required in severe cases

42. A 35-year-old pregnant woman presents with acute dyspnea. The following are likely causes:
    a. Mitral stenosis
    b. Pulmonary embolism
    c. Asthma
    d. Acute myocardial infarction
    e. Pneumonia

43. The following drugs when given in therapeutic dosage may cause cardiac failure:
    a. Phenylbutazone
    b. Carbimazole
    c. Daunorubicin
    d. Propranolol
    e. Pioglitazone

44. The following lifestyle measures are effective in the treatment of heart failure:
    a. Weight reduction
    b. Reduction of salt in diet
    c. Adequate rest
    d. Avoidance of exercise
    e. Moderate consumption of alcohol

45. Regarding the treatment of heart failure:
    a. There is no benefit in giving frusemide by the intravenous route compared to oral route
    b. Large meals should be avoided
    c. Bed rest is beneficial
    d. Frusemide is better given at night
    e. Oral nitrates are usually given at 8 hourly intervals

46. The following are true regarding the treatment of heart failure:
    a. ACE inhibitors reduce mortality
    b. Digoxin improves symptoms but worsens mortality
    c. Spironolactone improves survival
    d. Beta blockers are contraindicated
    e. Cardiac inotropes like dobutamine improve survival

39. a. F; b. T; c. T; d. F; e. T
40. a. T; b. F; c. T; d. T; e. T
41. a. F; b. F; c. T; d. F; e. T
42. a. T; b. T; c. T; d. F; e. T
43. a. T; b. F; c. T; d. T; e. T
44. a. T; b. T; c. T; d. F; e. F
45. a. F; b. T; c. T; d. F; e. F
46. a. T; b. F; c. T; d. F; e. F

47. The following are true of right ventricular failure:
    a. It results in ankle oedema
    b. Emphysema is a rare cause
    c. Primary pulmonary hypertension is a cause
    d. Central venous pressure is usually greater than 4 mm Hg
    e. The prognosis is better than that for left ventricular failure

48. The following drugs are of proven benefit in improving prognosis in chronic heart failure:
    a. Enalapril in mild heart failure
    b. Digoxin
    c. Nitrates and prazosin combination
    d. Nitrates and hydralazine combination
    e. Dobutamine infusion

49. In left ventricular failure:
    a. The development of pulmonary hypertension results in oligemic lung fields
    b. Breathlessness is usually due to hypoxemia
    c. The $PaCO_2$ is increased in pulmonary oedema
    d. Effort dyspnea always precedes orthopnea and paroxysmal nocturnal dyspnea
    e. The X-ray picture may be mistaken for solid lung tumor

50. A 70-year-old man with dilated cardiomyopathy remains symptomatic in NYHA class 2 due to chronic heart failure. On examination his pulse is 90 regular, BP 140/90, heart sounds normal, chest auscultation did not reveal any abnormalities. He is currently taking enalapril 10 mg bd and Frusemide 40 mg bd. Which of the following drugs could be considered to optimize his therapy?
    a. Amiodarone
    b. Carvedilol
    c. Digoxin
    d. Spironolactone
    e. Candesarten

Hypertension

51. The following are true regarding hypertension:
    a. A sustained blood pressure of 150/85 mm Hg in a 65-year-old man is indicative that he is hypertensive
    b. In a 20-year-old male, blood pressure of 135/85 is optimal
    c. In diabetic with nephropathy, the target blood pressure is below 120/70 mm Hg
    d. In a hypertensive patient with a history of ischemic stroke 6 months ago, a blood pressure of 140/90 mm Hg indicates adequate control
    e. A patient who has sustained an ischemic stroke 24 hours ago, a blood pressure of 170/95 mm Hg requires antihypertensive treatment

52. The following are true regarding thiazide diuretics in the management of hypertension:
    a. They are usually administered once daily in the morning
    b. The antihypertensive effect is due to sustained reduction in plasma volume
    c. Combination with other antihypertensives in not recommended due to drug interactions
    d. There are no recent clinical trials showing efficacy of thiazides in hypertension
    e. They should be avoided in patients with diabetes

47. a. F; b. F; c. T; d. F; e. F
48. a. T; b. F; c. F; d. T; e. F
49. a. T; b. F; c. F; d. F; e. T
50. a. F; b. T; c. T; d. T; e. T
51. a. T; b. F; c. T; d. F; e. F
52. a. T; b. F; c. F; d. F; e. T

53. A 56-year-old diabetic man is seen by his general practitioner. He is found to have a blood pressure of 180/110 mm Hg. He is not obese, and is a non smoker. His serum cholesterol and renal function are normal:
    a. He should be given sunlingual nifedipine to reduce the blood pressure
    b. He should be tried on lifestyle modification alone for 3 months
    c. Ramipril is an appropriate first line antihypertensive
    d. Thiazide diuretics are contraindicated
    e. His target blood pressure is 140/90 mm Hg

54. The following non pharmacological methods have been shown to reduce the blood pressure in subjects with hypertension:
    a. Weight reduction
    b. Increased fruit and vegetable intake
    c. Regular aerobic exercise
    d. Cessation of smoking
    e. Reduced alcohol consumption

55. Hypertension is caused by:
    a. Renal artery stenosis
    b. Coarctation of the aorta
    c. Porphyria
    d. Oral contraception
    e. Rennin secreting tumors

56. A 45-year-old man is found to have a blood pressure of 150/90. He is overweight, and smokes a pack of cigarettes a day, but has no other risk factors. The following are true:
    a. He should be started on a thiazide diuretic
    b. He should be advised to reduce weight
    c. Meditation is an effective method of reducing his blood pressure
    d. He should reduce smoking
    e. He should reduce the amount of salt in his diet

57. The following non-pharmacological measures are useful in the treatment of hypertension:
    a. Moderate dietary sodium restriction
    b. Weight reduction in the obese
    c. Meditation
    d. Avoidance of excess alcohol intake
    e. Regular aerobic exercise

58. The following are true:
    a. Hypertension is defined as a sustained blood pressure above 140/90 mm Hg
    b. A blood pressure of 138/85 mm Hg is defined as normal
    c. A patient with a diastolic blood pressure above 100 mm Hg is considered to have stage 2 hypertension
    d. A patient systolic blood pressure of 150 mm Hg has stage 2 hypertension
    e. To stage hypertension, both systolic and diastolic values must be above the defined level

59. The following are true:
    a. Hypertension is the most important cause of stroke
    b. The prevalence of hypertension is on the increase
    c. Control of hypertension is achieved in only 50% of people worldwide
    d. Hypertension is commoner in poorer socioeconomic classes
    e. Hypertension is commoner in the elderly

53. a. F; b. F; c. T; d. F; e. F
54. a. T; b. T; c. T; d. T; e. T
55. a. T; b. T; c. T; d. F; e. T
56. a. F; b. T; c. F; d. F; e. T
57. a. T; b. T; c. F; d. T; e. T
58. a. T; b. F; c. T; d. F; e. F
59. a. T; b. T; c. F; d. F; e. T

60. The following people are more likely to be lacking in awareness of high blood pressure:
    a. A patient over the age of 65 years
    b. Males
    c. White women
    d. Those who have not visited a doctor within the last year
    e. Smokers

61. Regarding blood pressure measurement:
    a. A single blood pressure reading of 180/110 mm Hg is adequate to diagnose hypertension
    b. Strenuous exercise can result in a falsely low blood pressure
    c. Drinking coffee just before checking the blood pressure can result in a falsely high reading
    d. To measure the blood pressure in a regular smoker, he should not have smoked for the past 30 minutes
    e. Patients should be asked to skip their regular dose of antihypertensive medications prior to coming to check their blood pressure

62. Regarding measurement of blood pressure:
    a. Aneroid sphygmomanometers are as accurate as mercury sphygmo-manometers
    b. The length of the bladder should be 75% of the circumference of the upper arm
    c. The width of the bladder should be more than 50% of the length of the upper arm
    d. The use of a cuff which is too small will result in a falsely low blood pressure reading
    e. In pregnancy, the blood pressure should be measured in the lateral recumbent position

63. Regarding the measurement of blood pressure:
    a. The cuff should be inflated to 10 mm Hg above the systolic pressure detected by palpation of the brachial artery
    b. The arm must be supported so that the brachial artery is at the level of the heart
    c. The diastolic pressure is the point at which the Korotkoff's sounds disappear
    d. The point of muffling of the Korotkoff's sounds is taken in high output states
    e. The blood pressure apparatus must be placed at the level of the heart

64. Regarding "white coat" hypertension:
    a. Is present in less than 5% of people with elevated blood pressure
    b. Is less likely if the diastolic blood pressure measured by the doctor is >105 mm Hg
    c. Ambulatory blood pressure monitoring is useful in diagnosis
    d. It does not cause any abnormalities on echocardiography
    e. It does not give rise to sustained hypertension

65. Risk factors for the development of pre-eclampsia include:
    a. Multiparity
    b. Diabetes mellitus
    c. A pat history of renal disease
    d. A history of chronic hypertension
    e. Age below 15 years

66. Pre-eclampsia:
    a. Is associated with increase perinatal morbidity and mortality
    b. Is diagnosed by measurement of two elevated blood pressures, at least 6h apart
    c. When associated with proteinuria, denoted a worse prognosis
    d. Is reduced by the use of aspirin
    e. Oedema is a feature

60. a. T; b. T; c. F; d. T; e. F
61. a. F; b. T; c. T; d. T; e. F
62. a. F; b. T; c. T; d. F; e. T
63. a. F; b. T; c. T; d. T; e. F
64. a. F; b. T; c. T; d. F; e. F
65. a. F; b. T; c. T; d. T; e. T
66. a. T; b. T; c. T; d. F; e. T

67. Regarding severe pre-eclampsia:
    a. Renal failure occurs
    b. The presence of thrombocytopenia, hemolysis, and elevated livers enzymes indicates a poor prognosis
    c. Intracranial hemorrhage is a complication
    d. It does not occur after delivery
    e. Fits occur only in the presence of very high blood pressure

68. Regarding the management of pre-eclampsia:
    a. In severe pre-eclampsia delivery of the baby is recommended after 32 weeks of gestation
    b. Control of blood pressure to below 160/110 mm Hg reduces the risk of stroke
    c. Rapid reduction of blood pressure is indicated
    d. Intravenous labetalol is used
    e. Intravenous phenytoin is the preferred drug in seizures

69. Regarding the drug management of hypertension:
    a. An angiotensin converting enzyme inhibitor is the preferred first line drug
    b. Prazocin improves survival
    c. Short acting calcium channel blockers are associated with increased mortality
    d. Beta blockers reduce mortality
    e. Angiotensin receptor blockers are safe in pregnancy

70. Regarding hypertension due to endocrine causes:
    a. Hyperparathyroidism is a known cause
    b. In renal artery stenosis, hyperkalemia is a feature
    c. In ectopic ACTH syndrome, marked proximal muscle weakness is seen
    d. Retinal hemorrhages without other hypertensive changes in the retina suggests the possibility of phaeochromocytoma
    e. Carcinoid syndrome is a recognized cause

71. The following antihypertensive drugs are appropriate choices in the conditions named:
    a. Hydrochlorothiazide → benign prostatic hypertrophy
    b. Losarten → advanced renal failure
    c. Ramipril → diabetes mellitus
    d. Metroprolol → congestive heart failure
    e. Methyldopa → elderly

72. In a patient with moderate chronic renal failure:
    a. Tight blood pressure control is beneficial
    b. Diltiazem reduces proteinuria in diabetic nephropathy
    c. Angiotensin receptor blockers are the preferred drug for blood pressure control
    d. Dietary sodium restriction is helpful in reducing the blood pressure
    e. Hyperkalemia may occur with ACE inhibitors

73. Regarding renocascular hypertension:
    a. It is commoner in blacks
    b. A low serum potassium is seen
    c. The presence of asymmetry in renal sizes suggestive of the diagnosis
    d. Renal arteriography is the gold standard in diagnosis
    e. Plasma rennin activity is reduced

67. a. T; b. T; c. T; d. F; e. F
68. a. T; b. T; c. F; d. T; e. F
69. a. F; b. F; c. T; d. T; e. F
70. a. T; b. F; c. T; d. T; e. F
71. a. F; b. T; c. T; d. T; e. F
72. a. T; b. T; c. F; d. T; e. T
73. a. F; b. T; c. T; d. T; e. F

74. Regarding hypertensive emergency:
    a. The blood pressure must be reduced within 5 minutes to prevent hypertensive encephalopathy
    b. Intravenous labetalol is the drug of choice
    c. Sublingual nifedipine is indicated
    d. Mannitol is indicated to reduce cerebral edema
    e. Aortic dissection is a complication

75. Hypertension increases the risk of developing the following:
    a. Renal failure
    b. Asthma
    c. Congestive cardiac failure
    d. Stroke
    e. Angina

Cardiovascular Drugs

76. Aspirin:
    a. Reduces mortality after a myocardial infarction
    b. Must be discontinued if the patient complains of dyspepsia
    c. Is effective in primary prevention of myocardial infarction
    d. Prevents stroke
    e. Gives additive benefit when combined with warfarin after pulmonary embolism

77. Regarding anticoagulation:
    a. Warfarin is indicated in patients with mitral stenosis and atrial fibrillation
    b. Low molecular weight heparin is less effective than unfractionated heparin in unstable angina
    c. After a pulmonary embolism, warfarin treatment is indicated for at least 3 months
    d. Patients with recurrent transient ischemic attacks should be treated with warfarin
    e. In patients on long term warfarin it is sufficient to check the INR every 3 months

78. Isosorbide dinitrate:
    a. Improves in angina by causing coronary vasodilatation
    b. Reducing mortality after myocardial infarction
    c. Causes headache
    d. Causes tolerance
    e. Is effective when administered transcutaneously

79. Beta blockers:
    a. Reduce angina by reducing myocardial oxygen demand
    b. Are contraindicated in heart failure
    c. Are contraindicated in chronic obstructive airways disease
    d. Reduce left ventricular hypertrophy
    e. Reduce the incidence of sudden cardiac death after myocardial infarction

80. Thiazide diuretics:
    a. Are first line drugs in heart failure
    b. Are first line drugs in hypertension
    c. Are unsuitable for use in patients with stage 2 hypertension
    d. May be safely combined with angiotesin receptor blockers
    e. Are contraindicated in diabetes mellitus

74. a. F; b. F; c. F; d. F; e. T
75. a. T; b. F; c. T; d. T; e. T
76. a. T; b. F; c. T; d. T; e. F
77. a. T; b. F; c. T; d. F; e. F
78. a. F; b. T; c. T; d. T; e. T
79. a. T; b. F; c. T; d. T; e. T
80. a. F; b. T; c. F; d. T; e. F

81. Spironolactone:
    a. Reduces mortality in heart failure
    b. High doses should be used in heart failure
    c. Can cause hyperkalemia when combined with ACE inhibitors
    d. Is safe in moderate renal failure
    e. Can cause gynecomastia

82. Digoxin:
    a. Is indicated in patients with mitral stenosis in sinus rhythm
    b. Improves survival in heart failure
    c. Reduces symptoms in heart failure
    d. Can cause tachyarrhythmia
    e. Can cause heart block

83. Angiotensin converting enzyme inhibitors are indicated in:
    a. In a 40-year-old patient with idiopathic dilated cardiomyopathy
    b. In a patient after a myocardial infarction
    c. In a patient with aortic stenosis
    d. A hypertensive patient with proteinuria
    e. A normotensive diabetic without proteinuria

84. Angiotensin receptor blockers:
    a. Are contraindicated in renal failure
    b. Have beneficial effects in diabetes mellitus
    c. Can be safely combined with other antihypertensives
    d. Have antiarrhythmic properties
    e. Reduce mortality in heart failure

85. True or false:
    a. Vitamin E is of proven value in the treatment of hypertension
    b. Prazocin has survival benefit in hypertension
    c. Folic acid supplementation may be beneficial in preventing ischemic heart disease
    d. Beta carotene has beneficial effects in ischemic heart disease through its antioxidant effects
    e. Nicotinic acid is an effective cholesterol lowering agent

86. The side effects of angiotensin converting enzyme inhibitors include:
    a. Cough
    b. Headache
    c. Hyperkalemia
    d. Worsening of renal function in patients with chronic renal failure
    e. Hypotension with the first dose

87. Amiodarone:
    a. Can cause hypothyroidism
    b. Has a half life of 3 days
    c. Causes prolongation of the QT interval
    d. Is useful in the treatment of atrial fibrillation
    e. Is safe in pregnancy

81. a. T; b. F; c. T; d. T; e. T
82. a. F; b. F; c. T; d. T; e. T
83. a. T; b. T; c. F; d. T; e. F
84. a. F; b. T; c. T; d. F; e. T
85. a. F; b. F; c. T; d. F; e. T
86. a. T; b. F; c. T; d. T; e. T
87. a. T; b. F; c. T; d. T; e. F

88. Regarding calcium channel blockers:
    a. Reduce mortality in patients with ischemic heart disease
    b. Are effective antianginal agents
    c. Reduce proteinuria
    d. Short acting mifedipine increases mortality in hypertension
    e. Can be used to delay surgery in patients with aortic regurgitation

89. Side effects of thiazide diuretics include:
    a. Hypercalcemia
    b. Acute pancreatitis
    c. Hyperglycemia
    d. Cholestatic jaundice
    e. Hyperkalemia

90. Streptokinase treatment in acute myocardial infarction:
    a. Has now been shown to be effective if given via the intramuscular route
    b. May be associated with an anaphylactic reaction
    c. Is associated with a 25% reduction in mortality
    d. Is indicated in non ST elevation MI
    e. Is as effective improving prognosis in patients with inferior as well as anterior infarctions

91. Frusemide:
    a. Given intravenously takes 6 hours to bring relief in acute left ventricular failure
    b. Reduces preload
    c. Is a less efficacious diuretic than amiloride
    d. Is preferred to hydrochlorothiazide in the management of hypertension
    e. Is known to precipitate pre-renal uremia

92. In heart failure:
    a. Carvedilol is contraindicated as it has negative inotropic effects
    b. The compensatory pathophysiological mechanisms have harmful effects in the long term
    c. Salt restriction is used as a form of therapy
    d. Edema is initially detected in the face
    e. Captopril improves survival

93. Aspirin:
    a. Is indicated in the management of acute thrombotic stroke
    b. In low dose (150 – 300 mg daily) is known to influence the regular tests of bleeding function
    c. Allergy manifests as bronchospasm
    d. Does not improve survival in patients after myocardial infarction
    e. And streptokinase should not be given concurrently

94. The following drugs and their actions are correctly paired:
    a. Dipyridamole – inhibits platelet phosphodiesterase
    b. Clopidogrel – inhibits activation of the glycoprotein llb/llla receptors in the platelets
    c. Tirofiban – inhibits lipoxygenase receptors
    d. Low dose aspirin – alters the balance between thromboxane A2 and prostaglandin I2 in platelets and vessel wall
    e. Abciximab – blocks glycoprotein llb/llla receptors in the platelets

88. a. F; b. T; c. T; d. T; e. T
89. a. F; b. T; c. T; d. T; e. F
90. a. F; b. T; c. T; d. F; e. T
91. a. F; b. T; c. F; d. F; e. T
92. a. F; b. T; c. T; d. F; e. T
93. a. T; b. F; c. T; d. F; e. F
94. a. T; b. F; c. F; d. T; e. T

95. Streptokinase:
    a. Is extracted from cultures of beta-hemolytic streptococci
    b. Has high efficacy in dissolving arterial thrombi that are about 3 weeks old
    c. Does not have antigenic properties
    d. Is given as a rapid intravenous bolus
    e. Is classified as an antiplatelet drug

96. The following are true:
    a. Aspirin is converted to salicylate by first pass metabolism in the liver
    b. Fibrinolytic drug are ineffective in reducing mortality after myocardial infarction in those over 70 years
    c. Atenolol is a lipid soluble beta blocker
    d. Fibrinolytic drug are contraindicated in severe uncontrolled hypertension
    e. Streptokinase when used to treat myocardial infarction is known to produce arrhythmias

97. The following drug and their effect are correctly paired:
    a. Simvastati – lowers hepatic cholesterol synthesis
    b. Vitamin E – increases HDL cholesterol
    c. Gemfibrozil – inhibits hepatic lipid synthesis
    d. Cholestyramine – inhibits enterohepatic reuptake of bile salts
    e. Nicotinic acid – decreases serum triglycerides

98. Statins:
    a. Are contraindicated if serum transaminases are persistently elevated
    b. Cause thabdomyolysis
    c. Are safely used during pregnancy
    d. Are effective in the primary prevention of coronary events
    e. Are recommended to be taken in the morning

99. Cautions about the use of digitalis include:
    a. Hypokalemia
    b. Old age
    c. Diabetes mellitus
    d. Low platelets
    e. Presence of atrial fibrillation

100. Which of the following is true regarding the action of clopidogrel?
    a. It is useful in stroke
    b. It is indicated in unstable angina
    c. It can cause thrombocytopenia
    d. It should not be combined
    e. It causes hypertension

Rheumatic Heart Disease

101. The following epidemiological factors increase the risk of acute rheumatic fever:
    a. Lower standards of living
    b. Poor dental hygiene
    c. Overcrowding
    d. Poor socioeconomic class
    e. Lack of access to health care

95. a. T; b. F; c. F; d. F; e. F
96. a. F; b. F; c. F; d. T; e. T
97. a. T; b. F; c. F; d. T; e. T
98. a. T; b. T; c. F; d. T; e. F
99. a. T; b. T; c. F; d. F; e. F
100. a. T; b. T; c. F; d. F; e. F
101. a. T; b. F; c. T; d. T; e. T

102. Acute rheumatic fever:
   a. Occurs after pharyngeal infections with *Streptococcus pyogenes* lancefield Group A
   b. Occurs predominantly in children under the age of 10 years
   c. Causes diffuse inflammatory edema of the endocardium
   d. Causes permanent deformity of affected joints
   e. Is complicated by fibrosis of affected valves

103. In a 12-year-old child with fever and joint pains, the following clinical features are suggestive of acute rheumatic fever:
   a. Pain and swelling of the small joints of the hands
   b. Migratory arthritis
   c. The leg joints typically being involved first
   d. An early diastolic murmur at the left sterna edge

104. Vegetation in acute rheumatic fever:
   a. Are most commonly situated on tricuspid and pulmonary valves
   b. Are large and friable
   c. Are aseptic
   d. Contain microscopic Aschoff bodies
   e. Cause rupture of valve cusps

105. Regarding the pathology of mitral valve stenosis:
   a. Large friable vegetations are seen on the mitral valve during episodes of acute rheumatic fever
   b. Fibrosis of the valve occurs
   c. Fusion of the valve commissures occurs
   d. Thickening and shortening of the chordae tendineae limitation of valve mobility
   e. A valve area of less than 2 cm^2 is defined as tight mitral stenosis

106. In acute rheumatic carditis:
   a. Complete heart block is known to occur
   b. Cardiomegaly is seen on the chest radiograph
   c. The presence of a pericardial rub indicates the presence of pericarditis
   d. Mitral stenosis is the commonest valvular lesion
   e. Severe congestive heart failure is known to occur

107. Regarding sydenhams chorea:
   a. Peripheral sensory loss is seen
   b. The abnormal movements are often asymmetrical
   c. Emotional changes may occur in children
   d. Is known to occur 6 months after streptococcal infection
   e. It is self limiting

108. Regarding the subcutaneous nodules of rheumatic fever:
   a. They are tender
   b. The overlying skin can be moved easily over the nodules
   c. They are characteristically seen in association with chorea
   d. They are usually symmetric
   e. Nodules are present for approximately six weeks

102. a. T; b. F; c. T; d. F; e. T
103. a. F; b. T; c. T; d. F; e. F
104. a. F; b. F; c. T; d. T; e. F
105. a. F; b. T; c. T; d. T; e. F
106. a. T; b. T; c. T; d. F; e. T
107. a. F; b. T; c. T; d. T; e. T
108. a. F; b. T; c. F; d. F; e. F

109. Regarding acute rheumatic fever:
   a. In young children, is preceded by sore throat in more than 70 percent of patients
   b. Streptococcal skin infection is a recognized cause
   c. Adequate treatment of streptococcal pharyngitis markedly reduces the incidence
   d. Antistreptococcal antibodies have a high sensitivity in diagnosis of antecedent streptococcal infection
   e. The incidence is on the rise in developing countries

110. Regarding the treatment of acute rheumatic fever:
   a. Corticosteroids are the first line treatment for arthritis
   b. Carditis is treated with high dose aspirin
   c. Oral penicillin in a dose of 500 mg two to three times daily for adults for 10 days is indicated to eradicate streptococcal infection
   d. Erythromycin is used for treatment in patients who are allergic to penicillin
   e. Treatment with aspirin is continued until the ESR returns to normal

111. Regarding the prevention of acute rheumatic fever:
   a. Family contacts should have throat swab culture
   b. The disease is notifiable
   c. Treatment of documented streptococcal pharyngitis has been shown to reduce the incidence
   d. Long term penicillin prophylaxis reduces the recurrence rate
   e. Early treatment of streptococcal skin sepsis has been shown to reduce the incidence

112. Regarding the recurrence of rheumatic fever:
   a. Recurrence is most common within first 2 years after the first episode
   b. Intramuscular benzathine penicillin is more efficacious at preventing a recurrence than oral penicillin
   c. Benzathine penicillin prophylaxis should be given every 4 weeks in patients with rheumatic carditis
   d. In a patient with documented carditis, penicillin prophylaxis is continued until the age of 21 years
   e. The streptococcal vaccine is used as an alternative to penicillin prophylaxis

113. Regarding chronic rheumatic heart disease:
   a. Less than 25% of patients with acute rheumatic fever will develop chronic valvular heart disease
   b. Rheumatic mitral valve stenosis is known to occur in patients under the age of 20 years
   c. Nearly all patients with mitral stenosis recall a history of rheumatic fever
   d. Aortic valve regurgitation is the commonest valvular lesion
   e. Tricuspid valve regurgitation is always secondary to pulmonary hyper-tension

114. Causes of sudden acute breathlessness in a patient with mitral stenosis include:
   a. The development of atrial fibrillation
   b. The development of a tachyarrhythmia
   c. Myocardial infarction
   d. Infective endocarditis
   e. Chest infection

115. In mitral stenosis:
   a. Left ventricular failure is a characteristic feature
   b. Atrial dilatation leads to atrial fibrillation
   c. The risk of embolic stroke is increased
   d. The pulse volume is high
   e. Hemoptysis is known of occur

109. a. F; b. F; c. T; d. T; e. F
110. a. F; b. F; c. T; d. T; e. F
111. a. T; b. F; c. T; d. T; e. F
112. a. T; b. F; c. F; d. F; e. F
113. a. F; b. T; c. F; d. F; e. F
114. a. T; b. T; c. F; d. T; e. T
115. a. F; b. T; c. T; d. F; e. T

116. In a patient with mital stenosis, the following features on echocardiography indicate that the valve is unsuitable for balloon mitral valvuloplasty:
    a. Tight mitral stenosis
    b. Calcification of the valve
    c. An audible opening snap
    d. Atrial fibrillation
    e. Fibrosis of the subvalvular apparatus

117. Patient with tight mitral stenosis:
    a. The development of atrial fibrillation will result in worsening of symptoms
    b. An pulmonary regurgitant murmur may be heard
    c. The presystolic accentuation of the mid-diastolic murmur is not heard if atrial fibrillation is present
    d. The presence of a displaced cardiac apex is suggestive of tight mitral stenosis
    e. A thrusting apex beat is felt

118. Regarding the electrocardiographic findings in mitral stenosis:
    a. The presence of a tall p wave in Lead II and an upright p wave in V1 indicates the presence of left ventricular dilatation
    b. The presence of p-mitrale indicates the development of pulmonary hypertension
    c. Left ventricular hypertrophy is present
    d. Left axis deviation is seen
    e. Right bundle branch block is seen

119. Regarding the chest radiography appearance in mitral stenosis:
    a. Cardiomegaly is a characteristic feature
    b. A straight left heart border is seen
    c. Dilatation of the upper lobe pulmonary veins is a feature
    d. In a lateral radiography, the esophagus may be compressed
    e. Oligemic lung fields indicate significant pulmonary hypertension

120. Regarding the pharmacological treatment of mitral stenosis:
    a. Frusemide will reduce symptoms by reducing total blood volume
    b. Beta blockers are contraindicated
    c. Digoxin is indicated even in the absence of atrial fibrillation
    d. Vasodilators are contraindicated
    e. Warfarin is indicated in atrial fibrillation

121. In a patient with chronic rheumatic heart disease, the following are indication for mitral valve replacement:
    a. Tight mitral stenosis in pregnancy
    b. Severe pulmonary hypertension
    c. Associated mitral regurgitation
    d. Severly calcified valves
    e. Disorted valves with a valve area below 1 cm^2

122. In a patient with mixed mitral valve disease, the following clinical features suggest significant mitral valve regurgitation:
    a. A thrusting apex beat
    b. A displaced apex
    c. Poor volume pulse
    d. A pan systolic murmur
    e. Atrial fibrillation

116. a. F; b. T; c. F; d. F; e. T
117. a. T; b. T; c. F; d. F; e. F
118. a. F; b. F; c. F; d. F; e. F
119. a. F; b. T; c. T; d. T; e. T
120. a. F; b. F; c. F; d. F; e. T
121. a. F; b. F; c. T; d. T; e. F
122. a. T; b. T; c. F; d. T; e. F

123. Regarding mitral regurgitation:
   a. In western populations, rheumatic fever is the commonest cause of mitral regurgitation
   b. Mitral valve prolapse is a cause
   c. It is a high risk lesion for infective endocarditis
   d. It occurs inhypertropic obstructive cardiomyopathy
   e. Functional mitral regurgitation occurs in dilated cardiomyopathy

124. The following are indications for valve replacement in a patient with mitral regurgitation:
   a. Acute mitral regurgitation after myocardial infarction
   b. Symptomatic patients with severe chronic regurgitation
   c. Left ventricular ejection fraction <60%
   d. Left ventricular systolic dimension >45 mm
   e. Severe left ventricular dysfunction

125. The following clinical features are seen in aortic regurgitation:
   a. A collapsing pulse
   b. Duroziezs sign
   c. An ejection systolic murmur radiating to the neck
   d. A mid-diastolic murmur in the mitral area
   e. A displaced apex beat

126. Regarding aortic valve disease:
   a. Acute aortic regurgitation may occur in infective endocarditis due to valve cusp rupture
   b. Severe regurgitation with a left ventricular ejection fraction < 55% in an asymptomatic patient is an indication for valve replacement
   c. Symptomatic patients with aortic stenosis can be managed medically if their left ventricular function is preserved
   d. Patient s with aortic stenosis can be treated with vasodilators
   e. Patient s with aortic stenosis over the age of 40 years should have a coronary angiogram prior to valve surgery

Arrhythmias

127. A 24-year-old man is referred after and army medical for investigation of multiple unifocal ventricular ectopics:
   a. He is likely to have serious organic heart disease
   b. He should be advised to stop smoking
   c. An echocardiogram is indicated
   d. A history of excessive coffee drinking should be looked for
   e. He should be started on antiarrhythmics

128. A 45-year-old man admitted with an acute myocardial infarction develops multiple ectopics. His blood pressure is stable:
   a. He should be treated with intravenous amiodarone
   b. Hypomagnesemia is a possible cause
   c. Hypokalemia should be looked for
   d. It is a sign of ongoing myocardial ischemia
   e. If an R on T phenomenon is present he is at risk of developing ventricular fibrillation

123. a. F; b. T; c. T; d. T; e. T
124. a. T; b. T; c. T; d. T; e. F
125. a. T; b. T; c. F; d. T; e. T
126. a. T; b. T; c. F; d. F; e. T
127. a. F; b. T; c. T; d. T; e. F
128. a. F; b. T; c. T; d. T; e. T

129. The following are indications to refer patients to a cardiologist for evaluation of an arrhythmia:
    a. AF with a rate that is difficult to control or recurrences that are refractory to standard therapies
    b. Nonsustained VT, particularly in a patient with suspected or proven structural heart disease
    c. Symptomatic sinus bradycardia
    d. Second AV block
    e. Asymptomatic first degree heart block

130. A patient with an acute inferior myocardial infarction develops complete heart block:
    a. Urgent temporary cardiac pacing is immediately indicated
    b. It is unlikely to recover spontaneously
    c. It is a sign of extensive infarction
    d. Isoprenaline infusion is indicated
    e. Atropine may revert his rhythm to normal

131. The following changes can occur in hyperkalemia:
    a. Shortening of the PR interval
    b. Tall peaked T waves
    c. Widening of the QRS complex
    d. Asystole
    e. Bradycardia

132. The following cardiac rhythm changes may be normally present in athletes:
    a. Sinus bradycardia
    b. Sinus arrest of less than three second's duration
    c. Wandering atrial pacemaker
    d. Nodal bradycardia
    e. Atrial flutter

133. The following can cause dangerous arrhythmias:
    a. Digoxin overdose
    b. Snake bite
    c. Myocarditis
    d. Yellow oleander poisoning
    e. Organophosphate poisoning

134. The following are true:
    a. A narrow complex tachycardia with a heart rate of 150 beats per minutes suggests the possibility of atrial flutter with 2:1 block
    b. Ventricular tachycardia is almost always pathological
    c. A narrow complex tachycardia cannot be ventricular tachycardia
    d. A broad complex tachycardia can occur in supraventricular tachycardia with bundle branch block
    e. The rhythm in ventricular tachycardia is regular

135. In pregnancy:
    a. The presence of multiple ectopic beats warrants treatment
    b. Supraventricular tachycardias often indicate underlying structural heart disease
    c. The presence of atrial fibrillation raises the possibility of underlying mitral disease
    d. Atrial flutter is common
    e. Second degree heart block is a common finding

129. a. T; b. T; c. T; d. T; e. F
130. a. F; b. F; c. F; d. F; e. T
131. a. F; b. T; c. T; d. T; e. T
132. a. T; b. T; c. T; d. F; e. F
133. a. T; b. T; c. T; d. T; e. T
134. a. T; b. T; c. F; d. T; e. T
135. a. F; b. F; c. T; d. F; e. F

136. The following are indications for permanent cardiac pacing:
   a. Sinus bradycardia with a rate of 45 beats per minute
   b. Second degree heart block
   c. Complete heart block
   d. Symptomatic tachy-brady syndrome
   e. Hypertrophic obstructive cardiomyopathy

137. A long corrected QT interval in the ECG:
   a. Is recognized consequence of hypokalemia
   b. May be due to amiodarone
   c. Can be congenital
   d. Is a recognized consequence of rheumatic carditis

138. The following conditions may be suggested by characteristic features on the ECG:
   a. Hypercalcemia
   b. Hyponatremia
   c. Mitral valve prolapsed
   d. Hypothermia
   e. Hypomagnesemia

139. The following are true of Wolff-Parkinson-White syndrome:
   a. Patients present with episodic SVT
   b. Ventricular tachycardia does not occur
   c. Digoxin is the treatment of choice
   d. The ECG taken at the time of the SVT shows characteristic changes
   e. Atrial fibrillation with wide QRS complexes can occur

140. The following are true of atrial fibrillation:
   a. Digoxin is of use in the prevention of paroxysmal atrial fibrillation
   b. Mitral stenosis is a cause
   c. Hypertrophic obstructive cardiomyopathy is a cause
   d. Digoxin will convert the atrial fibrillation to sinus rhythm
   e. It results in increased risk of stroke

141. Adenosine is used in:
   a. Atrial flutter with 2:1 artioventricular block
   b. Atrial fibrillation
   c. Atrioventricular nodal re-entry tachycardia
   d. Multiple ectopics
   e. Ventricular tachycardia

142. Supraventricular tachycardia with aberrant conduction is the likely diagnosis in broad complex tachycardia when:
   a. The blood pressure is normal
   b. T waves are inveted
   c. The QRS complexes are very wide
   d. The rhythm is irregularly irregular
   e. P waves are seen following each QRS complex

143. Multifocal atrial tachycardia:
   a. Is usually associated with chronic respiratory disease
   b. Is irregularly irregular
   c. Is abolished by digoxin
   d. The morphology of the p wave is variable
   e. May be caused by digoxin

136. a. F; b. T; c. T; d. T; e. T
137. a. F; b. F; c. T; d. T; e. T
138. a. F; b. F; c. T; d. T; e. F
139. a. T; b. F; c. F; d. F; e. T
140. a. F; b. T; c. T; d. F; e. T
141. a. T; b. F; c. T; d. F; e. F
142. a. F; b. F; c. F; d. T; e. F
143. a. T; b. T; c. F; d. T; e. T

144. In the sick sinus syndrome:
   a. Patients are typically under 65 years
   b. Complete heart block is a common feature
   c. Systemic embolism may occur
   d. Failure to increase heart rate with exercise is a feature
   e. Symptomatic patients should have a permanent pacemaker implanted

145. Typical features of complete heart block include:
   a. Regular heart rate
   b. Irregular cannon 'a' waves
   c. Paradoxical splitting of the second heart sound
   d. A loud first heart sound
   e. A mid-diastolic murmur over the apex

146. The first sound is likely to be variable in:
   a. Atrial fibrillation
   b. Atrial flutter
   c. Multiple ectopic beats
   d. Complete atrioventricular block
   e. Left bundle branch block

147. The following can cause bradycardia:
   a. Hypothermia
   b. Hypothyroidism
   c. Severe anaemia
   d. Subdural hematoma
   e. Shock

148. The following are true regarding the treatment of ventricular tachycardia (VT):
   a. DC cardioversion is indicated in hemodynamically unstable VT
   b. Amiodrone is effective
   c. Intravenous magnesium is used in polymorphic VT
   d. Verapamil is effective
   e. Unsynchronized DC cardioversion can result in ventricular fibrillation

149. A broad complex tachycardia is more likely to be supraventricular tachycardia with aberration than ventricular tachycardia if:
   a. Cannon waves are seen in the neck waves
   b. Fusion beats are seen on the ECG
   c. The tachycardia is abolished by carotid massage
   d. The previous ECG is normal
   e. There is a concordant pattern across the precardial leads

150. Causes of atrial fibrillation include:
   a. Constrictive pericarditis
   b. ASD
   c. Anxiety
   d. Recent MI
   e. Complete heart block

151. A 35-year-old woman presented with a history of intermittent lightheadedness. The following are possible causes:
   a. Atrial premature beats
   b. Sinus pauses
   c. Supraventricular tachycardia
   d. Transient Mobitz type 1 atrioventricular block
   e. Ventricular premature beats

144. a. T; b. F; c. T; d. T; e. T
145. a. T; b. T; c. F; d. F; e. F
146. a. T; b. F; c. T; d. T; e. F
147. a. T; b. T; c. F; d. T; e. F
148. a. T; b. T; c. T; d. F; e. T
149. a. F; b. F; c. T; d. F; e. F
150. a. T; b. T; c. T; d. T; e. F
151. a. T; b. T; c. T; d. T; e. T

Cardiac Arrest

152. The following are true regarding a cardiac arrest occurring out of hospital:
   a. A more than 50% will survive
   b. Patients with asystolic arrest are more likely to survive than those with ventricular fibrillation
   c. Youger patients are more likely to survive
   d. A patient with a witnessed cardiac arrest is more likely to survive
   e. Treatment with atropine for a bradyarrhythmia after resuscitation

153. Regarding sudden cardiac death:
   a. It is defined as death occurring within 10 minutes of the terminal clinical event
   b. 50% of all cardiac death are due to cardiac arrest
   c. The risk of sudden cardiac death is higher during the first 6 months of life compared to children over the age of 1 year
   d. It is commoner in men than in women
   e. Up to 30% of sudden cardiac deaths are due to non cardiac causes

154. The following are causes of sudden cardiac death:
   a. Acute coronary syndrome
   b. Viral myocarditis
   c. Wolff Parkinson White syndrome
   d. Treatment with erythromycin and astemizole in combination
   e. Hyperkalemia

155. True or false regarding drugs used in cardiopulmonary resuscitation:
   a. The initial dose of adrenaline is 1 mg (10 mL of 1:10000 solution) given intravenously
   b. Sodium bicarbonate should be given during the first cycle of resuscitation
   c. Intravenous magnesium is routinely used
   d. The dose of atropine used in non ventricular fibrillation/ventricular tachycardia arrest is 3 mg intravenously
   e. Tracheal administration of drugs needs 2 to 3 times the doses used

156. The following are true:
   a. Atrial fibrillation causes cardiac arrest in adults
   b. Defibrillation is the treatment for pulseless ventricular tachycardia
   c. 1 mg of adrenaline intravenously is given for ventricular fibrillation
   d. Calcium gluconate is the drug of choice for treatment of non VF/VT cardiac arrest
   e. Thromboembolism is a known cause of non VF/VT arrest

157. Regarding basic life support:
   a. Responsiveness of the victim is assessed by applying a painful stimulus
   b. Jaw thrust is the best airway maneuver in suspected cervical spine injury
   c. If there is no breathing, 2 effective breaths should be given
   d. Check of circulation in an adult is by palpating for the presence of a brachial pulse
   e. Location for chest compressions is the upper half of the sternum

152. a. F; b. F; c. T; d. T; e. F
153. a. F; b. T; c. T; d. T; e. T
154. a. T; b. T; c. T; d. T; e. T
155. a. T; b. F; c. F; d. T; e. T
156. a. F; b. T; c. T; d. F; e. T
157. a. F; b. T; c. T; d. F; e. F

158. A 56-year-old patient develops sudden chest pain and faintishness. His blood pressure is 90/50 mm Hg, and peripheries are cold. ECG shows a ventricular tachycardia:
   a. He should be positioned in the head down position
   b. The most likely diagnosis is an acute myocardial infarction
   c. He should be given cardiac massage
   d. Intravenous lignocaine is indicated
   e. Intravenous adrenaline 1 mg is indicated

159. A 55-year-old woman with ischemic heart disease and left ventricular failure develops ventricular fibrillation while in hospital. The following are true:
   a. Her chances of survival are approximately 25%
   b. She should be given cardiac massage
   c. Intravenous amiodarone is the first line drug
   d. Intravenous adrenaline is indicated
   e. Defibrillation is the treatment of choice

160. Noncardiac causes of sudden death include:
   a. Nontraumatic bleeding
   b. Poisoning
   c. Drowning
   d. Stroke
   e. Pulmonary embolism

161. An elderly man walking to the hospital clinic suddenly collapses about 50 meters away from the intensive care unit. On the examination he is unresponsive, but is breathing:
   a. You should call for help before attempting to resuscitate the patient
   b. If many bystanders are present, the patient should be quickly carried to intensive care unit
   c. His radial artery should be palpated to feel the pulse
   d. He should be positioned in the supine position if his circulation is intact
   e. Cardiac massage should be commenced if his pulse cannot be felt

162. The following clinical features are seen in patient with cardiac arrest:
   a. Absent pulses
   b. Cyanosis
   c. Tachypnea
   d. Warm extremities
   e. Flushing of the face

163. Regarding cardiac arrest:
   a. Ventricular fibrillation has a better prognosis than a systole
   b. Early defibrillation is the single most important therapeutic determinant of survival
   c. Atrial fibrillation is a cause
   d. Complete heart block is a known predisposing cause
   e. Respiration is always absent

164. The following maneuvers are used in cardiopulmonary resuscitation:
   a. Calling for help before attempting to resuscitate the patient
   b. Unplugging the electrical device in the case of electrocution
   c. Head tilt chin lift maneuver in a patient injured in road traffic accident
   d. The presence of spontaneous breathing is assessed by feeling for the flow of air from the nostrils
   e. Mouth to mouth respiration should be started prior to assessment of breathing and circulation if the patient is unconscious

158. a. T; b. T; c. F; d. F; e. F
159. a. T; b. T; c. F; d. T; e. T
160. a. T; b. T; c. T; d. T; e. T
161. a. T; b. F; c. F; d. F; e. T
162. a. T; b. T; c. F; d. F; e. F
163. a. T; b. T; c. F; d. T; e. F
164. a. T; b. F; c. F; d. T; e. F

165. The following are effective in the treatment of supraventricular tachycardia:
   a. Digoxin
   b. Propranolol
   c. Adenosine
   d. Isoprenaline
   e. Verapamil

166. In cardiogenic shock:
   a. Dopamine is the drug of first choice
   b. Dobutamine will help augment cardiac output
   c. Noradrenaline will increase the workload on the heart
   d. Vasopressin is used
   e. Intravenous nitrates are used

167. The following are used to assess whether the patient is breathing or not:
   a. Looking for the chest rising and falling
   b. Listening for air escaping during exhalation
   c. Holding a mirror in front of the patients nose
   d. Feeling for the flow of air
   e. Pinching the patient to see if he takes a deep breath

168. When cardiopulmonary resuscitation is undertaken:
   a. Initial rescue breathing should be provided to the unresponsive, nonbreathing victim before looking for circulation
   b. Chest compressions should be started only if the person is sure that there is no pulse, because chest compressions are dangerous if the heart is beating
   c. Chest compression and ventilations should be given in a ratio of 5 compressions to 1 ventilation
   d. In giving chest compressions, the heel of the hand is placed over the xiphisternum
   e. If the rescuer is unwilling to perform mouth to mouth breathing, it is purposeless to continue with chest compressions

169. The following are complications of cardiac massage:
   a. Rib fractures
   b. Fracture of the sternum
   c. Pneumothorax
   d. Hemothorax
   e. Cardiac rupture

170. A 46-year-old woman is admitted with a polymorphic ventricular tachycardia. After reversion to sinus rhythm it is noted that she has an abnormally long QT interval:
   a. The condition could be congenital
   b. The use of the combination of erythromycin and astemizole is a likely cause
   c. Hypocalcemia is a known cause
   d. Beta blockers are recommended in treatment
   e. Intravenous magnesium is the drug of choice in the presence of ventricular tachycardia in this patient

171. In the treatment of cardiac arrest, if the electrocardiogram shows ventricular fibrillation:
   a. Three DC shocks using energies of 200, 200 to 300, and 360 Joule should be given in sequence
   b. If there is no response the sequence of three shocks should be repeated immediately
   c. Bicarbonate should be given immediately to reduce acidosis
   d. Intubation is indicated if there is no response to initial therapy
   e. Intravenous adrenaline is indicated

165. a. T; b. T; c. T; d. F; e. T
166. a. F; b. T; c. T; d. F; e. F
167. a. T; b. T; c. F; d. T; e. F
168. a. T; b. F; c. F; d. F; e. F
169. a. T; b. T; c. T; d. T; e. F
170. a. T; b. T; c. T; d. F; e. T
171. a. T; b. F; c. F; d. T; e. F

172. A 50-year-old patient with ischemic heart disease develops ventricular tachycardia. Her blood pressure is 130/80 mm Hg. The following are true:
    a. Antiarrhythmic therapy is not indicated as she is hemodynamically stable
    b. Synchronized DC cardioversion at 100 Joule is the recommended management
    c. Intravenous lignocaine 50-100 mg is effective
    d. Amiodarone is the drug of first choice
    e. Verapamil is effective

173. In the management of a patient with anaphylaxis:
    a. Intravenous fluids must be given
    b. H_2 receptor antagonists are effective as adjunctive therapy
    c. Adrenaline should be given subcutaneously
    d. Atropine is indicated
    e. Hydrocortisone will act with 10 minutes

174. In a patient with cardiac arrest, if the electrocardiogram shows asystole:
    a. Three DC shocks using energies of 200, 200 to 300, and 360 joules should be given in sequence
    b. CPR should be continued
    c. Ventricular fibrillation may develop
    d. Adrenaline 1 mg intravenously every three to five minutes should be administered
    e. Vasopressin is more effective than adrenaline

175. A 50-year-old male develops cardiac arrest. He is not breathing, and pulses are not palpable. His electrocardiogram shows a regular rhythm with a rate of 60 beats per minute:
    a. Pulseless electrical activity is the likely diagnosis
    b. Pulmonary embolism is a cause
    c. Sodium bicarbonate is indicated in the presence of hyperkalemia
    d. If the complexes are wide, the prognosis is poor
    e. Has a better prognosis than asystole

176. On discovering an unconscious patient outside hospital:
    a. Rapid assessment of the airway and breathing must be performed initially
    b. Cross infection with *Neisseria meningitides* may occur during CPR
    c. Two effective rescue breaths should be given once apnoea is confirmed
    d. On confirming an arrest, one minute of CPR should be performed before leaving the patient and getting help
    e. On confirming an arrest, a ratio of 15 compressions to 2 ventrilations should be adopted al all times

Cardiomyopathies

177. Regarding dilated cardiomyopathy:
    a. Hypertension is a recognized cause
    b. The majority of cases are idiopath
    c. 25% of idiopathic dilated cardiomyopathies are familial
    d. It has a better prognosis compared to ischemic cardiomyopathy
    e. Persistent viral infection has been implicated as a possible cause

172. a. F; b. F; c. T; d. T; e. F
173. a. T; b. T; c. F; d. F; e. F
174. a. F; b. T; c. T; d. T; e. F
175. a. T; b. T; c. T; d. T; e. F
176. a. T; b. F; c. T; d. F; e. T
177. a. T; b. T; c. T; d. F; e. T

178. The following are recognized causes of dilated cardiomyopathy:
   a. Hemochromatosis
   b. Friedrich's ataxia
   c. Cyclophosphamide therapy
   d. Wilson's disease
   e. Systemic sclerosis

179. The following are suggestive of idiopathic dilated cardiomyopathy rather than ischemic heart cardiomyopathy:
   a. Dilatation of all four chambers of the heart on echocardiography
   b. Occurrence in a young patient
   c. The absence of pulmonary hypertension
   d. Asymmetrical hypertrophy of the septum of the heart on echocardiography
   e. A normal ECG

180. Patients with dilated cardiomyopathy may present with:
   a. Stroke
   b. Hemoptysis
   c. Sudden cardiac death
   d. Syncope
   e. Superaventricular arrhythmia

181. Regarding investigation in dilated cardiomyopathy:
   a. The ECG shows T wave inversions in multiversions in multiple leads
   b. Atrial fibrillation may be seen on ECG
   c. Chest radiography shows a dilated heart with clear lung fields
   d. Coronary angiography is indicated in patients over the age of 40 years
   e. Echocardiogram shows dilatation of the left ventricle more than the right ventricle

182. In a pericardial effusion:
   a. On chest radiography the heart is globular
   b. The lung fields are plethoric
   c. Echocardiography is useful in diagnosis
   d. Bradycardia is a feature
   e. A low pulse volume is an indication for urgent aspiration

183. In dilated cardiomyopathy:
   a. Drug treatment is similar to that of heart failure
   b. Warfarin is indicated if the history of transient ischemic attacks is present
   c. Antiarrhythmias are indicated, if the patient has recurrent arrhythmias
   d. Weight reduction is helpful in management
   e. Cardiac transplantation is the main option of treatment for patients who do not respond to medical therapy

184. The following commonly cause myocarditis:
   a. Dengue fever
   b. Leptospirosis
   c. Malaria
   d. Radiation
   e. Trypanosome cruzi

185. In a patient with myocarditis due to dengue fever:
   a. The cardiac enzymes are usually normal
   b. Heart block may be seen
   c. The absence of T wave changes makes the diagnosis unlikely
   d. Ventricular arrhythmias may cause death
   e. Echocardiography shows regional wall motion abnormalities

178. a. T; b. T; c. T; d. F; e. T
179. a. T; b. F; c. T; d. F; e. T
180. a. T; b. F; c. T; d. T; e. T
181. a. T; b. T; c. F; d. T; e. F
182. a. T; b. F; c. T; d. F; e. T
183. a. T; b. T; c. T; d. T; e. T
184. a. T; b. T; c. T; d. T; e. T
185. a. F; b. T; c. T; d. T; e. F

186. Regarding atrial myxoma:
   a. The symptoms and signs can mimic infective endocarditis
   b. A mid diastolic murmur may be present
   c. The left atrium is a common site
   d. It is malignant
   e. Surgical removal is indicated

187. The following clinical features suggest a diagnosis of hypertrophic obstructive cardiomyopathy:
   a. Double apical pulsation
   b. A mitral regurgitation murmur
   c. Collapsing pulse
   d. An ejection systolic murmur made louder by sequatting
   e. A fourth heart sound

188. The following are seen in hypertrophic obstructive cardiomyopathy:
   a. Asymmetrical septal hypertrophy on echocardiography
   b. Left ventricular hypertrophy
   c. ST segment elevation in the lateral leads on ECG
   d. Anterior movement of the mitral valve during systole on echocardiography
   e. Cardiomegaly on chest radiograph

189. The following are causes of restrictive cardiomyopathy:
   a. LoeffLers endocardities
   b. Amyloidosis
   c. Tuberculosis
   d. Diabetes mellitus
   e. Sarcoidosis

190. In restrictive cardiomyopathy:
   a. There is a cardiomegaly on chest radiography
   b. The drug fields are clear
   c. Low voltage complexes are seen on the ECG
   d. Endomyocardial biopsy is useful in diagnosing the cause
   e. There is no specific treatment

191. A 35-year-old man presents with recurrent syncope. On one episode he is documented to have ventricular tachycardia. His ECG shows T wave inversions in V1 to V3. Echocardiography shows right ventricular dilation. A diagnosis of arrythmogenic right ventricular dysplasia is made:
   a. Choronic lung disease is a likely cause
   b. Right heart failure may develop
   c. It may present with sudden death
   d. MRI demonstrates fatty infiltration of the right ventricle
   e. It is treated with beta blockers

192. Peripartum cardiomyopathy:
   a. May develop after delivery
   b. Is commoner in women under 30 days of age
   c. It is due to a viral infection
   d. It is commoner in multiparous women
   e. It has a mortality of up to 50%

186. a. T; b. T; c. T; d. F; e. T
187. a. T; b. T; c. F; d. F; e. T
188. a. T; b. T; c. T; d. T; e. F
189. a. T; b. T; c. F; d. F; e. T
190. a. T; b. F; c. F; d. T; e. F
191. a. F; b. T; c. T; d. T; e. F
192. a. T; b. F; c. F; d. T; e. T

193. Regarding constrictive pericarditis:
   a. Tuberculosis is the most important cause in the developing world
   b. Pericardial calcification may be seen on a lateral chest radiograph
   c. Hypothyroidism is a known cause
   d. It is a cause of atrial fibrillation
   e. The treatment is pericardiotomy

194. True or false:
   a. In diabetes mellitus, heart failure is always secondary to coronary artery disease
   b. Carcinoid syndrome causesa dilated cardiomyopathy
   c. Myocarditis is caused by coxsackle virus infection
   d. Viral myocarditis may result in irreversible dilated cardiomyopathy
   e. Persistent tachycardia can result in cardiomyopathy

195. The following are recognized causes reversible dilated cardiomyopathy:
   a. Alcohol
   b. Selenium deficiency
   c. Acromegaly
   d. Lead poisoning
   e. Coxsackievirus

196. Specific heart muscle disease may result from:
   a. Vitamin B_1 deficiency
   b. Cholera
   c. Cushing's syndrome
   d. Carcinoid syndrome
   e. Scleroderma

197. Hypertrophic cardiomyopathy:
   a. Is familial
   b. Is associated with friedrich's ataxia
   c. May be usefully treated with nitrates
   d. Treated with beta blockers has a lower risk of sudden death
   e. Is best screened for by a 12 lead electrocardiogram

198. The following are causes of specific heart muscle disease:
   a. Amyloidosis
   b. Sarcoidosis
   c. Emphysema
   d. Hemosiderosis
   e. Pregnancy

199. Which of the following infections cause myocarditis?
   a. Coxsackievirus
   b. Diphtheria
   c. Chagas disease
   d. Syphilis
   e. Toxoplasmosis

200. A 21-year-old man with hypertrophic cardiomyopathy presents in clinic with dizzy spells but has not had any syncopal episodes. Which of the following, if present, would indicate an increased risk of sudden cardiac death?
   a. Asymmetric septal hypertrophy
   b. Blood pressure drop of 20 mm Hg during peak exercise tolerance testing
   c. A family history of sudden death
   d. Systolic anterior movement of the mitral valve on echocardiography
   e. Worsening exertional angina

193. a. T; b. T; c. F; d. T; e. T
194. a. F; b. F; c. T; d. T; e. T
195. a. T; b. T; c. T; d. F; e. T
196. a. T; b. F; c. F; d. T; e. T
197. a. T; b. T; c. F; d. T; e. F
198. a. T; b. T; c. F; d. T; e. T
199. a. T; b. T; c. T; d. T; e. T
200. a. F; b. T; c. T; d. F; e. F

201. A 28-year-old man who is known to have hypertrophic cardiomyopathy has an out of hospital cardiac arrest and is successfully resuscitated. The following are possible treatment options:
   a. Alcohol septal ablation
   b. Amiodarone
   c. Beta blocker
   d. Implantable defibrillator
   e. Myomectomy

Cerebrovascular Disease

202. Stroke:
   a. It is defined as a focal neurological deficit of vascular origin
   b. It is the third most important cause of death in the developed world
   c. It is more common in the elderly
   d. Rheumatic heart disease is an important causative factor
   e. It is more common in women

203. Regarding the cause of stroke:
   a. In hypertensive patients. Cerebral hemorrhage is more common than infarction
   b. Subarachnoid hemorrhage is more common in patients with hypertension
   c. A tumor of the brain can mimic a stroke
   d. Isolated, or lone atrial fibrillation increases the risk of stroke
   e. Dissection of the carotid artery is a recognized cause

204. The following are important risk factors for stroke:
   a. Hypertension
   b. Smoking
   c. Moderate alcohol consumption
   d. Polycythemia vera
   e. Elevated homocysteine levels in the blood

205. Regarding transient ischemic attacks:
   a. They are usually due to cerebral embolism
   b. The usually last about 7–8 hours
   c. Postural hypotension is a recognized cause
   d. Transient loss of vision in one eye can occur
   e. Focal epilepsy can mimic a transient ischemic attack

206. Regarding transient ischemic attacks:
   a. There is an increased risk in valvular heart disease
   b. Antiphospholipid syndrome is a cause
   c. 50% of people with a TIA will develop a stroke within a year
   d. It is never caused by hemorrhage
   e. Long term aspirin reduces the risk of stroke after a TIA

207. The following should be looked for in a patient with a TIA:
   a. A carotid artery bruit
   b. Heart murmur
   c. Bradycardia
   d. Vasculitic rash
   e. Diabetes mellitus

208. The following are recognized manifestations of a TIA:
   a. Migraine
   b. Aphasia
   c. Vertigo
   d. Transient global amnesia
   e. Loss of consciousness

201. a. T; b. T; c. T; d. T; e. T
202. a. T; b. T; c. T; d. T; e. F
203. a. F; b. T; c. T; d. F; e. T
204. a. T; b. T; c. F; d. T; e. T
205. a. T; b. F; c. T; d. T; e. T
206. a. T; b. T; c. F; d. F; e. T
207. a. T; b. T; c. T; d. T; e. T
208. a. F; b. T; c. T; d. T; e. T

209. Regarding ischemic stroke:
   a. The most common site is the parietal cortex
   b. A very dense stroke in a patient who is fully conscious and alert is likely to be in the internal capsule
   c. Headache is common
   d. The reflexes are brisk soon after the occurrence of the stoke
   e. Epilepsy is a common presentation

210. Regarding infarction of the brain stem:
   a. The lateral medullary syndrome occurs due to thrombosis of the posterior inferior cerebellar artery
   b. A painful third nerve palsy with a pupil which does not react to light suggests a midbrain infarct
   c. Coma can occur in a brain stem stroke
   d. Weakness of the upper and lower limb on the right side, with facial weakness on the left side occurs in a medullary stroke
   e. Weakness of the right facial nerve and right lateral rectus palsy indicates a pontine infarct

211. The following can occur due to stroke:
   a. Dementia
   b. Hemianopic visual loss
   c. Parkinsonism
   d. Tremor
   e. Ataxia

212. The following clinical features are reliable in distinguishing an infarct from a hemorrhage:
   a. Headache
   b. Loss of consciousness
   c. A history of hypertension
   d. A CT scan brain
   e. EEG

213. A 60-year-old man is admitted with a dense right face arm leg weakness. He is fully alert. His blood pressure is 180/110 mm Hg:
   a. He should be given aspirin 300 mg stat
   b. He should be started on intravenous heparin
   c. His blood pressure should be urgently reduced to 140/90
   d. Nifedipine sublingually is the drug of choice for blood pressure reduction
   e. If he has been on antihypertensives, these should be continued

214. Regarding the management of acute stroke:
   a. Oxygen by mask should be given
   b. Hyperglycemia with a blood glucose under 250 mg/dL need not be treated
   c. Hypertension must be treated if the blood pressure is above 220/130 mm Hg
   d. Fever should be treated with antipyretics and tepid sponging
   e. Thrombolysis with tissue plasminogen activator is indicated in most large strokes

215. Regarding acute stroke:
   a. Swallowing is assessed by checking the gag reflex
   b. A CT scan brain is indicated only in patients with severe headache or drowsiness
   c. Cerebeller hemorrhage is an indication for urgent referral to the neurosurgeon
   d. In the presence of swallowing difficulty, the patient is kept on NG feeds for 3 months
   e. Referral to a multidisciplinary stroke unit improves outcome

209. a. F; b. T; c. F; d. F; e. F
210. a. T; b. T; c. T; d. F; e. T
211. a. T; b. T; c. T; d. F; e. T
212. a. F; b. F; c. F; d. T; e. F
213. a. F; b. F; c. F; d. F; e. T
214. a. T; b. F; c. T; d. T; e. F
215. a. F; b. F; c. T; d. F; e. T

216. Regarding the CT scan in stroke:
   a. A contrast CT scan brain is indicated immediately after the stroke
   b. A hemorrhage can be detected in a CT scan within 2 hours
   c. An infarct is detectable in a non-contrast CT scan within 6 hours
   d. The main place of a CT scan brain is to exclude a hemorrhage
   e. The CT scan is a sensitive investigation to detect infarcts in the posterior cranial fossa

217. Regarding the management of acute stroke:
   a. Aspirin is indicated in all ischemic strokes
   b. In the presence of atrial fibrillation, warfarin is indicated in a large middle cerebral artery territory stroke
   c. Low molecular weight heparin is indicated in ischemic stroke
   d. The goals of blood pressure control are lower in hemorrhagic stroke compared to ischemic stroke
   e. Clopidogrel is useful in the secondary prevention of ischemic stroke

218. The following investigations are routinely indicated in a 45-year-old patient with a stroke:
   a. MRI brain
   b. ECG
   c. Hemoglobin level
   d. Blood homocysteine level
   e. Lumbar puncture

219. In a patient with chronic atrial fibrillation who develops a stroke:
   a. There is a high risk of a second stroke
   b. Warfarin is indicated
   c. Aspirin, when combined with warfarin, has addictive protective effects
   d. Conversion of atrial fibrillation to sinus rhythm should be attempted
   e. Warfarin increases the risk of cerebral hemorrhage

220. Regarding the prognosis after a stroke:
   a. 25% of patients die within 2 years of a stroke
   b. The majority of deaths after stroke occur within the first month
   c. The majority of deaths occur due to recurrent stroke
   d. The majority of survivors of stroke return to independent mobility
   e. Patients with a hemorrhage stroke are twice as likely to die early compared to those with ischemic stroke

221. The following are poor prognostic features after stroke:
   a. Drowsiness
   b. Conjugate gaze palsy
   c. Swallowing difficulty
   d. Aphasia
   e. Hypertension soon after the stroke

222. Regarding hemorrhage stroke:
   a. It is responsible for around 10% of strokes
   b. It is caused by rupture of large arterial aneurysms most commonly
   c. The basal ganglia are a characteristic site
   d. Cerebral amyloid angiopathy is a cause
   e. Hypertension is the most important risk factor

216. a. F; b. T; c. F; d. T; e. F
217. a. T; b. F; c. F; d. F; e. T
218. a. F; b. T; c. T; d. T; e. F
219. a. T; b. T; c. F; d. F; e. T
220. a. T; b. T; c. F; d. F; e. T
221. a. T; b. T; c. T; d. T; e. F
222. a. T; b. F; c. T; d. T; e. T

223. The following symptoms/sign are correctly paired with the site of the stroke:
   a. Dysarthria → brain stem
   b. Right homonymous hemianopia → right occipital cortex
   c. Expressive dysphasia → temporal lobe
   d. Hemisensory loss → parietal cortex
   e. Transient global amnesia → frontal cortex

224. Regarding hemorrhagic stroke:
   a. Clot evacuations considered in large bleeds causing a midline shift
   b. Aspirin is contraindicated
   c. Cerebellar hemorrhage is an indication for urgent surgical evacuation of the clot
   d. The prognosis is poor
   e. Intracranial arteriovenous malformations should be looked for as a cause

225. Regarding subarachnoid hemorrhage:
   a. Is often associated with a history of trauma to the head
   b. It is usually due to rupture of a berry aneurysm in the circle of Willis
   c. It accounts for 5% of strokes
   d. It is commoner in patients with polycystic kidney disease
   e. Sudden severe occipital headache is a feature

226. Regarding the management of subarachnoid hemorrhage:
   a. The blood pressure must be controlled to less than 140 mm Hg systolic
   b. Nimodipine reduces secondary cerebral vasospasm and improves outcome
   c. Constipation must be avoided
   d. A four vessel angiogram must be done within 48–72 hours
   e. Surgical clipping of the aneurysm is indicated

Diabetes Mellitusia

227. Diabetes mellitus:
   a. Affects more than 120 million people worldwide
   b. The incidence is worldwide
   c. Is curable if detected in the early stages
   d. Reduces life expectancy even with optimal treatment
   e. The incidence in asia is lower than that in Europe

228. Regarding the pathogenesis of diabetes:
   a. Low birth weight is a risk factor for developing diabetes later in life
   b. Obesity increases the risk of developing diabetes
   c. Low intake of fruit and vegetables increases the chance of getting diabetes
   d. Physical activity protects against the development of diabetes
   e. Taking a lot of sugar containing food in predisposes to diabetes

229. Regarding the types of diabetes mellitus:
   a. Type I diabetes is due to insulin deficiency
   b. Type II diabetes is due to insulin resistance
   c. Chronic pancreatitis results in type I diabetes
   d. Gestational diabetes is a form of type II diabetes
   e. Type I diabetes does not occur in those over the age of 30 years

223. a. T; b. F; c. F; d. T; e. F
224. a. T; b. T; c. T; d. T; e. T
225. a. F; b. T; c. T; d. T; e. T
226. a. T; b. T; c. T; d. T; e. T
227. a. T; b. T; c. F; d. T; e. T
228. a. T; b. T; c. T; d. T; e. F
229. a. T; b. T; c. F; d. F; e. T

230. Regarding type I diabetes mellitus:
   a. It is often immune mediated
   b. It is commonest in asia
   c. The risk of developing type I diabetes is greater with a diabetes father than a diabetes mother
   d. It is associated with other autoimmune disorders
   e. Patient are usually obese

231. Regarding type II diabetes mellitus:
   a. It runs in families
   b. It is commoner among more affluent people
   c. Patient are usually obese
   d. It can occur in children
   e. C-peptide disappears

232. The following skin lesions are common in diabetcs:
   a. Cellulitis of the leg
   b. Non-healing ulcers of the foot
   c. Balanitis
   d. Vulvovaginitis
   e. Eczema

233. The following presentation should make one suspect the possibility equently up the patient having diabetes:
   a. Balanitis
   b. Unexplained weight loss
   c. Cellulitis of the leg
   d. Getting up frequently at night to pass urine
   e. Tinea infection in the skin

234. Regarding the diagnosis of diabetes:
   a. The normal fasting plasma glucose is <11 mg/dL (6.1 mmol/L)
   b. Diabetes is diagnosed when the FPG is above 126 mg/dL (7.0 mmol/L)
   c. Random blood glucose above 200 mg/dL (11.1 mmol/L) is diagnostics of diabetes
   d. The oral glucose tolerance test is performed in borderline patients
   e. Impaired glucose tolerance is a risk factor for cardiovascular complications

235. A 40-year-old man is found to be diabetic, he is obese, smokes 10 cigarettes a day and takes a lot of fatty foods in his diet. He is otherwise healthy:
   a. He should be stated on drug treatment right away
   b. Weight reduction will reduce his risk of getting a heart attack
   c. He should reduce the fats in his diet
   d. He should not eat fruits
   e. He should be referred to a dietician

236. The following measures are effective inducing the risk of complications in a diabetic patient:
   a. A high protein diet
   b. Low salt diet
   c. Regular meals
   d. Control of blood pressure
   e. Low dose aspirin

237. Patient with type I diabetes:
   a. Can be tried on oral hypoglycemics first
   b. Should be started on insulin to prevent ketosis
   c. Must be advised to stop insulin if he skips a meal
   d. Should be taught to monitor for ketoacidosis
   e. Should be advised to drink plenty of water

230. a. T; b. F; c. T; d. T; e. F
231. a. T; b. T; c. T; d. T; e. F
232. a. T; b. T; c. T; d. T; e. F
233. a. T; b. T; c. T; d. T; e. T
234. a. T; b. T; c. T; d. T; e. T
235. a. F; b. T; c. T; d. F; e. T
236. a. F; b. T; c. T; d. T; e. T
237. a. F; b. T; c. F; d. T; e. T

238. Regarding the use of insulin in type I diabetics:
   a. The dose should be skipped if the patient is skipping a meal
   b. Insulin should be stored in the freezer
   c. Patients who do not have a refrigerator could store it suspended inside a narrow mouth clay pot with a little water at the bottom
   d. Insulin can be combined with metformin
   e. Should be given to the same skin site every day

239. Regarding insulin injections:
   a. Soluble insulin should be administered together with the meals
   b. Insulin should be stored in the door of the refrigerator
   c. Long acting insulin should never be given intravenously
   d. The needle should be inserted at an angle of 45° to the skin
   e. The needle can be used only once

240. In the treatment of type II diabetes:
   a. Weight reduction alone will be adequate in a proportion of patients
   b. Insulin is the ideal treatment
   c. Metformin is recommended in thin patients
   d. Glibenclamide can cause weight gain
   e. Pioglitazone improves the action of insulin on the tissues

241. Biguanides have the following advantages over sulfonylureas:
   a. They cause loss of weight and are useful in obese patients
   b. They can be used safely in renal impairment
   c. Are less likely to cause hypoglycemia
   d. They have lipid lowering activity
   e. They are less likely to cause Lactic acidosis

242. Sulfonylureas have the following advantages over biguanides:
   a. They can be used safely in patients with cirrhosis
   b. Are less likely to cause hypoglycemia
   c. They are effective in patients with type I diabetes
   d. They cause weight loss
   e. They can be used in pregnancy

243. Regarding newer oral hypoglycemia drugs:
   a. The glitazones should be avoid in heart failure
   b. Acarbose enhances insulin action in the tissues
   c. Repaglinide increases insulin secretion
   d. Glitazones can be combined with sulfonylureas
   e. Glitazones reduce boold triglyceride levels

244. Regarding diabetic nephropathy:
   a. It manifests within 5 years of diagnosis
   b. Is commoner in young diabetics
   c. Microalbuminuria is the earliest manifestation
   d. It is unlikely in a patient with no diabetic retinopathy
   e. It results in renal failure

238. a. F; b. F; c. T; d. T; e. F
239. a. F; b. T; c. T; d. F; e. F
240. a. T; b. F; c. F; d. T; e. T
241. a. T; b. F; c. T; d. T; e. F
242. a. F; b. F; c. F; d. F; e. F
243. a. T; b. F; c. T; d. T; e. F
244. a. F; b. T; c. T; d. T; e. T

245. Regarding diabetic nephropathy:
   a. The kidneys are usually small in diabetic nephropathy
   b. ACE inhibitors prevent the progression of nephropathy
   c. Dietary measures are useful in prevention
   d. The bood pressure must be controlled to 140/90 mm Hg
   e. A rising plasma creatinine is the first sign of diabetic nephropathy

246. Regarding screening for complications in a diabetic patient:
   a. A patient with type I diabetes must be sent for retinopathy screening at the time of first diagnosis
   b. Urine for microalbuminuria is usful for detecting early nephropathy
   c. The serum lipids should be measured
   d. An exercise ECG is recommended in all patient above the age of 40 years
   e. Retinopathy screening should be performed annually in type II diabetes

247. The following are indications for urgent (within one week) referral to an ophthalmologist find with diabetes retinopathy:
   a. Pre-proliferative
   b. Reduced visual acuity suggestive of macular edema
   c. Hard exudates within one disc diameter of the fovea
   d. New vessel formation
   e. Rubeosis iridis

248. The following are useful in preventing diabetic retinopathy:
   a. Tight control of blood glucose
   b. Control of blood pressure to less then 130/80
   c. Low salt diet
   d. Vitamins
   e. Lipid lowering therapy

249. Tight glycemic control:
   a. Reduces the risk of developing diabetic nephropathy
   b. Reduces the risk of myocardial infection
   c. Reduces the risk of peripheral vascular disease
   d. Is beneficial in patient soon after acute myocardial infection
   e. Reduces the risk of importence

250. Regarding diabetic ketoacidosis:
   a. Is commoner in type II diabetics
   b. Urine ketones are always positive
   c. The patient is usually very dehydrated
   d. Urgent referral to a hospital is indicated
   e. The patient will require lifetime insulin in future

251. Diabetic neuropathies which have a good prognosis and may resolve completely include:
   a. Autonomic neuropathy
   b. Diabetic amyotrophy
   c. Mononeuritis involving cranial nerves
   d. Entrapment neuropathies
   e. Mixed sensory motor neuropathy

245. a. F; b. T; c. T; d. F; e. T
246. a. F; b. T; c. T; d. F; e. T
247. a. F; b. F; c. F; d. T; e. T
248. a. T; b. T; c. T; d. F; e. F
249. a. T; b. T; c. F; d. T; e. T
250. a. F; b. F; c. T; d. T; e. T
251. a. F; b. T; c. T; d. T; e. F

Miscellaneous Topics in CA

252. A 43-year-old dockyard worker sustains an open chest wound. Appropriate management at the site of the accident includes:
   a. Intubation and ventilation
   b. Insertion of a chest drain
   c. Packing the wound and taping it with water–resistant tape
   d. Immediate referral to hospital without disturbing the wound
   e. Telling the patient to cover the wound with his own hand

253. In an otherwise fit patient, development of postoperative atelectasis can cause:
   a. An increase in alveolar-arterial oxygen gradient:
   b. Hypercarbia
   c. Tachypnoea
   d. Fever
   e. Pleuritic pain

254. Midazolam:
   a. Inhibits the action of gamma-aminobutyric acid (GABA)
   b. Is water-soluble at physiological pH
   c. Acts synergistically with flumazenil
   d. Has an elimination half-life of 2 hours
   e. Is largely excreted unchanged in the urine

255. In the jugular venous pressure (JVP) wave form:
   a. Canon waves occur with atrial contraction on a closed tricuspid valve
   b. The υ wave is in time with ventricular systole
   c. The *x* descent follows the υ waves
   d. The α wave increases in size in atrial fibrillation
   e. Constrictive pericarditis will produce a steepy descent

256. Physiological changes in the morbidly obese patient include:
   a. Decrease in renal clearance
   b. Decrease in functional residual capacity (FRC)
   c. Increase in red cell volume
   d. Increase in volume of distribution
   e. Decrease in systemic vascular resistance (SVR)

257. The cervical sympathetic chain:
   a. Lies superficial to the prevertebral fascia
   b. Terminates near the internal carodtid artery
   c. Receives gray rami from the spinal cord
   d. May be affected by a brachial plexus block
   e. Includes the stellate ganglion close to the 5th cervical vertebra

258. Incidence of nosocomial (hospital-acquired) infection in the intensive care unit (ICU) can be reduced by:
   a. The presence of a hospital infection control team
   b. Regular handwashing
   c. Selective decontamination of the patient's digestive tract
   d. Omeprazole
   e. Use of H_2 antagonists

252. a. F; b. T; c. F; d. F; e. F
253. a. T; b. F; c. T; d. T; e. T
254. a. F; b. F; c. F; d. T; e. F
255. a. T; b. T; c. F; d. F; e. T
256. a. F; b. T; c. T; d. T; e. T
257. a. T; b. F; c. F; d. T; e. F
258. a. T; b. T; c. T; d. F; e. F

259. Regarding non-depolarizing neuromuscular blocking agents:
   a. Vecuronium has a similar duration of action as rocuronium
   b. Rocuronium has a shorter onset of action than vecuronium
   c. Cis-atracurium is associated with histamine release
   d. Doxacurium is longer acting than pancuronium
   e. Vecuronium has no active metabolites

260. Increased susceptibility to malignant hyperthermia (MH) occurs with:
   a. Ketamine
   b. Propofol
   c. Desflurane
   d. Lignocaine
   e. Prolonged masseter muscle spasm

261. The systemic inflammatory response syndrome (SIRS):
   a. Can be provoked by acute pancreatitis
   b. Can be initiated by Gram-positive septicemia
   c. Requires a pyrexia greater than 38°C for diagnosis
   d. Frequently progresses to multiple organ failure
   e. Can be effectively treated with antiendotoxin antibodies

262. The following have been successfully used in the treatment of asthma:
   a. Ipratropium bromide
   b. Ketamine
   c. Beclomethasone
   d. Halothane
   e. Metoprolol

263. Cigarette-smoking:
   a. Triggers release adrenaline from the adrenal medulla
   b. Delays gastric emptying
   c. Increases variability of fetal heart rate
   d. Requires abstinence for 24 hours prior to surgery to eliminate carbon monoxide
   e. Induces pharmacological dependence

264. In DIC:
   a. Prothrombin time is normal
   b. Fibrinolysis occurs
   c. Vitamin K is required if severe
   d. Cryoprecipitate is a source of fibrinogen
   e. Heparin may be of value

265. The normal ECG:
   a. Has a standard paper speed of 50 mm/s
   b. Has a mean frontal axis between 0° and + 110°
   c. Has a maximal QT interval of 0.42 s
   d. Has a QRS duration of 0.08-0.1s
   e. May have an inverted T wave in lead 1

266. Positive end-expiratory pressure (PEEP):
   a. Reduces mixed venous oxygen content
   b. Increases functional residual capacity (FRC)
   c. May reduce urine output
   d. Increase airway resistance
   e. May reduce cardiac output

259. a. T; b. T; c. F; d. T; e. F
260. a. F; b. F; c. T; d. F; e. T
261. a. T; b. T; c. F; d. T; e. F
262. a. T; b. T; c. T; d. T; e. F
263. a. T; b. F; c. F; d. T; e. T
264. a. F; b. T; c. F; d. T; e. T
265. a. F; b. F; c. T; d. T; e. F
266. a. F; b. T; c. T; d. F; e. T

267. Carbon dioxide elimination:
   a. Is exponential
   b. Is transported mainly by haem groups
   c. Is facilitated by carbonic anhydrase
   d. Is normally about 100 mL/min at rest
   e. Involves the Bohr effect

268. Unstable blood pressure during a carotid endarterectomy may be due to:
   a. Chemoreceptor damage
   b. Baroreceptor damage
   c. Blood loss
   d. Vagal stimulation
   e. Preoperative hypertension

269. Automated blood pressure monitors:
   a. Under-read at high pressure
   b. Over-read at low pressure
   c. Need a cuff width 20% greater than diameter of the arm
   d. Extrapolate diastolic pressure
   e. Tend to be inaccurate with atrial fibrillation (AF)

270. Isoprenaline:
   a. Is arrhythmogenic
   b. Causes peripheral vasodilatation
   c. Has an inotropic action
   d. Has a chronotropic action
   e. Can precipitate asthma

271. A low arterial oxygen saturation:
   a. Is characteristic of pulmonary edema
   b. Can be due to an alveolar diffusion problem
   c. Is a feature of polycythemia rubra vera
   d. Tends to cause dilatation of most arteries and arterioles
   e. Stimulates ventilation by an effect on peripheral chemoreceptors

272. The following can occur after a stellate ganglion block (SGB):
   a. Ipsilateral dilated pupil
   b. Difficulty in swallowing
   c. Supraglottic loss of sensation
   d. Pneumothorax
   e. Hoarse voice

273. Inhaled nitric oxide:
   a. Is a bronchodilator
   b. Can be limited by tachyphylaxis
   c. Is responsible for systemic vasodilatation
   d. Is synthesized from asparate
   e. Can cause methemaglobinemia

274. Phosphodiesterase inhibitors:
   a. Act by blocking the sodium/potassium pump
   b. Increase intracellular cAMP
   c. Cause peripheral vasoconstriction
   d. Represent a homogenous drug group
   e. Have a positive inotropic action

267. a. F; b. F; c. T; d. F; e. F
268. a. F; b. T; c. T; d. T; e. T
269. a. F; b. F; c. T; d. T; e. T
270. a. T; b. T; c. T; d. T; e. F
271. a. T; b. T; c. F; d. F; e. T
272. a. F; b. T; c. F; d. T; e. T
273. a. T; b. F; c. F; d. F; e. T
274. a. F; b. T; c. F; d. F; e. T

275. Prophylactic antibiotics are needed for the following procedures in a patient with a prosthetic heart valve:
   a. Insertion of intrauterine contraceptice device
   b. Cystoscopy
   c. Cataract extraction under LA
   d. Dental scaling
   e. Sigmoidoscopy

276. A normal plain posteroanterior (PA) chest radiograph of a male adult in full inspiration will show:
   a. Anterior ends of the sixth ribs
   b. Cardiac diameter less than 16 cm
   c. Hilar lymph nodes
   d. Right oblique fissure
   e. Right hemidiaphragm higher than the left

277. Delayed recovery from neuromuscular blockade after vecuronium may be due to:
   a. Hyperglycemia
   b. Hypocalcemia
   c. Hypokalemia
   d. Hypoglycemia
   e. Hypermagnesemia

278. Regarding the heart:
   a. Coronary blood flow is regulated by sympathetic innervation
   b. Infarction of the AV node may cause complete heart block
   c. Adenosine constricts coronary arterioles
   d. The ventricular myocardium responds to an increased workload by hyperplasia
   e. Stroke volume falls with vagal stimulation

279. Sudden onset of complete heart block is associated with:
   a. An increase in stroke volume
   b. Variable intensity of the first heart sound
   c. Variable loudness of the first heart sound
   d. Canon waves visible in the neck
   e. Syncope

280. The following drug combinations may be disadvantageous:
   a. Amiodarone and warfarin
   b. Trimethoprim and sulphamethoxazole
   c. Vecuronium and gentamicin
   d. Propranolol and glibenclamide
   e. Tranylcypromine and fentanyl

281. An intra-atoric balloon pump (IABP) may cause:
   a. An increase in heart rate
   b. An increase in left ventricular end-diastolic pressure
   c. An increase in myocardial oxygen demand
   d. An increase in diastolic blood pressure
   e. An improvement in coronary artery perfusion

282. Atrial flutter:
   a. Is commonly due to ischemic heart disease
   b. Gives a regular radial pulse
   c. Is identified on the electrocardiogram by 'f' waves
   d. Can be converted to atrial fibrillation by digoxin
   e. Cannot be effectively treated by direct curent (DC) cardioversion

275. a. T; b. T; c. F; d. T; e. T
276. a. T; b. T; c. F; d. F; e. T
277. a. F; b. T; c. T; d. F; e. T
278. a. F; b. T; c. F; d. F; e. T
279. a. T; b. T; c. T; d. T; e. T
280. a. T; b. F; c. T; d. T; e. F
281. a. F; b. F; c. F; d. T; e. T
282. a. T; b. T; c. T; d. T; e. F

283. Techniques for measuring cardiac output include:
   a. Measurement of oxygen consumption
   b. Radioactive technetium
   c. Echocardiography
   d. Indocyanine green
   e. Methylene blue

284. The following are normal values:
   a. Right atrial pressure - 8 cm H_2O
   b. Systemic vascular resistance (SVR) - 1200 dynes/cm^5
   c. Pulmonary vascular resistance - 80 dynes/cm^5
   d. Cardiac index - 2.01/min/m^2
   e. Mean pulmonary artery pressure (PAP) - 10 mm Hg

285. Following acute onset of cardiac tamponade:
   a. The pulse may slow
   b. Left and right atrial pressure will be raised
   c. Cyanosis and cool peripheries can occur
   d. Systolic and diastolic blood pressures will be low
   e. The pulse may disappear on inspiration

286. A pressure-cycled ventilator:
   a. Has a linear flow rate
   b. Provides a constant tidal volume
   c. Depends on lung compliance to determine end-inspiratory pressure
   d. Is not suitable for use in children
   e. Is a minute volume divider

287. The following can occur after massive transfusion of blood:
   a. Metabolic alkalosis
   b. Decrease in ionized calcium
   c. Decrease in serum potassium
   d. Increase in serum magnesium
   e. Prolonged TT

288. Transfusion of mismatched blood is associated with:
   a. Wheezing
   b. Polyuria
   c. A positive Coombs' test
   d. Fever
   e. Hemoglobinuria

289. A confused 60-year-old man has the following arterial blood gases (ABGs):

PaO_2	7.5 kPa
$PaCO_2$	7.5 kPa
Hb	16.9 g/dL

   These values are compatible with:
   a. Type 1 respiratory failure
   b. The presence of central cyanosis
   c. Pulmonary embolus
   d. Central depression of respiration
   e. Oxygen therapy

290. Cytokines:
   a. Are glycoproteins
   b. Include tumor necrosis factor (TNF)
   c. Are released from macrophages
   d. Have autocrine function
   e. Mediate development of systemic inflammatory response syndrome (SIRS)

283. a. T; b. T; c. T; d. T; e. F
284. a. T; b. T; c. T; d. F; e. T
285. a. F; b. T; c. T; d. F; e. T
286. a. F; b. F; c. F; d. F; e. F
287. a. T; b. T; c. T; d. F; e. F
288. a. T; b. F; c. T; d. T; e. T
289. a. F; b. T; c. F; d. T; e. T
290. a. T; b. T; c. T; d. T; e. T

291. The Goldman cardiac risk index gives a score for:
   a. Atrial fibrillation
   b. Hypertension
   c. Hypokalemia
   d. Previous cardiac surgery
   e. Recent myocardial infarction (MI)

292. The trachea in the adult:
   a. Is 1.5-2.0 cm wide
   b. Begins at the level of the 4th cervical vertebra
   c. Bifurcates at the 6th thoracic vertebra
   d. Is lined with transitional epithelium
   e. Receives most of its blood supply from the bronchial arteries

293. A low fixed cardiac output is a feature of:
   a. Constrictive pericarditis
   b. Cor pulmonale
   c. Aortic stenosis
   d. Cardiac tamponade
   e. Aortic regurgitation

294. Synchronized direct current (DC) cardioversion is indicared in:
   a. Pulseless ventricular tachycardia (VT)
   b. Atrial fibrillation
   c. Atrial flutter
   d. Ventricular fibrillation (VF)
   e. Supraventricular tachycardia

295. In an acute severe asthma attack:
   a. Pulsus paradoxus is a reliable indicator of severity
   b. A high $PaCO_2$ is an indication for immediate ventilation
   c. Sodium cromoglycate is of no immediate benefit
   d. Oxygen therapy should be at 28% until arterial blood gases are available
   e. Corticosteroid therapy should be given promptly

296. In tetralogy of Fallot:
   a. There is right axis deviation
   b. There is an overriding aorta
   c. Palliative surgery is all that is available
   d. Cyanotic spells are worsened by squatting
   e. Pulmonary plethora is present radiographically

297. Pulmonary artery occlusion pressure (PAOP) is a good indicator of left ventricular (LV) diastolic pressure:
   a. In aortic regurgitation
   b. After a pneumonectomy
   c. With constrictive pericarditis
   d. Following a myocardial infarction
   e. In pulmonary hypertension

298. Features of cor pulmonale include:
   a. Third heart sound
   b. Pleural effusion
   c. Barely palpable liver
   d. Hypertrophic pulmonary osteoarthropathy (HPOA)
   e. Pulmonary valve incompetence

291. a. T; b. F; c. F; d. F; e. T
292. a. T; b. F; c. F; d. F; e. F
293. a. T; b. F; c. T; d. T; e. F
294. a. F; b. T; c. T; d. F; e. T
295. a. T; b. T; c. T; d. F; e. T
296. a. T; b. T; c. F; d. F; e. F
297. a. F; b. F; c. T; d. T; e. T
298. a. T; b. T; c. F; d. F; e. T

299. Complications of central venous line insertion include:
   a. Cardiac tamponade
   b. Pneumothorax
   c. Horner's syndrome
   d. Phrenic nerve palsy
   e. Thrombosis

300. When investigating a patient with a hemorrhagic disease:
   a. An increased prothrombin time (PT) is found with hemophilia A
   b. An increased PT occurs with factor V deficiency
   c. A decreased PT indicates increased plasma fibrinogen
   d. An increased bleeding time indicates factor VIII deficiency
   e. A low platelet count occurs in von Willebrand's disease

301. The following indicate a poor prognosis after a myocardial infarction (MI):
   a. Age over 70 years
   b. Pulmonary edema
   c. Primary VF
   d. Complete heart block with an anterior myocardial infarction
   e. Pre-existing non-insulin dependent DM

302. As regards double lumen tubes:
   a. A right-sided tube is preferred to a left-sided tube
   b. A right-sided tube is easier to insert than a left-sided tube
   c. A Robertshaw tube has a cranial hook
   d. They cannot be used in children under 8 years of age
   e. Rupture of the bronchus is a well-recognized problem

303. Acute pulmonary contusion is closely associate with:
   a. Interstitial lung damage
   b. Crackles on auscultation within 6 hours of the accident
   c. Opacities on chest radiograph within 6 hours of blunt trauma to the chest
   d. Pulmonary laceration
   e. Progressive pulmonary fibrosis

304. Streptokinase therapy:
   a. Reduce mortality following myocardial infarction
   b. Is contraindicated in diabetic patients
   c. Can give rise to massive hemorrhage
   d. Is inhibited by concurrent aspirin therapy
   e. Can be effective up to 12 hours after a myocardial infarction.

305. The following can be used in the measurement of cardiac output by the Fick principle:
   a. Arterial oxygen content
   b. Venous oxygen content
   c. Oxygen consumption
   d. Respiratory quotient
   e. Arterial carbon dioxide content

306. Effects of H1 blcokers include:
   a. Excitation of the CNS
   b. Cholinergic effects
   c. Adrenergic effects
   d. An antiemetic action
   e. Hemolytic anemia

299. a. T; b. T; c. T; d. T; e. T
300. a. F; b. T; c. F; d. F; e. F
301. a. T; b. T; c. F; d. T; e. T
302. a. F; b. T; c. F; d. T; e. T
303. a. F; b. F; c. T; d. T; e. F
304. a. T; b. F; c. T; d. F; e. T
305. a. T; b. F; c. T; d. F; e. T
306. a. T; b. F; c. F; d. T; e. T

307. Consistently reliable methods to detect esophageal intubation include:
   a. Pulse oximetry
   b. Capnography
   c. Condensation seen in a clear tracheal tube
   d. Light wand
   e. Chest auscultation

308. As regards colloids:
   a. Hydroxyethyl starch can interfere with blood coagulation
   b. Hemaccel has a half-life of 6-8 hours
   c. Dextran 70 infusion can increase bleeding time
   d. All forms of dextran are antigenic
   e. Gelatin solutions can interfere with blood cross-matching

309. The following are true of the T wave of the ECG:
   a. It represents ventricular depolarization
   b. It is normally more than 2 mV in the standard leads
   c. The amplitude is increased in hyperkalemia
   d. The amplitude is increased in digoxin toxicity
   e. It is normal in atrial fibrillation

310. Digoxin:
   a. Increase in intracellular sodium levels
   b. Can be used in the management of Wolff-Parkinson-White (WPW) syndrome
   c. Can cause bradycardia and prolonged PR interval
   d. Can produce abnormal red-green color perception
   e. Toxicity increases with hyperkalemia

311. Immediate management of acute anaphylaxis includes:
   a. Chlorpheniramine
   b. Hydrocortisone
   c. Adrenaline
   d. Isoprenaline
   e. 0.9% normal saline

312. Mixed venous oxygen saturation is increased in:
   a. Anemia
   b. Cyanide toxicity
   c. Hypothermia
   d. Sepsis with peripheral shunting
   e. Strenuous exercise

313. In one-lung ventilation, hypoxic pulmonary vasoconstriction in the non-dependent lung is inhibited by:
   a. Clonidine
   b. Inhalational agents
   c. Intravenous induction agents
   d. Hypocapnia
   e. Positive end-expiratory pressure (PEEP) to the dependent lung

314. Predisposing factors for postoperative deep vein thrombosis (DVT) include:
   a. Sickle cell anemia
   b. Congestive cardiac failure
   c. Hypotensive anesthesia
   d. Presence of varicose veins
   e. Antithrombin III deficiency

315. Blood, platelets are important in hemostasis as they:
   a. Adhere to collagen
   b. Help to intiate the coagulation cascade
   c. Stimulate local vasoconstriction
   d. Encourage fibrinolysis
   e. Play a part in clot retraction

307. a. F; b. T; c. F; d. F; e. F
308. a. T; b. F; c. T; d. T; e. F
309. a. F; b. F; c. T; d. F; e. T
310. a. T; b. F; c. T; d. T; e. F
311. a. F; b. F; c. T; d. F; e. T
312. a. F; b. T; c. T; d. T; e. F
313. a. F; b. T; c. F; d. T; e. T
314. a. F; b. T; c. T; d. T; e. T
315. a. T; b. T; c. T; d. F; e. T

316. The following are compatible with a diagnosis of acute respiratory distress syndrome (ARDS):
   a. An increase in lung compliance
   b. An arterial PaO_2 of 10 kPa in air
   c. A pulmonary capillary wedge pressure (PCWP) of 12 mm Hg
   d. Bilateral diffuse infiltrates on chest radiograph
   e. Rapid resolution of chest radiograph changes following intravenous frusemide

317. Mitral stenosis causes:
   a. A displaced apex beat
   b. Systemic thromboembolism
   c. Hemoptysis
   d. A loud first heart sound
   e. An early diastolic murmur

318. Remifentanil:
   a. Has a larger volume of distribution than alfentanil
   b. Is broken down by plasma esterases
   c. Should be avoided in the presence of cholinesterase deficiency
   d. Can be used intrathecally
   e. Accumulates with repeated dosages

319. Appropriate for extubation after long-term ventilation include:
   a. A minute ventilation of 151/min
   b. A tidal volume of 7 mL/kg
   c. A respiratory rate of 20 breaths per min
   d. Functional residual capacity (FRC) of less than 50% of predicted
   e. Clinical judgment

320. Transesophageal echocardiography (TEE):
   a. Can detect myocardial ischemia
   b. Can detect aortic dissection
   c. Is contraindicated with esophageal varices
   d. Can evaluate left ventricular function
   e. Can cause cardiac arrhythmias

321. Appropriate treatment of established ARDS includes:
   a. Inverse ratio ventilation
   b. Steroids
   c. Diuretics
   d. Positive end-expiratory pressure (PEEP)
   e. Nitric oxide

322. Spontaneous pneumothorax:
   a. Is commonly associated with emphysema
   b. Is found equally in men and women
   c. Requires surgical repair in more than 50% of cases
   d. Requires oxygen therapy
   e. More commonly affects the right lung

323. In myasthenia gravis:
   a. There is increased sensitivity to depolarizing muscle relaxants
   b. A cholinergic crisis can occur with edrophonium
   c. There is fade on electromyelogram (EMG) after repetitive stimulation
   d. Thymectomy may be useful in the young patient
   e. Extradural anesthesia is contraindicated

316. a. T; b. F; c. T; d. T; e. F
317. a. F; b. T; c. T; d. T; e. F
318. a. T; b. T; c. F; d. F; e. F
319. a. F; b. T; c. T; d. F; e. T
320. a. T; b. T; c. F; d. T; e. T
321. a. T; b. F; c. T; d. T; e. T
322. a. T; b. F; c. F; d. F; e. F
323. a. F; b. F; c. T; d. T; e. F

324. Dopamine:
   a. Is a physiological neurotransmitter
   b. Must be administered through a central venous catheter
   c. Interferes with the release of thyroid-stimulating hormone (TSH) from the pituitary gland
   d. Has diuretic effects
   e. Action is antagonized by droperidol

325. A jaundiced male drug addict has a fever and a pansystolic murmur. The following may be true:
   a. He has viral infection
   b. He has bacterial infection
   c. Diagnosis and treatment of the viral infection, if present, is more important
   d. The murmur could be due to tricuspid regurgitation
   e. Suitable treatment would initially be with oral antibiotics

326. Baroreceptor activity is:
   a. Mediated via the IXth cranial nerve
   b. Responsive to oxygen concentration
   c. Located primarily in the carotid body
   d. Increased in response to increased venous pressure
   e. Minimally suppressed by isoflurane

327. Regarding a permanent pacemaker:
   a. The use of bipolar diathermy is contraindicated
   b. It is a risk for microshock
   c. It should be inactivated intraoperatively
   d. The use of pancuronium is contraindicated
   e. It has a normal life span of 3-5 years.

328. A massive pulmonary embolus (PE) commonly results in:
   a. Hemoptysis
   b. Pyrexia
   c. Increase in blood pressure
   d. Pleuritic chest pain
   e. A gallop rhythm

329. Dopexamine:
   a. Has significant α-adrenergic agonist action
   b. Is structurally similar to dopamine
   c. Has an inotropic action
   d. Increase renal blood flow
   e. Decreases splanchnic blood flow

330. The following are true:
   a. Phenoxybenzamine causes non-specific adrenoceptor blockade
   b. Metaraminol causes presynaptic sympathetic blockade
   c. Sodium nitroprusside works by direct action on blood vessels
   d. Methyldopa is a sympathetic ganglion blocker
   e. Hydralazine is an α_1 adrenoceptor blocker

331. Fresh-frozen plasma (FFP):
   a. Is suitable for use as a plasma volume expander
   b. Contains all the coagulation factors
   c. Can be to reverse the action of warfarin
   d. Is a source of cholinesterase
   e. Is treated to prevent viral transmission

324. a. T; b. F; c. T; d. T; e. T	325. a. T; b. T; c. F; d. T; e. F	326. a. T; b. F; c. F; d. T; e. T
327. a. F; b. T; c. F; d. F; e. F	328. a. F; b. F; c. F; d. F; e. T	329. a. F; b. T; c. T; d. T; e. F
330. a. T; b. F; c. T; d. F; e. F	331. a. F; b. T; c. T; d. T; e. F	

332. Appropriate postoperative analgesia for a thoracotomy includes:
   a. Intrapleural bupivacaine
   b. Transcutaneous electrical nerve stimulation (TENS)
   c. Lumbar extadural anesthesia
   d. NSAIDs
   e. Intercostal cryoanalgesia

333. Pulseless electrical activity (PEA):
   a. Is always fatal
   b. Can be due to a pulmonary embolus
   c. Is an indication for intravenous calcium
   d. Is an indication for temporary pacing
   e. Can result from cardiac tamponade

334. Clonidine:
   a. Is contraindicated in pregnancy
   b. Has intravenous analgesic properties
   c. Can produce significant postural hypotension
   d. Reduces the MAC of isoflurane
   e. Can result in rebound hypertension on withdrawal

335. Bundle branch block (BBB) on the ECG:
   a. Will show a prolonged PR interval
   b. Is represented with widening of the QRS complex
   c. Will show ST depression over the blocked ventricle
   d. Will show T wave inversion over the ventricle with normal conduction
   e. Is always pathological

336. Causes of overdamping in a transducer system include:
   a. Blood clots
   b. Wide tubing
   c. Saline as a priming fluid
   d. Short manometer tubing
   e. Air bubbles

337. Pulse oximetry:
   a. Is reliable in the presence of hyperbilirubinemia
   b. Compensates for ambient light
   c. Requires pulsatile flow to work
   d. Is accurate in the presence of carboxyhemoglobin
   e. Has a faster response time than a transcutaneous oxygen electrode

338. When a patient presents with a femoropopliteal thrombosis:
   a. Limb survival is usually 2 years
   b. Anticoagulation is indicated
   c. Pain is a late feature
   d. Paralysis is an early feature
   e. Early treatment with thrombolytic agents improves prognosis

339. Enteral feeding in the critically ill in the intensive care unit (ICU):
   a. Can frequently achieve a positive protein balance
   b. Is usually preferable to total parenteral nutrition (TPN)
   c. Reduces the incidence of septic complications
   d. Is as expensive as total parenteral nutrition
   e. May result in *Clostridium difficile* diarrhea

332. a. F; b. F; c. T; d. F; e. T
333. a. F; b. T; c. T; d. F; e. T
334. a. F; b. T; c. F; d. T; e. T
335. a. F; b. T; c. T; d. F; e. F
336. a. T; b. F; c. F; d. F; e. T
337. a. F; b. T; c. T; d. F; e. T
338. a. F; b. T; c. F; d. T; e. T
339. a. F; b. T; c. T; d. F; e. F

340. Coarctation of the aorta is associated with:
   a. Intracranial aneurysms
   b. Most commonly a preductal position
   c. Upper limb hypertension
   d. Turner's syndrome
   e. A bicuspid aortic valve

341. Hartmann's solution contains:
   a. Sodium - 112 mmol/L
   b. Chloride - 131 mmol/L
   c. Bicarbonate - 29 mmol/L
   d. Calcium - 2.0 mmol/L
   e. Potassium - 5.0 mmol/L

342. Human immunodeficiency virus (HIV):
   a. Is a retrovirus
   b. Is incorporated into host ribonucleic acid (RNA)
   c. Can be transmitted via breast milk
   d. Sufferers commonly develop *Pneumocystis carinii* pneumonia (PCP)
   e. Should be treated as a first line with protease inhibitors

343. Patients with acute intermittent porphyria should not be given:
   a. Paracetamol
   b. Barbiturates
   c. Sulphonamides
   d. Propofol
   e. Pethidine

344. Likely findings with a ruptured abdominal aortic aneurysm include:
   a. Raised jugular venous pressure
   b. Anuria
   c. Absent femoral pulses
   d. Bruising on the flanks
   e. Continuous abdominal pain

345. An infusion of albumin:
   a. Carries a risk of viral transmission
   b. Commonly causes anaphylactoid reactions
   c. Can be derived from bovine or human plasma
   d. Is suitable for a volume expander
   e. Is a useful source of protien for malnourished patients

346. Indications for insertion of a temporary preoperative pacing wire include:
   a. Asymptomatic congenital complete heart block
   b. Mobitz type II second-degree heart block
   c. Wenckebach type I second-degree heart block
   d. Sick sinus syndrome
   e. Wolff-Parkinson-White (WPW) syndrome

347. With a pulmonary artery (PA) flotation catheter:
   a. The thermistor is situated at 20 cm from the balloon
   b. The pulmonary artery pressure (PAP) waveform must be displayed continuously
   c. Cardiac output can be derived from pressure measurements
   d. Readings are more accurate if it is inserted through a jugular vein
   e. The proximal lumen is used for measuring CVP

340. a. T; b. F; c. T; d. T; e. T
341. a. F; b. F; c. F; d. T; e. T
342. a. T; b. F; c. T; d. T; e. T
343. a. F; b. T; c. T; d. F; e. F
344. a. F; b. F; c. T; d. T; e. F
345. a. F; b. F; c. F; d. T; e. F
346. a. F; b. T; c. F; d. T; e. F
347. a. F; b. T; c. F; d. F; e. T

348. Heparin:
   a. Is very acidic
   b. Can be given orally
   c. Abolishes the risk of deep vein thrombosis (DVT) after hip replacement
   d. Is antagonized by aprotinin
   e. Has the same mode of action as prostacyclin

349. Which of the following are suggestive of severe aortic stenosis (AS)?
   a. Angina
   b. Effort syncope
   c. Cardiomegaly
   d. Apex pulsation in 6th intercostal space in the anterior displaced apex beat
   e. Collapsing pulse

350. In established congestive cardiac failure:
   a. Glomerular filtration rate (GFR) is reduced more than renal blood flow
   b. Diuretics are an important first line of treatment
   c. Digoxin decreases myocardial tension
   d. Aldosterone secretion is high
   e. ACE inhibitors are contraindicated

351. Magnesium sulphate:
   a. Decreases uterine contractility
   b. Potentiates non-depolarizing muscle relaxants
   c. Potentiates depolarizing muscle relaxants
   d. Causes epileptiform convulsions
   e. Increase the bleeding time

348. a. T; b. F; c. F; d. F; e. F
349. a. T; b. T; c. F; d. F; e. F
350. a. F; b. T; c. F; d. T; e. F
351. a. T; b. T; c. T; d. F; e. T

13

Echocardiography for Left-to-Right Shunts

1. Which echocardiographic scan plane is most optimal to define a secundum atrial septal defect (ASD)?
   a. Suprasternal long-axis view
   b. Parasternal long-axis view
   c. Parasternal short-axis view
   d. Subcostal four-chamber view
   e. Apical four-chamber view

2. Which of the following is the most common associated anatomic lesion found with a sinus venosus ASD?
   a. Anomalous right pulmonary venous connection
   b. Inlet ventricular septal defect (VSD)
   c. Bicuspid aortic valve (AV)
   d. Persistent left superior vena cava
   e. Coarctation of the aorta

3. Which of the following associated congenital heart defects is most common in a patient with Down's syndrome and an atrioventricular septal defect (AVSD)?
   a. Coarctation of the aorta
   b. Total anomalous pulmonary venous connection
   c. AV stenosis
   d. Tetralogy of Fallot
   e. Left ventricular (LV) hypoplasia

4. Which of the following is the most common anatomic finding in a complete AVSD?
   a. Cleft in posterior leaflet of mitral component of AV
   b. Medial rotation of LV papillary muscles
   c. Ratio of LV inlet to outlet distance >1.0
   d. Left ventricular outflow tract (LVOT) is "sprung" anteriorly
   e. Left and right atrioventricular valve attachments are present at different levels

5. The best echocardiographic view to delineate a subpulmonary (supracristal) VSD is:
   a. Parasternal long-axis view
   b. Apical four-chamber view
   c. Suprasternal long-axis view
   d. Parasternal short-axis view
   e. Apical five-chamber view

1. d 2. a 3. d 4. d 5. d

6. Which of the following is the most characteristic acquired lesion resulting from a subpulmonary (supracristal) VSD?
   a. Aortic insufficiency
   b. LVOT obstruction
   c. Right ventricular (RV) outflow tract obstruction
   d. Pulmonary valve stenosis
   e. AV stenosis

7. Which of the following is the most characteristic physiologic effect of a large VSD?
   a. RV volume overload
   b. Low pulmonary arterial pressure
   c. Equal RV and LV pressure
   d. Increased systemic blood flow
   e. Decreased pulmonary blood flow

8. The most common anatomic type of subaortic stenosis is:
   a. Tunnel-type
   b. Discrete membrane
   c. Asymmetric septal hypertrophy
   d. Systolic anterior motion of mitral valve
   e. Anomalous mitral chordal insertion within the LVOT

9. A neonate with valvar pulmonary stenosis has a peak Doppler velocity by continuous-wave Doppler of 4.1 m/sec. The estimated peak instantaneous Doppler gradient is:
   a. 67 mm Hg
   b. 77 mm Hg
   c. 72 mm Hg
   d. 50 mm Hg
   e. Cannot be calculated.

10. The most common associated cardiac abnormality in a patient with coarctation of the aorta is:
   a. Bicuspid AV
   b. VSD
   c. ASD
   d. Pulmonary valve stenosis
   e. Coronary artery anomaly

11. In patients with coarctation of the aorta, systemic arterial pressure begins to be significantly affected when the overall aortic lumen is narrowed by:
   a. 20%
   b. 30%
   c. 50%
   d. 75%
   e. 90%

12. The most common type of VSD that is associated with coarctation of the aorta is:
   a. Apical muscular
   b. Anterior malalignment
   c. Perimembranous
   d. Inlet
   e. Subpulmonary (supracristal)

13. The Doppler phenomenon often seen in patients with supravalvar aortic stenosis has been demonstrated to be a high-velocity poststenotic jet that hugs the aortic wall and preferentially transfers kinetic energy into the right innominate artery. Which of the following best describe this Doppler finding?
   a. Coanda effect
   b. Ohm's law
   c. Continuity equation
   d. Poiseuille's law
   e. Bernouilli's equation

6. a 7. c 8. b 9. a 10. a 11. c 12. c 13. a

14. Interruption of the aortic arch is most common in which syndrome?
    a. DiGeorge
    b. Down
    c. Turner
    d. Alagille's
    e. Holt-Oram

15. A Type A interruption of the aortic arch occurs:
    a. Between the right innominate and left common carotid arteries
    b. Proximal to the right innominate artery
    c. Between the left common carotid and left subclavian arteries
    d. Distal to the left subclavian artery
    e. Just distal to the sinotubular junction in the ascending aorta

16. An echocardiogram is obtained on a 3-month-old with a loud cardiac murmur. The parasternal short-axis scan in Figure 13.1 is obtained. Which of the following best describes the cardiac defect?

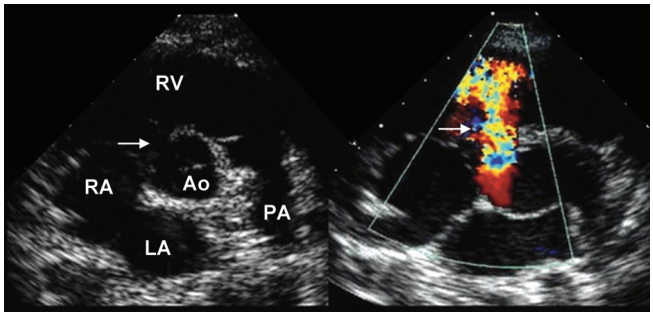


Fig. 13.1

    a. Large membranous VSD
    b. Large muscular VSD
    c. Ruptured sinus of Valsalva aneurysm
    d. Severe valvar pulmonary stenosis
    e. Severe AV insufficiency

17. An echocardiogram is obtained after interventional device closure of a VSD (Fig. 13.2). What anatomic type of VSD has been closed with this procedure?

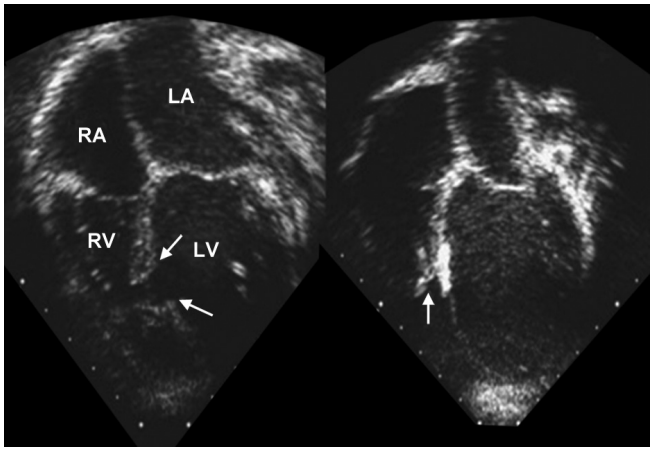


Fig. 13. 2

14. a 15. d 16. a

a. Membranous VSD
b. Inlet VSD
c. Subpulmonary (supracristal) VSD
d. Trabecular muscular VSD
e. Anterior malalignment VSD

18. What anatomic type of VSD is demonstrated in the parasternal short-axis image in Figure 13.3?

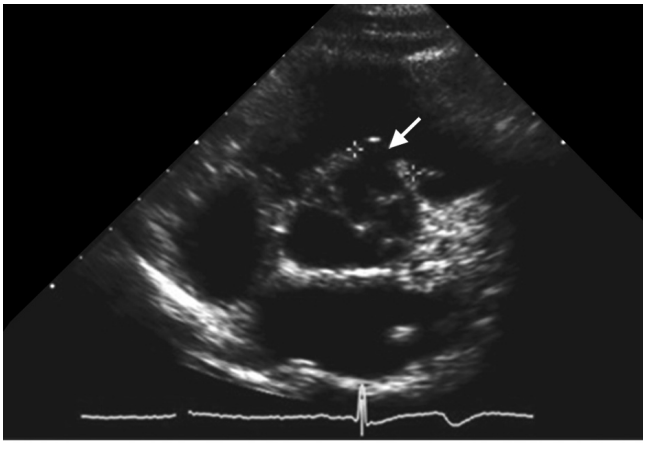


Fig. 13.3

a. Membranous VSD
b. Inlet VSD
c. Subpulmonary (supracristal) VSD
d. Trabecular muscular VSD
e. Anterior malalignment VSD

19. A 1-month-old infant undergoes an echocardiogram secondary to a cardiac murmur. What aortic to pulmonary artery peak pressure gradient is predicted by the Doppler tracing in Figure 13.4?

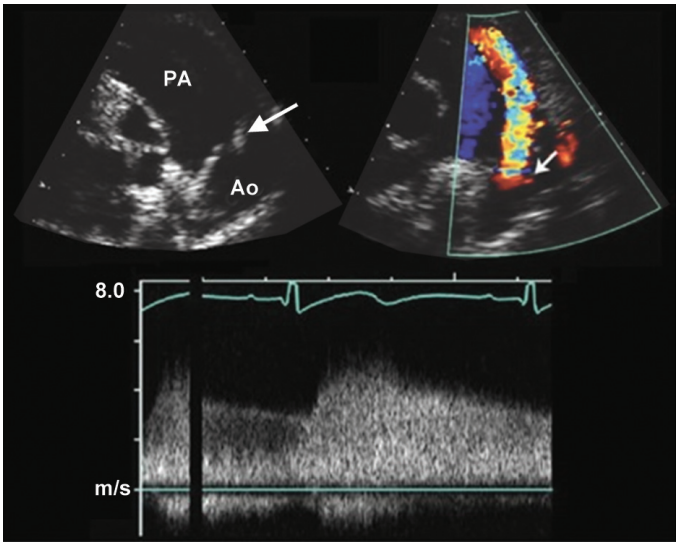


Fig. 13.4

17. d 18. c

a. 16 mm Hg
b. 36 mm Hg
c. 48 mm Hg
d. 64 mm Hg
e. The peak aorta to pulmonary artery gradient cannot be calculated

20. A 2-day-old infant undergoes an echocardiogram because of respiratory distress. What anatomic lesion and hemodynamic physiology is demonstrated in Figure 13.5?

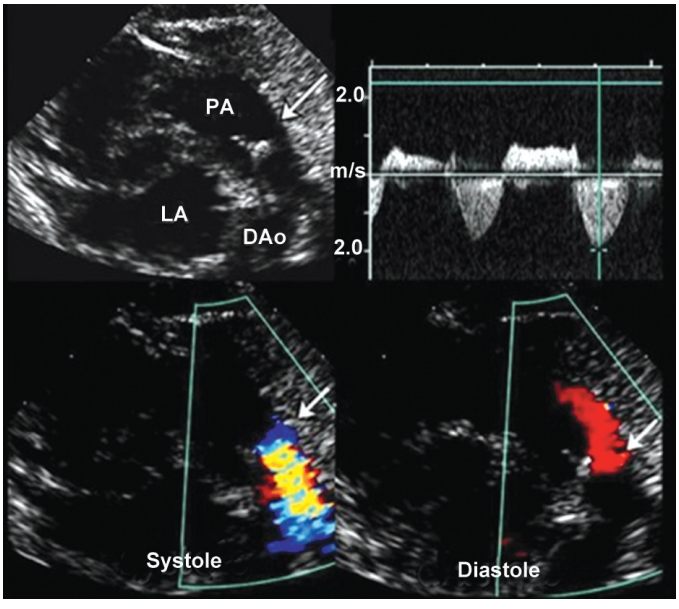


Fig. 13.5

a. Patent ductus arteriosus (PDA) with exclusive left-to-right shunting
b. Aortopulmonary window with bidirectional shunting
c. Severe coarctation of the aorta with exclusive right-to-left shunting through the ductus arteriosus
d. PDA with bidirectional shunting
e. Aortopulmonary collateral vessel with exclusive right-to-left shunting

21. The parasternal long-axis image in Figure 13.6 is obtained in a 12-year-old with a new onset cardiac murmur. Which of the following cardiac diagnoses best describes this image?
a. Severe AV stenosis
b. Subaortic membrane with moderate stenosis
c. Systolic anterior motion of the mitral valve with mild stenosis
d. Cardiac rhabdomyoma within the LVOT with moderate obstruction
e. Anomalous mitral valve chordal insertion with severe LVOT obstruction

19. d 20. d 21. b

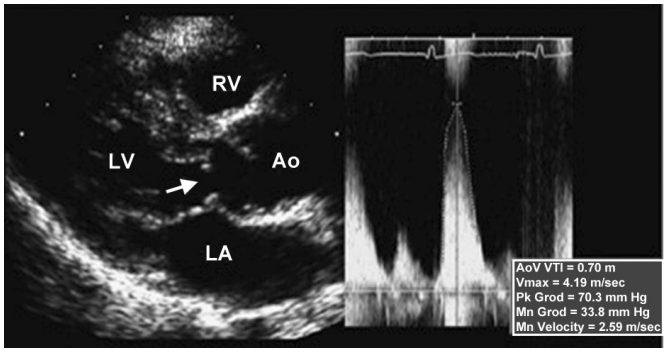


Fig. 13.6

22. A 2-year-old with Down's syndrome presents for cardiac evaluation. The echocardiographic images in Figure 13.7 are obtained. What cardiac defect is best demonstrated by color Doppler (arrow)?

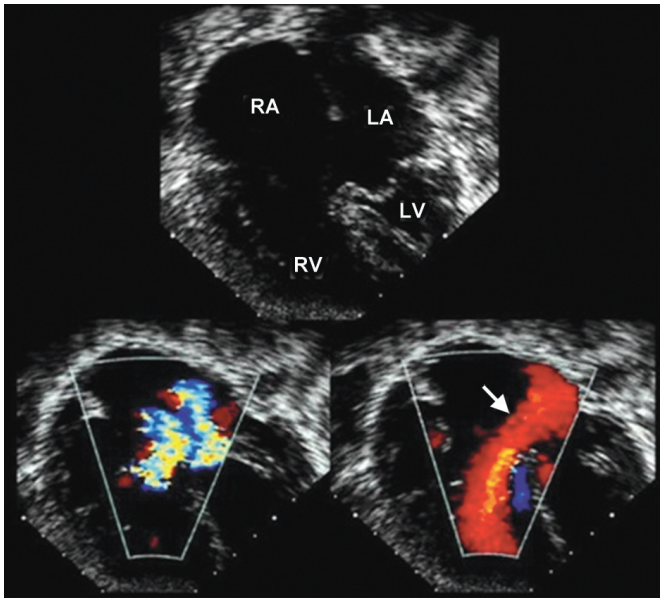


Fig. 13.7

a. Primum ASD
b. Inlet VSD
c. Sinus venosus ASD
d. Persistent left superior vena cava to dilated coronary sinus
e. Malalignment outlet VSD

23. A previously healthy 6-year-old girl presents due to a recent episode of syncope with exercise. The suprasternal images in Figure 13.8 are obtained.

Which of the following best describes her cardiac diagnosis?

22. a

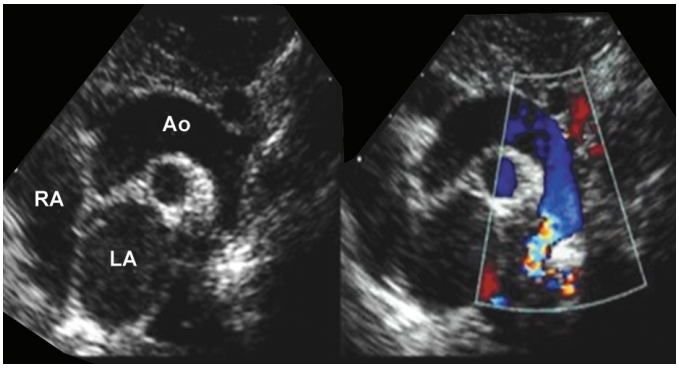


Fig. 13.8

a. Left pulmonary artery stenosis
b. PDA
c. Coarctation of the aorta
d. Interruption of the aortic arch
e. Transposition of the great arteries

24. The Doppler pattern in Figure 13.9, in the abdominal aorta, is most consistent with:

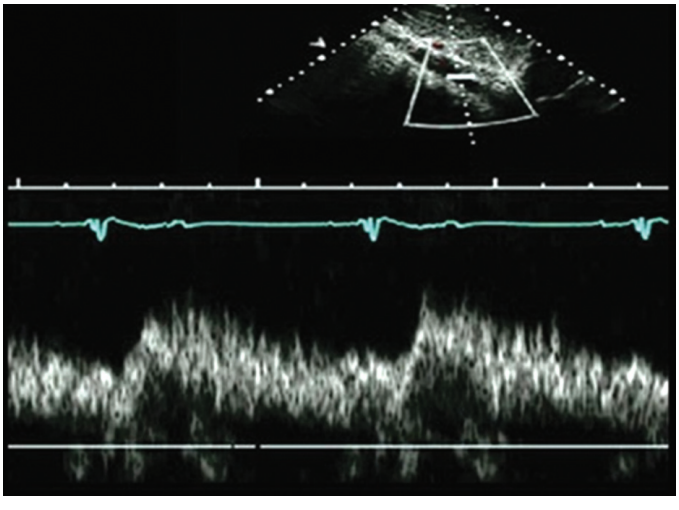


Fig. 13.9

a. Severe aortic insufficiency
b. Large PDA
c. Normal aortic flow pattern
d. Coarctation of aorta
e. Renal artery stenosis

25. A 15-year-old presents for evaluation due to the presence of a cardiac murmur on auscultation. The echocardiographic images in Figure 13.10 are most compatible with which of the following diagnoses?

23. c 24. d

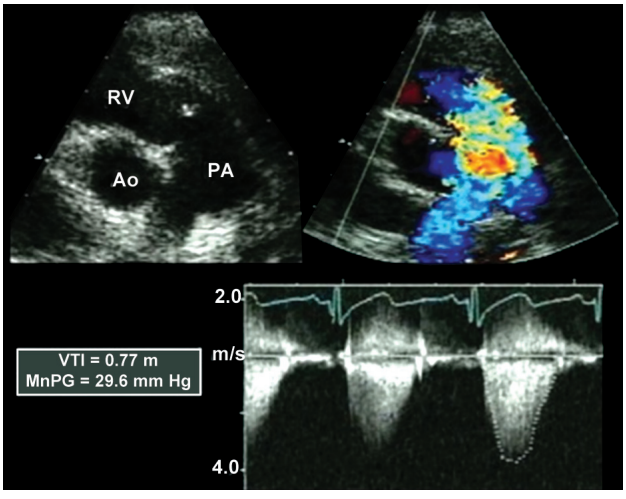


Fig. 13.10

a. Pulmonary valve stenosis
b. Left pulmonary artery stenosis
c. Dynamic right ventricle (RV) infundibular obstruction
d. Tetralogy of Fallot with absent pulmonary valve
e. Double-chambered RV

CASE SCENARIO A

A neonate presents for evaluation secondary to a new cardiac murmur heard at his 2-week well-child outpatient visit. An echocardiogram was performed and the images in Figure 13.11 were obtained.

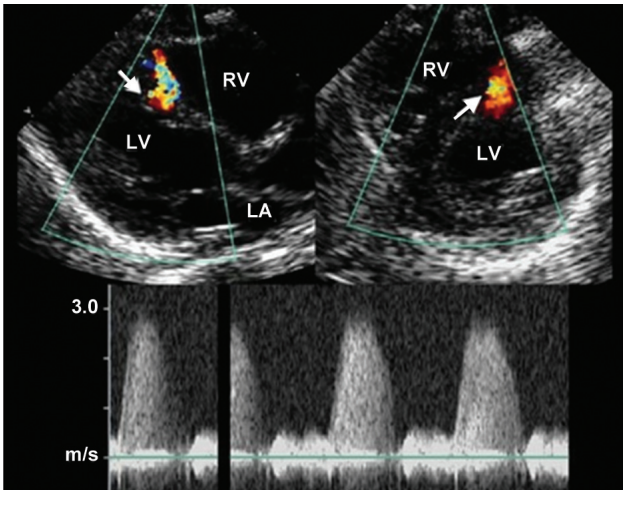


Fig. 13.11

25. a

26. Which of the following diagnoses are most consistent with these images?
    a. Small anterior muscular VSD with left-to-right shunting
    b. Small posterior inlet VSD with left-to-right shunting
    c. Large nonrestrictive muscular VSD with bidirectional shunting
    d. Multiple "swiss cheese" VSDs with right-to-left shunting
    e. Small outlet VSD with left-to-right shunting

27. What is the peak LV to RV pressure gradient based upon the Doppler velocity displayed?
    a. 16 mm Hg
    b. 36 mm Hg
    c. 64 mm Hg
    d. 100 mm Hg
    e. The peak pressure gradient cannot be calculated

28. What is the likelihood of spontaneous closure of this defect during childhood?
    a. 5%–10%
    b. 20%–30%
    c. 40%–50%
    d. 60%–70%
    e. 80%–90%

CASE SCENARIO B

A 7-year-old boy presents to your office with exercise intolerance. You note a 3/6 systolic ejection murmur at the left upper sternal border with a widely split S2 and a soft mid-diastolic rumble. The echocardiographic image in Figure 13.12 is obtained

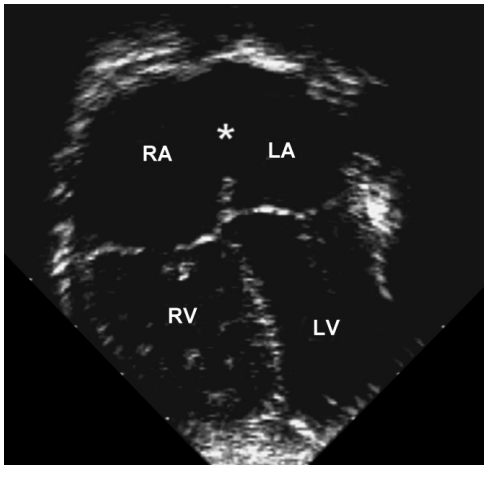


Fig. 13.12

29. Which of the following diagnoses is correct?
    a. Primum ASD
    b. Secundum ASD
    c. Sinus venosus ASD
    d. Coronary sinus ASD
    e. Atrial septal aneurysm

30. The direction in which blood flows across an ASD is primarily related to which of the following anatomic or hemodynamic factors?
    a. Relative compliances of the ventricles
    b. Pulmonary vascular resistance
    c. Systemic vascular resistance
    d. Relative atrial pressures
    e. Size and morphology of the ASD

26. a 27. b 28. e 29. b 30. a

31. What is the most likely diagnosis?
    a. Coarctation of the aorta
    b. Interruption of the aortic arch type A
    c. Supravalvar aortic stenosis
    d. Valvar aortic stenosis
    e. Subaortic stenosis

CASE SCENARIO C

A 3-week-old infant presents to the ED with tachypnea and a cardiac murmur as seen in Figure 13.13.

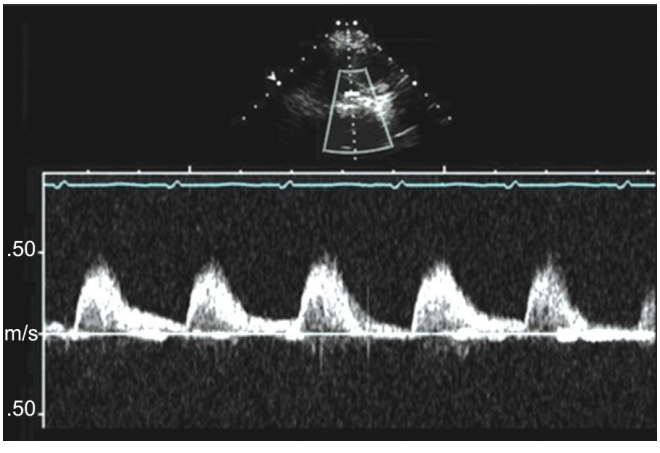


Fig. 13.13

32. After the echocardiogram is completed, the on-call resident performs four-extremity blood pressure measurements. The findings are as follows:

    Right leg: 40/25 mm Hg.

    Left leg: 42/22 mm Hg.

    Right arm: 48/27 mm Hg.

    Left arm: 72/35 mm Hg.

    Which of the following is the most likely diagnosis?
    a. Interruption of the aortic arch with restrictive PDA
    b. Coarctation of the aorta with VSD
    c. Coarctation of the aorta with aberrant right subclavian artery
    d. Truncus arteriosus with pulmonary artery ostial stenosis
    e. Normal aortic arch with stenosis of the left subclavian artery

33. Which of the following statements regarding coarctation of the aorta is correct?
    a. It is caused by formation of an anterior ledge of thickened aortic wall media tissue
    b. The most common site of coarctation is opposite the ductal insertion
    c. Involvement of the left subclavian artery is very common
    d. It commonly presents in the neonatal period with systemic hypertension and LV hypertrophy
    e. It is rarely associated with other congenital heart abnormalities

31. a 32. c 33. b

Answers

1. d. The subcostal imaging window is optimal to demonstrate the atrial septum and any associated atrial septal defects (ASDs) that may be present. To visualize the atrial septum without potential drop-out, the imaging plane of sound should be perpendicular to the cardiac structure of interest. With respect to the atrial septum, the imaging plane that is optimally perpendicular is the subcostal four-chamber and sagittal views. ASDs can be demonstrated in other imaging windows including the parasternal short axis, apical four-chamber, and high right parasternal views but care must be taken not to diagnose an ASD when the plane of sound is more parallel to the atrial septum creating the potential for false drop-out in the two-dimensional image. The addition of color Doppler and spectral Doppler interrogation in these views may also facilitate the diagnosis of an ASD.
2. a. Sinus venosus ASDs are most commonly associated with anomalous connection of the right pulmonary veins. Either a single right upper pulmonary vein or the right upper and middle pulmonary veins insert anomalously to the superior vena cava (SVC) or the SVC-right atrial junction. Sinus venosus defects are found most commonly in the superior portion of the atrial septum creating a "biatrial" insertion of the SVC. These defects can also be located inferiorly near the entrance of the inferior vena cava into the right atrium.
3. d. Patients with Down's syndrome (trisomy 21) have an almost 50% incidence of congenital heart disease, with atrioventricular septal defects (AVSDs) being the most common cardiac anomaly in this cohort. AVSD in association with tetralogy of Fallot is a common constellation of cardiac anomalies in patients with Down's syndrome. Obstruction of the left ventricular outflow tract (LVOT) and coarctation of the aorta are also common cardiac abnormalities in patients with AVSD but are not as common in Down's syndrome patients. Left ventricular (LV) hypoplasia can also occur in the setting of AVSD ("unbalanced AVSD with right ventricular [RV] dominance") but is less commonly seen in this cohort. Aortic valve stenosis and anomalous pulmonary venous connections are uncommon.
4. d. Anatomic hallmarks of AVSDs include a cleft in the anterior leaflet of the left atrioventricular valve, lateral rotation of the LV papillary muscles, and attachments of the left and right atrioventricular valves at the same level at the cardiac crux. In addition, due to the absence of the atrioventricular septum in these defects, the LV inflow is shortened and the LV outflow is elongated ("goose-neck deformity") creating a ratio of LV inlet to LV outlet ratio <1. Due to the presence of a common atrioventricular valve, the aortic valve is no longer "wedged" between the tricuspid and mitral valves and is pushed anteriorly ("sprung").
5. d. Subpulmonary ventricular septal defects (VSDs) are located adjacent to the pulmonary valve and aortic valve and have been termed subpulmonary, supracristal, or doubly committed defects. These defects can be optimally demonstrated in the parasternal short-axis scan plane but can also be demonstrated from the subcostal and apical windows with appropriate angulation into the right ventricular outflow tract (RVOT).
6. a. Aortic insufficiency is the most common associated abnormality because of prolapse of the aortic cusp into a subpulmonary VSD. While this associated prolapse of aortic tissue limits the size of the VSD and can lessen the left-to-right shunt, the progression of aortic insufficiency due to distortion of the aortic valve is well-recognized. If this regurgitation is significant and progresses, then surgical closure is indicated (and is not dependent upon the size of the left-to-right shunt).
7. c. Large VSDs result in equalization of right and left ventricular pressures as well as elevated pulmonary arterial pressure. Left-to-right shunting at the ventricular level results in a substantial increase in pulmonary blood flow with left atrial and ventricular volume overload. Systemic blood flow is not significantly increased in this setting.
8. b. The most common type of subaortic stenosis is related to a discrete membrane proximal to the aortic valve within the LVOT. This membrane is most often circumferential and can

be adherent to both the aortic valve as well as the anterior leaflet of the mitral valve. LVOT obstruction in the setting of hypertrophic cardiomyopathy is often related to asymmetric septal hypertrophy in combination with systolic anterior motion of the mitral valve chordal and leaflet tissue. Anomalous mitral chordal insertions within the LVOT can be isolated or found in association with congenital heart disease and may result in obstruction but are not as common as discrete membranes.

9. a. Utilizing the modified Bernoulli equation to obtain the peak instantaneous gradient across the pulmonary valve, 4 × [velocity]2, then 4 × [4.1] 2 = 67 mm Hg.
10. a. Bicuspid aortic valve is the most commonly associated cardiac finding in patients with simple coarctation with some studies showing as high as an 80% occurrence in patients with coarctation. ASDs and VSDs are also common in patients with coarctation. Pulmonary valve stenosis and coronary arterial anomalies are much less frequent in this cohort.
11. c. The aortic lumen must be narrowed by at least 50% to significantly affect systemic arterial pressure.
12. c. The most common VSD associated with coarctation is a perimembranous defect. While less common, a posterior malalignment VSD often results in severe coarctation or interruption of the aortic arch. Muscular VSD as well as inlet VSD can also occur in the setting of coarctation, in particular with an unbalanced RV-dominant AVSD.
13. a. The systolic jet in patients with supravalvar aortic stenosis propagates further than the jet originating with aortic valvar stenosis and has a tendency to be entrained along the aortic wall thereby transferring its kinetic energy into the right innominate artery. This physical principle often is expressed clinically in these patients by marked discrepancy in upper arm blood pressures, with the right arm pressure higher than the left arm blood pressure.
14. a. Interruption of the aortic arch is most commonly found in DiGeorge syndrome and is a deletion in chromosome 22q11. This chromosome deletion results in conotruncal defects, with interruption of the aortic arch type B being the most frequent cardiac abnormality. Down syndrome (trisomy 21) is frequently associated with congenital heart disease, most commonly atrioventricular canal defects and VSDs. Turner syndrome (46 XO) has coarctation and bicuspid aortic valve as hallmark lesions while Holt-Oram is associated with secundum ASDs. Alagille's syndrome is most characteristically associated with pulmonary branch stenosis or RVOT obstruction.
15. d. Type A interruption of the aortic arch occurs distal to the origin of the left subclavian artery. Type B interruption occurs between the left common carotid and left subclavian arteries. Type C interruption occurs between the right innominate and left common carotid arteries.
16. a. The parasternal short-axis image in Figure 13.1 demonstrates a defect in the membranous portion of the ventricular septum adjacent to the tricuspid valve. The color Doppler image demonstrates a high-velocity mosaic jet from the left ventricle to the right ventricle.
17. d. The apical four-chamber image in Figure 13.2 demonstrates the muscular ventricular septum with a midmuscular defect occluded by a closure device. The apical four-chamber view demonstrates the inlet portion of the ventricular septum (near the atrioventricular valves) and the mid and apical muscular septum.
18. c. The parasternal short-axis image in Figure 13.3 demonstrates a defect in the subpulmonary region (supracristal) of the ventricular septum adjacent to the pulmonary valve. This defect has also been termed an infundibular or conal VSD due to the defect's position within the infundibular muscular septum.
19. d. The high left parasternal short-axis image in Figure 13.4 demonstrates a patent ductus arteriosus. Color Doppler is consistent with a left-to-right shunt from the aorta to the pulmonary artery (red color flow). Continuous-wave Doppler confirms an exclusive left-to-right shunt in both systole and diastole. The peak Doppler velocity is approximately 4.0 m/sec predicting a peak instantaneous pressure gradient of 64 mm Hg utilizing the simplified Bernoulli equation.

20. d. The high left parasternal short-axis image in Figure 13.5 demonstrates a patent ductus arteriosus (PDA). Color Doppler is consistent with a bidirectional shunt from the aorta to the pulmonary artery (right-to-left shunting in systole and left-to-right shunting in diastole). Continuous-wave Doppler confirms bidirectional low-velocity shunting.
21. b. The parasternal long-axis image in Figure 13.6 demonstrates a circumferential subaortic membrane within the LVOT. Note the significant narrowing of the LVOT and the association of the membrane with the anterior leaflet of the mitral valve. The peak Doppler velocity obtained from a high right parasternal location predicts a mean gradient of ~34 mm Hg (moderate stenosis).
22. a. The apical four-chamber image in Figure 13.7 demonstrates a large primum ASD. The large left-to-right shunt is demonstrated across this defect by color flow imaging (arrow). Both atrioventricular valves are inserted at the same level at the cardiac crux consistent with an AVSD with a large primum component. No shunt is evident at ventricular level. Significant atrioventricular valve regurgitation is also demonstrated by color Doppler.
23. c. The suprasternal long-axis image of the aortic arch in Figure 13.8 demonstrates a juxtaductal coarctation of the aorta. Note the posterior shelf present in the descending aorta in the two-dimensional image and the area of coarctation demonstrated with color Doppler.
24. d. Pulsed-wave Doppler interrogation is demonstrated in the descending aorta. The Doppler pattern in Figure 13.9 demonstrates classic findings in coarctation of the aorta with delayed arterial upstroke and prominent diastolic runoff. Also note the absence of an early diastolic Doppler flow reversal, another hallmark of significant aortic obstruction.
25. a. The parasternal short-axis images in Figure 13.10 demonstrate a thickened pulmonary valve with prominent color flow acceleration originating at the pulmonary valve consistent with valvar stenosis. Continuous-wave Doppler predicts a mean gradient of ~ 30 mm Hg suggesting a moderate degree of stenosis.
26. a. The parasternal long-axis and short-axis scans in Figure 13.11 demonstrate a small anterior muscular VSD in the midmuscular septum. The continuous-wave Doppler velocity of ~3 m/sec suggests a restrictive defect. Remember, pulmonary vascular resistance in the neonate does not fall completely until 2–3 months of age so it would be expected with this small defect that the Doppler velocity will increase over the first few months of life consistent with a hemodynamically small defect. No additional VSDs are demonstrated by color Doppler imaging; however, the ventricular septum should be imaged by many different scan planes (parasternal long axis, parasternal short axis, apical four-chamber, and subcostal views) to assure no additional defects are present.
27. b. Utilizing the modified Bernoulli equation to obtain the peak instantaneous gradient across the VSD, 4 × [velocity]2, then 4 × [3.0] 2 = 36 mm Hg.
28. e. Small trabecular muscular VSDs have a very high likelihood of spontaneous closure, typically 80–90%. The majority will close within the first few years of life but spontaneous closure with these muscular defects can occur later in childhood and even in adulthood.
29. b. The clinical examination in this patient suggests a large ASD. The apical four-chamber image in Figure 13.12 demonstrates an enlarged right atrium and right ventricle consistent with a significant left-to-right atrial shunt. While not the optimal echocardiographic view to evaluate the entire atrial septum (this scan plane is more parallel than perpendicular to the atrial septum), it does appear that there is a large dropout in the atrial septum consistent with a secundum ASD (*). The primum septum is intact inferiorly and is confirmed by noting that the atrioventricular valves are inserted at different levels at the cardiac crux (atrioventricular septum is present). This apical view is not optimal to demonstrate a sinus venosus ASD. Lack of dilatation of the coronary sinus does not exclude a coronary sinus ASD but makes it much less likely. No atrial septal aneurysm is demonstrated in this image.
30. a. The direction of atrial level shunting is primarily related to the compliance of the ventricles. The right ventricle is typically more compliant than the left ventricle with characteristic left-

to-right shunting being most common. These other factors also contribute to the degree and direction of atrial level shunting but ventricular compliance is most important.

31. a. The images presented in Figure 13.13 are consistent with coarctation of the aorta. The suprasternal long-axis views demonstrate a juxtaductal coarctation of the aorta in the proximal descending aorta. Aliased color flow is demonstrated at the area of discrete narrowing. The parasternal long-axis images do not demonstrate any evidence of subaortic, valvar, or supravalvar aortic stenosis. A midmuscular VSD, however, is seen in this video. The pulsed-wave Doppler image from the descending aorta demonstrates diastolic runoff consistent with significant proximal obstruction (i.e. coarctation).

32. c. In patients with coarctation of the aorta, the brachiocephic vessels proximal to the coarctation typically have normal or increased systemic blood pressure while those vessels distal to the obstruction have decreased blood pressure. In a patient with a typical juxtaductal coarctation, the blood pressure in the arms is significantly higher than blood pressures recorded in the lower extremities. The blood pressures in the patient listed in this question are decreased in the right and left legs (as one would expect in coarctation) but the right arm also has decreased pressure. This is most likely due to an aberrant right subclavian artery that originates distal to the coarctation from the descending aorta.

33. b. The most common site of coarctation of the aorta in infants and children is juxtaductal—the narrowing is opposite the insertion site of the ductus arteriosus. This is accompanied by a posterior infolding ("ledge") of thickened aortic wall media tissue. The left subclavian artery is most often not involved in the narrowing but can be in some cases. The typical neonatal presentation of severe coarctation is cardiovascular collapse when the patent ductus closes. Systemic hypertension and LV hypertrophy often present later in childhood with coarctation. Coarctation is often associated with other congenital heart lesions including bicuspid aortic valves, VSDs, and additional left heart obstructive lesions.

14

Echocardiography for Right-to-Left Shunts

1. Which is the most common cyanotic congenital heart disease?
   a. Transposition of great arteries
   b. Total anomalous pulmonary venous return
   c. Truncus arteriosus
   d. Tetralogy of Fallot (TOF)
   e. Tricuspid atresia

2. A 22-year-old well-known patient with Ebstein's anomaly of the tricuspid valve is seen in the office for a routine visit and complains of exertional dyspnea. Pulse oximetry reveals that his resting oxygen saturation is 89%. Review of his previous visits reveals that the last time this was checked at age 14, the saturation was 95%. This relative drop in his oxygen saturation is most likely produced by what abnormality of intracardiac hemodynamics seen on his echocardiogram?
   a. Ventricular septal defect (VSD)
   b. Pulmonary valve stenosis
   c. Atrial septal defect (ASD)
   d. Aortic valve regurgitation
   e. Coarctation of the aorta

3. A newborn infant is evaluated because of a heart murmur. The echocardiogram reveals a large VSD with an overriding great vessel and a single large great artery giving rise to the aorta and the pulmonary artery. What is a TRUE statement about this congenital heart defect?
   a. There is a higher incidence of chromosomal abnormalities
   b. Survival is dependent upon a patent ductus arteriosus (PDA)
   c. Survival is dependent upon an ASD
   d. The oxygen saturation is normal
   e. Surgical repair may be deferred for up to 2 years

4. An echocardiogram is done on a 4-year-old patient with unrepaired TOF. He has a loud heart murmur at the upper right sternal border. The parasternal long-axis view reveals a typical large VSD with an overriding great aorta. The pulmonary arteries appear to be confluent and normal in size. There is right-to-left shunting at the ventricular level with no turbulence seen. Doppler interrogation of the tricuspid regurgitant signal reveals a velocity of 4.5 m/sec. What can be said about this patient's heart disease?
   a. He has developed pulmonary hypertension
   b. A tricuspid valve problem has developed
   c. This is an expected finding of no concern
   d. The VSD is becoming restrictive with time
   e. The Doppler signal from the tricuspid valve is incorrect

1. d 2. c 3. a 4. c

5. An echocardiogram is done on an infant with cyanosis and no heart murmur. The parasternal long-axis view reveals a large VSD with right-to-left shunt. The posterior great artery appears to bifurcate into two arteries. There is a patent foramen ovale with a small left-to-right shunt. A large PDA is seen with bidirectional shunt. What is the most likely cause of the cyanosis?
   a. Abnormalities of the great arteries
   b. Pulmonary arterial hypertension
   c. Coarctation of the aorta
   d. Decreased pulmonary blood flow
   e. Total anomalous pulmonary venous return

6. Which of the following cyanotic congenital heart defects is most likely to escape detection in childhood?
   a. TOF
   b. Supracardiac total anomalous pulmonary venous return
   c. Transposition of the great arteries
   d. Tricuspid valve atresia
   e. Ebstein's anomaly of the tricuspid valve

7. Cyanotic congenital heart disease is most frequently produced by what abnormality of intracardiac hemodynamics?
   a. Abnormal great artery position
   b. Pulmonary venous anomalies
   c. Arteriovenous connections
   d. Pulmonary hypertension
   e. Decreased pulmonary blood flow

8. Common echocardiographic features of Ebstein's anomaly include all of the following except:
   a. Atrial level shunting
   b. Apical displacement of the septal tricuspid leaflet
   c. Tricuspid regurgitation
   d. VSD
   e. Abnormal septal motion

9. Which of the following pulmonary venous connections is not a form of total anomalous pulmonary venous return?
   a. Connection to the innominate vein
   b. Connection to the right atrium
   c. Connection to the hepatic veins
   d. Connection to the coronary sinus
   e. Connection to the left atrium

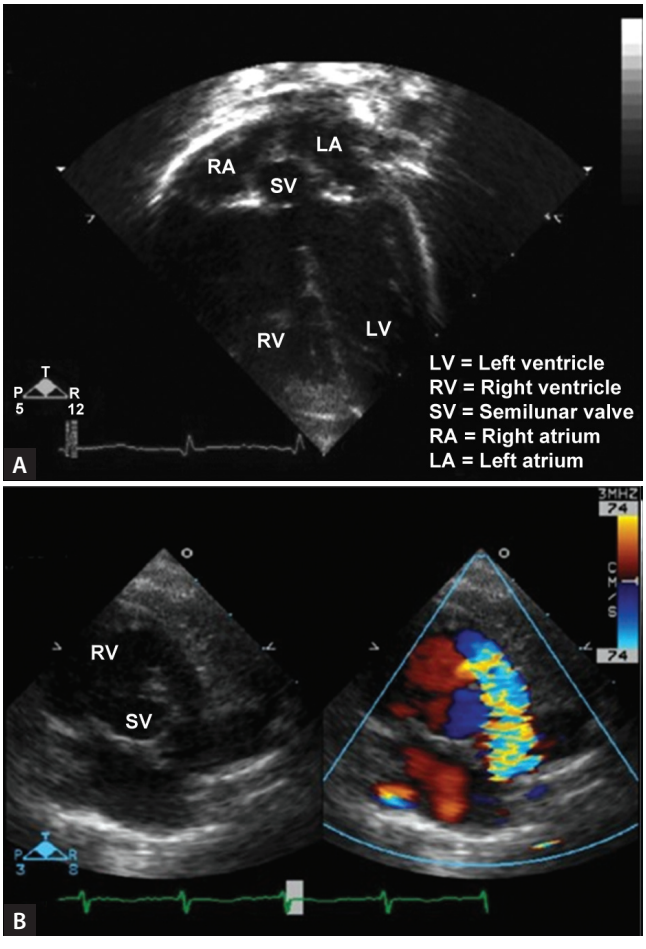
10. An echocardiogram is done on an infant with a heart murmur. The parasternal long-axis view reveals a large VSD with an overriding great vessel. The next important step in identifying this heart disease should be:
   a. Examine for the presence of an ASD
   b. Identify the pulmonary artery connection
   c. Find the side of the arch
   d. Measure the size of the VSD
   e. Perform Doppler on the tricuspid valve

11. A 2-month-old infant is seen for a heart murmur. The child is doing clinically well. The oxygen saturation is found to be 90% by pulse oximetry. Echocardiography reveals tricuspid valve atresia. What is a TRUE statement about this congenital heart defect?
   a. An ASD or patent foramen ovale (PFO) is present
   b. A PDA must be present for survival
   c. The great arteries are transposed
   d. The great arteries are normally related
   e. A right aortic arch is usually present

5. a 6. e. 7. e. 8. d 9. e 10. b 11. a

12. Which of the following cyanotic congenital heart defects is NOT dependent upon a PDA for survival in infancy?
    a. TOF with pulmonary valve atresia
    b. Infradiaphragmatic total anomalous pulmonary venous return
    c. Transposition of the great arteries
    d. Pulmonary valve atresia with intact ventricular septum (hypoplastic right heart syndrome)
    e. Severe Ebstein's anomaly of the tricuspid valve
13. What is the echocardiographic feature of Ebstein's anomaly which is of most value to the cardiovascular surgeon in determining the possible success of tricuspid valvuloplasty?
    a. Atrial level shunting
    b. Apical displacement of the septal tricuspid leaflet
    c. Presence of tricuspid regurgitation
    d. Presence of a VSD
    e. Mobility of the anterior tricuspid leaflet
14. An echocardiogram done on a newborn infant reveals a normal appearing left heart with a small right ventricle, diminutive tricuspid valve, and no identifiable pulmonary valve. There is moderately severe tricuspid regurgitation with a severely enlarged right atrium. The pulmonary arteries are seen to be confluent and of near-normal size, supplied by a large PDA. Prostaglandin E1 is begun intravenously. Which of the following is a reasonable next step in clinical management?
    a. Stop prostaglandin therapy
    b. Begin dobutamine
    c. Closed or interventional pulmonary valvotomy
    d. Tricuspid valvuloplasty
    e. Waterston shunt
15. An infant is born with transposition of the great arteries with intact ventricular septum. A PDA is present and the baby is placed on prostaglandin E1 to maintain this. The infant remains cyanotic with an arterial saturation of 60%–63%. Which area of the heart should be studied thoroughly with echocardiography that would most likely account for this problem?
    a. The pulmonary venous return
    b. The ductus arteriosus
    c. The aortic arch
    d. The systemic venous return
    e. The atrial septum
16. A 2-week-old newborn is being evaluated for cyanosis and murmur. Echocardiography was performed as shown in Figure 14.1A (apical four-chamber view) and Figure 14.1B (parasternal short-axis view). The diagnosis of congenital heart disease was made. Based on these echocardiographic findings, what is the best guess of right ventricular systolic pressure?
    a. 1/2 systemic
    b. 3/4 systemic
    c. Near systemic
    d. Systemic
    e. Suprasystemic
17. A 2-day-old baby was found to have a decreased oxygen saturation of 84%. Echocardiography was performed to rule out any congenital heart disease. Figure 14.2 demonstrates color flow in the atrial septum from a subcostal view. This color flow pattern is seen throughout the cardiac cycle. Based on Figure 14.2, which one of the following defects would most likely produce this?
    a. Total anomalous pulmonary venous return (TAPVR)
    b. Truncus arteriosus
    c. Critical aortic stenosis
    d. TOF
    e. D-Transposition

12. b 13. e 14. d 15. e 16. d 17. a



Figs 14.1A and B

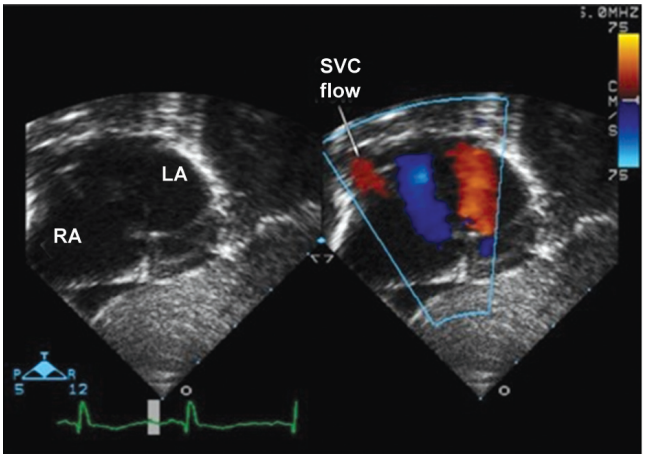


Fig. 14.2

18. A young adult was found to have an abnormal echocardiogram during evaluation of palpitations. The area marked with stars in Figure 14.3 demonstrates:

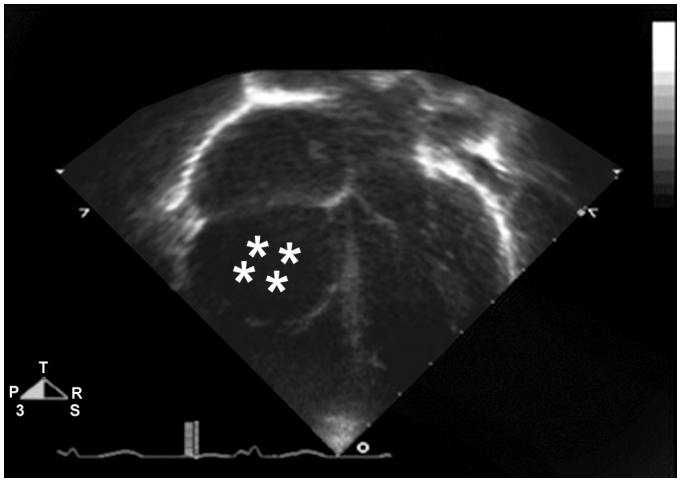


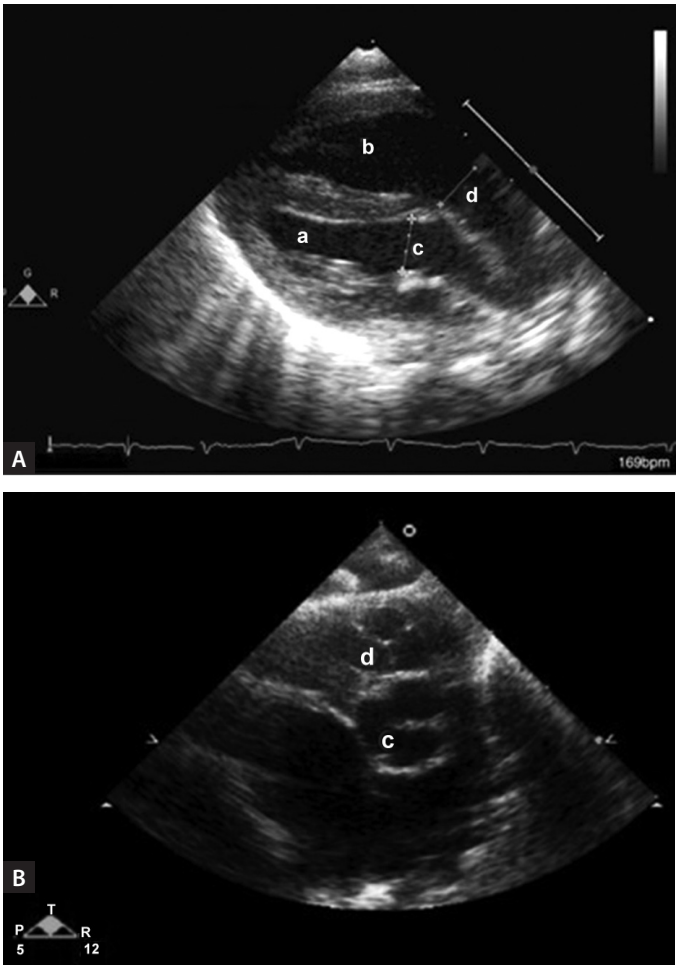
Fig. 14.3

a. Sail-like elongation of anterior tricuspid valve
b. Atrialized portion of right ventricle
c. Absence of tricuspid valve
d. Hypoplastic right ventricle
e. Left ventricular volume overload

19. A 1-day-old newborn is transferred from the newborn nursery to the NICU because of cyanosis. His oxygen saturation is 75% and does not improve with 100% FiO_2. Echocardiography is as shown in Figure 14.4A (parasternal long-axis view) and Figure 14.4B (parasternal short-axis view). Both ventricles (left ventricle = LV; right ventricle = RV) and both semilunar valves (aortic valve = AV; pulmonary valve = PV) are labeled. Which one of the following combinations is correct in this condition?
a. a = LV; b = RV; c = AV; d = PV
b. b = RV; a = LV; c = AV; d = PV
c. a = LV; b = RV; c = PV; d = AV
d. a = RV; b = LV; c = PV; d = AV

20. A 4-week-old girl presents to her primary care physician with parental complaints of bluish discoloration particularly with crying. On evaluation, her saturation is in the high 70s to low 80s. She was also found to have an ejection systolic murmur. Echocardiography was performed as shown in Figure 14.5A (parasternal long-axis) and Figure 14.5B (parasternal short-axis). Based on this information, which pathology will determine this girl's oxygen saturation?
a. Degree of right ventricular outflow tract obstruction
b. Size of the VSD
c. Degree of overriding of aorta
d. Size of the ASD

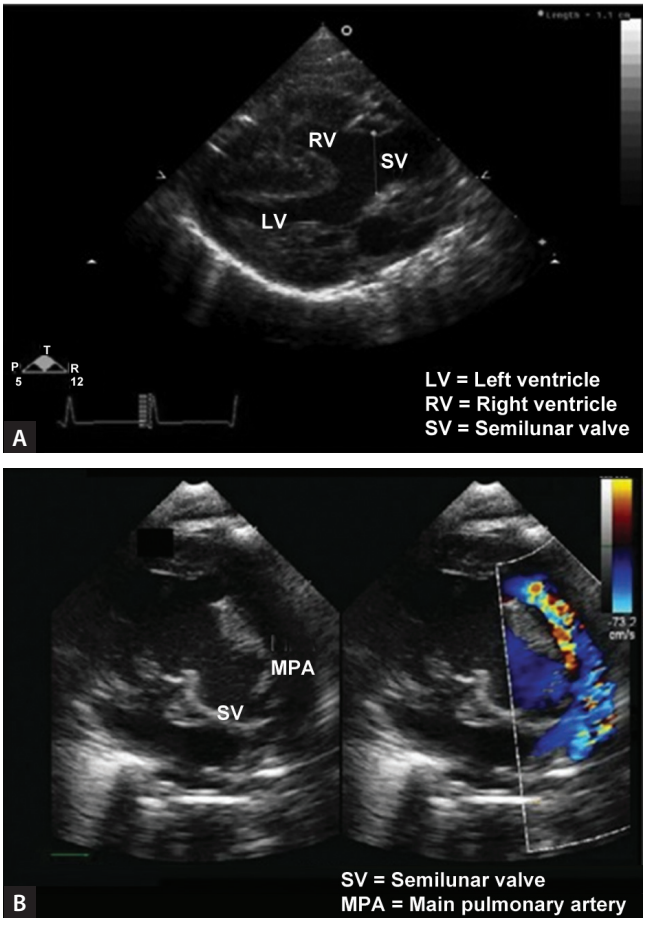
18. b 19. c 20. a



Figs 14.4A and B

21. A 19-year-old young man was referred to cardiology clinic for evaluation of easy fatigability with sports and exercise activity. His vitals were within normal limits except oxygen saturation which was 86%. Echocardiography was performed as shown in Figure 14.6 (apical view). Which one of the following describes the patient's condition?
    a. Tricuspid atresia
    b. Pulmonary hypertension
    c. Uhl's anomaly
    d. Ebstein's anomaly
    e. Large ASD

21. d



Figs 14.5A and B

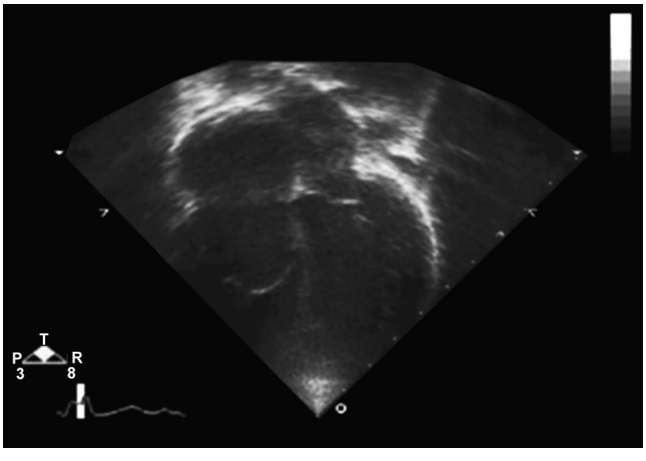


Fig. 14.6

22. A 6-week-old male infant was referred to the pediatric cardiology clinic for an ejection systolic murmur which was found during a routine clinic visit in the primary pediatrician's office. He was born at full term and was discharged home on the second day of life. His parents mentioned that he had frequent episodes of bluish discoloration particularly associated with crying. Detailed examination showed a normal growth pattern for his age. He was breathing comfortably with an oxygen saturation of 86% at room air. The lungs were clear to auscultation. He had a normal S1 and S2 along with an ejection systolic murmur at the upper left sternal border. There was no organomegaly. His pulses were equal without any radiofemoral delay. His echocardiogram was performed which is shown in Figure 14.7.

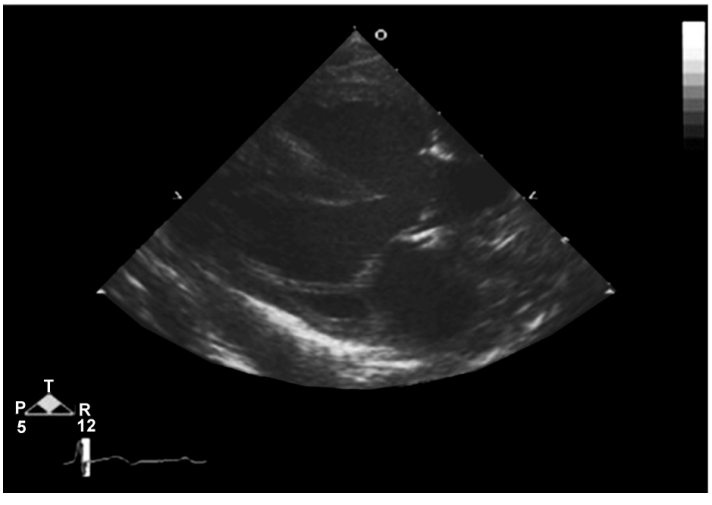


Fig. 14.7

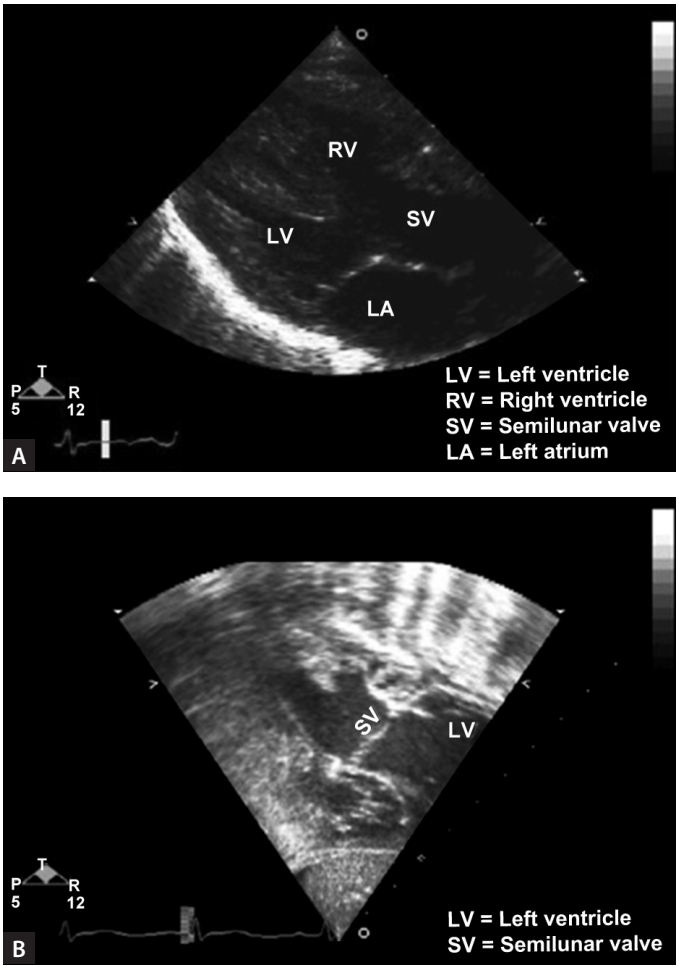
Based on his clinical presentation and echocardiography, the most likely defect is:

a. Truncus arteriosus
b. TOF
c. D-Transposition of great arteries with a VSD
d. Tricuspid atresia
e. Perimembranous VSD

23. A 6-week-old infant was admitted to the PICU with poor feeding, respiratory distress, and mild cyanosis. Chest X-ray showed pulmonary congestion. Echocardiography was performed and is shown in Figure 14.8A (parasternal long-axis) and Figure 14.8B (apical view). Which of the following best describes this child's condition?

a. The findings are consistent with a diagnosis of TOF
b. The findings suggest a lesion in which both great arteries arise from the right ventricle
c. The findings suggest a single artery giving rise to the systemic and pulmonary arteries
d. This condition is frequently seen in Trisomy 21
e. The child has anomalies of pulmonary venous return

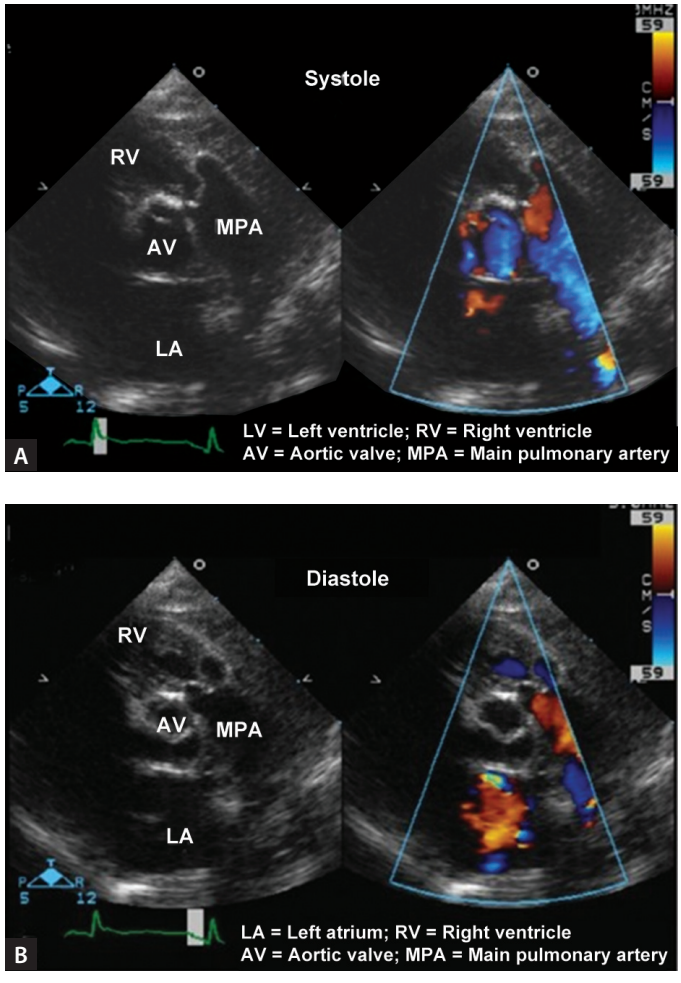
22. b. 23. c



Figs 14.8A and B

24. You are called for an echocardiogram in the NICU on a newborn infant whose saturation is 80% at room air. Parasternal short-axis views were performed as shown in Figures 14.9A and B (systole and diastole, respectively). What is the next most important piece of information you would like to find out in this patient that will define proper diagnosis of this condition, natural history of this lesion, and future surgical management?
    a. Evaluation of the atrial septum
    b. Evaluation of the ventricular septum
    c. Size of the left ventricle
    d. Evaluation of the aortic arch
    e. Evaluation of the pulmonary veins

24. b



Figs 14.9A and B

25. Echocardiography was performed on a 48-hour-old newborn because of persistent cyanosis. Figure 14.10 (apical view) is shown. Based on this, what is the diagnosis?
    a. TAPVR
    b. Complete atrioventricular canal defect
    c. Tricuspid atresia
    d. Ebstein's anomaly
    e. Transposition of the great arteries

26. The single anatomic hallmark responsible for each of the anatomic components in this condition is:
    a. Hypertrophy of RV muscle bundles
    b. Anterior deviation of the outlet septum
    c. Dysplasia of the pulmonary valve
    d. Posterior deviation of the outlet septum
    e. Distortion of the branch pulmonary arteries

25. c. 26. b.

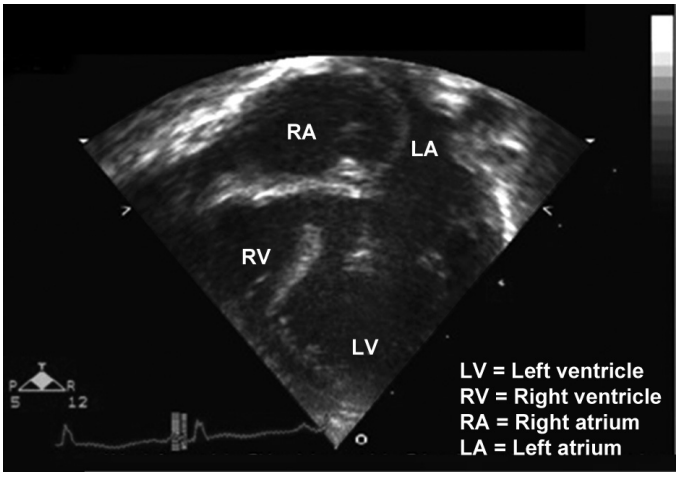

RA
LA
RV
LV
LV = Left ventricle
RV = Right ventricle
RA = Right atrium
LA = Left atrium

Fig. 14.10

Answers

1. d. Congenital heart disease is found in about 0.5–0.8% of live births. Tetralogy of Fallot (TOF) is the fourth most common form of congenital heart disease, comprising about 10% of the total cases. Transposition of the great arteries would be the next most common in frequency, accounting for about 5%. Truncus arteriosus, tricuspid atresia, and total anomalous pulmonary venous return are relatively rare, accounting for only about 1–2% of the total cases of congenital heart disease, respectively. A common mnemonic for remembering this has been that all forms of cyanotic disease begin with the "T." This is a reasonable way to remember the ones listed earlier, but this trick does not hold true completely. Additionally, the initial presentation for patients with "cyanotic" congenital heart disease, may not always be clinical cyanosis, even though these patients may eventually become cyanotic over time.
2. c. 50–70% of patients with Ebstein's anomaly also have an atrial septal defect (ASD). Ventricular septal defects (VSDs) and pulmonary atresia are also seen, but rarely. Left-sided heart lesions, such as aortic valve stenosis or coarctation of the aorta, are very uncommon in Ebstein's anomaly. The direction of shunting across this ASD can change during a patient's lifetime. During the newborn period, these patients will often be profoundly cyanotic due to right-to-left shunting. As pulmonary resistance drops and right ventricular compliance increases, the shunting will change to left-to-right and the cyanosis may disappear until young adulthood when the right ventricle stiffens and the right-to-left shunting resumes. From a clinical perspective, a patient with known Ebstein's anomaly who has any degree of cyanosis may be presumed to have an ASD.
3. a. The anatomic description is consistent with truncus arteriosus. There is also a malalignment VSD with override of the semilunar valve, in this case referred to as the "truncal" valve. Up to 33% of patients with truncus arteriosus will have DiGeorge syndrome, characterized by abnormal facies, thymic hypoplasia, and parathyroid hypoplasia or aplasia resulting in hypocalcemia. A large proportion (70%) of patients with DiGeorge syndrome have microdeletions of *22q11*. This is so prevalent that DiGeorge syndrome and 22q11 deletion have become almost synonymous, although that is not completely accurate. Truncus arteriosus is not generally a ductal-dependent lesion, as the pulmonary artery blood supply is usually vigorous. Ductal-dependent lesions include defects which compromise great artery flow such as aortic or pulmonary valve atresia. Atrioventricular valve atresia will usually require an ASD for survival. The oxygen saturation is likely to slightly decrease in truncus arteriosus, due to mixing at the great artery level. However, patients with truncus arteriosus are not usually profoundly cyanotic and may have near-normal saturations. Surgical repair is often carried out as a newborn, and should not be deferred for longer than a few months, if at all, due to a fairly high incidence of pulmonary vascular obstructive disease or Eisenmenger's syndrome, if it is not corrected early. Due to the absence of a main pulmonary artery, surgical repair involves closure of the VSD and placement of a right ventricle to pulmonary artery conduit—an important point for the future since the conduit may require multiple replacement operations during the lifetime of the patient.
4. c. The tricuspid regurgitant signal predicts a pressure in the right ventricle of about 90 mm Hg, using the modified Bernoulli equation. A patient with TOF will generally have a large VSD which has no real chance of closure or restriction. Therefore, the pressures in the right and left ventricles will equalize at systemic levels and the finding of a high tricuspid regurgitant velocity is expected in all cases. It is very unlikely (but not impossible) that pulmonary hypertension could develop in tetralogy patients. However, the usual presence of pulmonary valve and subvalvular stenosis generally protects the pulmonary arterial bed from hypertension. The presence of a loud murmur in the pulmonary area supports the presence of this finding.
5. a. This scenario describes a patient with transposition of the great arteries and VSD. The VSD is usually large in this scenario, so pulmonary pressures will be at systemic levels and pulmonary

"hypertension" is technically present. This does not imply the presence of pulmonary vascular obstructive disease, which would be unlikely in an infant. Coarctation of the aorta, even if present, is an answer of no significance. Most patients with transposition actually have somewhat increased pulmonary blood flow with newborn transposition, despite the cyanosis. Total anomalous pulmonary venous return may produce cyanosis but would require a right-to-left atrial shunt and there is nothing in this scenario which points in that direction.

6. e. Detection of congenital heart disease can occur for many reasons. An increasing number of patients are detected prenatally by ultrasound examination. Even though these problems are "cyanotic" problems, cyanosis may be relatively mild as a clinical clue and go undetected. All of the diagnoses listed in the question might go undetected for a period of time. Transposition of the great arteries usually presents with profound cyanosis as a newborn. However, those patients with transposition and VSD may be less cyanotic and may present later with a heart murmur. This scenario is rare. TOF frequently presents as an asymptomatic heart murmur. However, the heart murmur is not subtle and usually brings the patient to attention in the first few weeks of life. A patient with TOF with pulmonary atresia might be the silent exception. Tricuspid valve atresia may also present later in infancy with a heart murmur, but it is very rare for these patients to escape detection until adulthood. Supracardiac total anomalous pulmonary venous return will frequently have very mild, if any, clinical cyanosis. The heart murmur is soft and can be subtle. Some patients will escape detection in the first months of life and a very few patients have been known to escape detection until adulthood, but this is also fairly rare. Ebstein's anomaly can be very mild and patients may have little if any murmur. If there is no ASD, then they will not be cyanotic or have much exercise intolerance. Ebstein's can present with severe cyanosis as a newborn. However, mild forms of Ebstein's anomaly represent the most subtle of the choices and the most likely answer.

7. e. The spectrum of anomalies producing cyanosis is fairly broad and all of the reasons given may account for the clinical phenomenon of cyanosis. Realize that clinically cyanosis is due to a bluish discoloration of the skin. This is seen when the deoxyhemoglobin levels exceed about 4–5 gm%. Therefore, cyanosis may also be affected by the overall hemoglobin levels in the body since an oxygen saturation of 70% (30% of the hemoglobin will be desaturated as in the "deoxy" state) will reach the 5 gm% level much easier in a polycythemic patient than in an anemic patient. Patients who have decreased pulmonary flow and an intracardiac shunt, will be cyanotic because the amount of saturated pulmonary vein flow returning to the heart is diminished. Additionally, patients with simple shunts or even mixing lesions will not necessarily be cyanotic since they will have exuberant pulmonary flow and excessive pulmonary venous return. However, the answer is based more on the frequency of anomalies producing cyanosis. Tetralogy is common and has decreased pulmonary flow. Added to this are numerous other complex defects for which pulmonary stenosis is also a component. Patients with cyanosis due to great artery position or pulmonary vein anomalies are much rarer.

8. d. Ebstein's anomaly is characterized by apical displacement of the septal and inferior leaflets of the tricuspid valve. An established criterion for diagnosis of Ebstein's anomaly is apical displacement of the tricuspid valve septal leaflet from the crux of the heart by greater than 8 mm/m^2 body surface area. In addition, an elongated (sail-like) anterior leaflet is present. Because of its anatomical derangement, the malformed tricuspid valve is typically regurgitant (and in rare cases stenotic). An atrial-level communication (ASD or patent foramen ovale) is present in up to 75% of cases. The volume overload of the right heart caused by the tricuspid regurgitation commonly leads to paradoxical septal motion. VSDs are seen in about 5% of patients with Ebstein's anomaly, but they are not common, thus the correct answer is "(D)."

9. e. Anomalous pulmonary venous connections are to the systemic venous system and may occur in a variety of ways. The most common is connection to the innominate vein (supracardiac). There may also be connections to the right atrium or coronary sinus. Connections below the

diaphragm to the hepatic veins, through the liver, are frequently severely obstructed, creating a surgical emergency. A connection to the left atrium would be normal, and not anomalous, making this the answer.

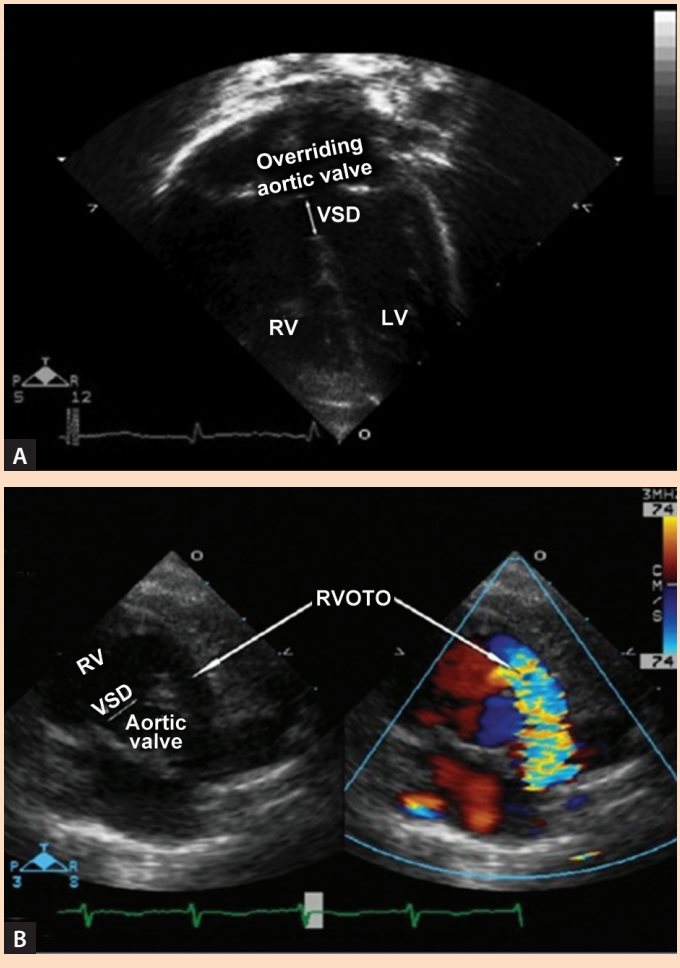
10. b. There are a number of congenital defects which may present with a large malalignment VSD and overriding great vessel. The most common of these would be TOF. However, the great vessel is not always the aorta. Other "look-alikes" for this particular view might be truncus arteriosus, double-outlet right ventricle, D-transposition with VSD, or pulmonary atresia with VSD. In each case, the parasternal view may be similar but the key is identifying the position and status of the pulmonary artery. This is the key for both the proper diagnosis as well as aiding in predicting the clinical course. The presence of an ASD and the position of the arch may be important adjunctive items to add to the overall imaging picture but they do not have great clinical significance. The size of the VSD in this situation is virtually always one of a large and unrestricted flow. Tricuspid valve Doppler adds little in this situation.
11. a. All forms of tricuspid valve atresia must have some type of atrial communication to decompress the right atrium and allow for egress of blood from that chamber. Tricuspid atresia does not have to be ductal-dependent. This is more likely to be the case in instances of outflow obstruction rather than inflow obstruction. In cases of tricuspid atresia with transposition, there is frequently aortic coarctation present and this might become ductal-dependent if it is severe. However, ductal dependency is generally a phenomenon of early infancy, which comes to light after ductal closure in the first day or two of life–not a very common likelihood in a 2-month-old patient. Tricuspid atresia will present anatomically in two forms: 1) normally related great arteries (75%) and 2) transposition of the great arteries (25%). With either great artery position, there is complete mixing of pulmonary venous and systemic venous blood at atrial and ventricular levels and saturations overall will depend upon the amount of pulmonary blood flow. In this instance, the saturation is fairly high, suggesting vigorous pulmonary blood flow, but one cannot specifically distinguish between normal or transposed great arteries based on that finding alone. The arch position is irrelevant, but it is very rare to see a right aortic arch with tricuspid atresia.
12. b. The ductus arteriosus connects the main pulmonary artery and the aorta and can provide flow from one to the other when that flow is compromised by a serious congenital heart defect. Most of the time the defects which are "ductal-dependent" will be defects involving outflow obstruction or atresia such as: aortic atresia, pulmonary atresia, severe or critical aortic stenosis, or critical pulmonary stenosis. Transposition of the great arteries may or may not be ductal-dependent depending upon all of the features of anatomy, but it can be in some cases. Inflow atresia like mitral or tricuspid atresia may or may not be ductal-dependent if they have concomitant outflow problems or atresia. Ebstein's anomaly in the newborn is unusual because there is often no outflow atresia anatomically, but the poor antegrade flow through the pulmonary valve created by the abnormal tricuspid valve and right ventricle, often makes then ductal-dependent until the pulmonary resistance falls after a few days or weeks. Total anomalous pulmonary venous return below the diaphragm (infradiaphragmatic) is a severe lesion with often obstructed pulmonary venous return. However, the hemodynamics has nothing to do with the ductus arteriosus. Indeed, keeping the ductus open with prostaglandin E1 in this situation is often detrimental by increasing pulmonary artery flow into an obstruction.
13. e. Ebstein's anomaly is characterized by apical displacement of the septal and inferior leaflets of the tricuspid valve. The anterior leaflet is enlarged, elongated, and will have varying degrees of tethering to the right ventricular free wall which can limit the mobility of the valve. Echocardiographically, physicians often concentrate on the unusual apical displacement of

the septal leaflet and the degree of tricuspid regurgitation. However, most surgical repairs (as opposed to replacement) of Ebstein's valves utilize the anterior leaflet as the primary portion of the apparatus which provides information about any valvular integrity. As such, this portion of the valve needs to be fairly mobile so that it can function as a "monocusp" valve after valvuloplasty. Therefore, the preoperative imaging must include multiple views of the anterior leaflet to be able to assess this mobility. Choices (A)–(D) are all features that may be present in Ebstein's anomaly but their presence does not necessarily determine success of a valvuloplasty.

14. d. The echocardiogram describes a patient with pulmonary valve atresia with an intact ventricular septum, often called the "hypoplastic right heart syndrome." This terminology is losing favor because there are other anatomic forms of congenital heart disease that may also have a small right ventricle which are markedly different and do not belong to the same category as noted earlier. There is a wide variety of anatomic situations within this group which include varying degrees of right ventricular hypoplasia. In the simplest form, with right ventricular hypoplasia that is not severe, patients may be treated with either surgical or even catheter-based pulmonary valvuloplasty. This approach addresses the primary problem of pulmonary valve atresia and potentially allows the patient to have a course of therapy which will lead to a four-chamber repair with two usable ventricles. Stopping prostaglandin therapy would be inadvisable in this setting. This is a ductal-dependent lesion and keeping the ductus arteriosus open with prostaglandin E1 is essential. Dobutamine is usually not needed unless there is decreased cardiac output. In this example, there is no clinical information to support that. In many instances, a Blalock-Taussig shunt (subclavian artery to pulmonary artery) is done either in isolation or in addition to the pulmonary valvuloplasty to augment the pulmonary blood flow. A Waterston shunt would do the same thing but these are almost never done any more because of difficulties controlling pulmonary blood flow. Patients with diminutive right ventricles may also have very high pressure (suprasystemic) in that chamber which can lead to the development of coronary fistulae and retrograde flow into the left coronary system. This "RV-dependent coronary circulation" can be an ominous sign and is associated with arrhythmia and sudden death. In these instances, a heart transplant may be the best viable option. Frequently, there may be significant tricuspid regurgitation and subsequent right atrial enlargement. Despite this, the tricuspid valve is usually left alone. Decreasing the tricuspid regurgitation may be a goal later in the course of management but it would never be the next step at this stage. Ultimately, the decisions would be to: (1) proceed with a four-chamber repair (if the right ventricle is big enough), (2) go the pathway of a single ventricle repair with an ultimate Fontan operation, and (3) heart transplant. All of these widely variant options make the decision tree for these patients very interesting and individualized.

15. e. Patients with transposition of the great arteries have two parallel circulations and survive with areas where the systemic and pulmonary circulations can mix. These include the atrial septum, the ventricular septum, and the ductus arteriosus. The atrial septum is by far the most effective place for infants with transposition to have mixing. If the atrial defect is small and constricted, this will likely result in more cyanosis, even if the ductus arteriosus is widely patent. Infants with a large VSD may also have problems mixing at the ventricular level. In this case, the ductus arteriosus should be examined, but prostaglandin is generally an effective drug and keeps the ductus widely patent. Checking the dosage, route of delivery, and status is always a good idea and would be a close second to the atrial septum as a place to check right away. The aortic arch should not have any bearing on cyanotic or hypoxemic issues. Anomalies of systemic and pulmonary venous return may be involved in cyanosis, but are less likely as answers here.

16. d. This patient has TOF. Figure 14.11A shows malaligned VSD and overriding of aorta. Figure 14.11B shows right ventricular outflow tract obstruction in the form of infundibular (subpulmonary) narrowing. TOF is a conotruncal anomaly that is classically defined as having the following four components: (1) right ventricular hypertrophy, (2) VSD, (3) overriding aorta, and (4) pulmonary stenosis. Tetralogy occurs in approximately 9% of children born with congenital heart defects. The VSD in TOF is usually large and nonrestrictive. Only in rare cases, will it be restrictive. In Figures 14.11A and B, the VSD appears to be typically large and nonrestrictive. This will result in equalization of pressure between the ventricles. Since the left ventricle will always pump systemic pressure, this will also be the pressure in the right ventricle.
17. a. This example shows an intra-atrial shunt which is right to left and is present throughout the cardiac cycle. This suggests that the patient has an exclusive right-to-left shunt at the atrial level. In TAPVR, all of the venous return (systemic and pulmonary) comes to the right atrium. Some of the returning blood must be shunted through an ASD and enter into the left side



Figs 14.11A and B

of the heart and into the systemic circulation. Thus, in TAPVR, the only source of blood into the left atrium, is from the right atrium resulting from an obligatory right-to-left shunt at the atrial level. It would be quite unusual for the other cyanotic lesions listed to have right-to-left atrial shunting. However, in tricuspid atresia, the only egress from the right atrium is through the atrial septum to the left atrium, and in Ebstein's anomaly the right heart antegrade flow is impaired. So, in TAPVR, tricuspid atresia, and early in Ebstein's anomaly, the shunt at the atrial level is right-to-left as seen in this patient. In critical aortic stenosis, the shunt at the atrial level is predominantly left-to-right. There is a bidirectional shunt at the atrial septal level in truncus arteriosus.

18. b. This patient has Ebstein's anomaly of the tricuspid valve. This lesion was initially described in 1866 by the German physician Wilhelm Ebstein. Characteristic pathologic findings include apical displacement of the septal and posterior leaflets of the tricuspid valve into the right ventricle to varying degrees. The arrowheads in Figure 14.12 show the tricuspid valve annulus. The portion of the right ventricle between the true valve annulus and the apically displaced valve leaflets forms an "atrialized" portion of the right ventricle that is continuous with the true right atrium. Although the atrialized portion of the right ventricular anterior wall may be thin, the distal unaffected portion of the right ventricular wall is usually normal in thickness.

    In Ebstein's anomaly, the effective right ventricular size is reduced depending upon the severity of the tricuspid valve displacement. However, it is not associated with hypoplasia of the right ventricle. The choice (C) is incorrect as the tricuspid valve is seen to be displaced apically. The anterior leaflet of the tricuspid valve cannot be seen in the apical four-chamber view. Instead, the posterior and septal leaflets are very well seen in Figure 14.12.

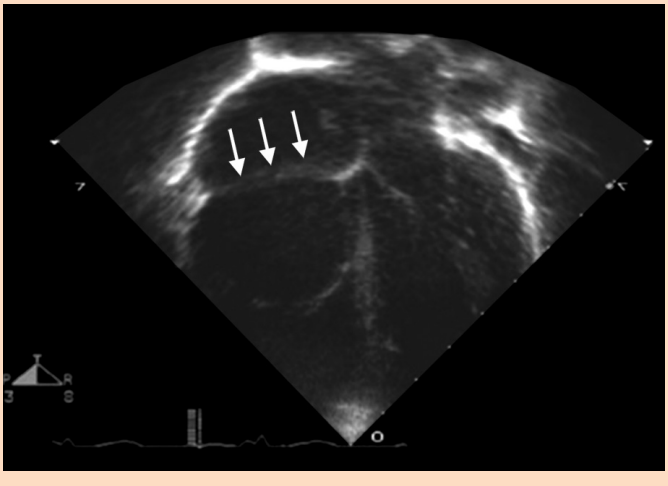
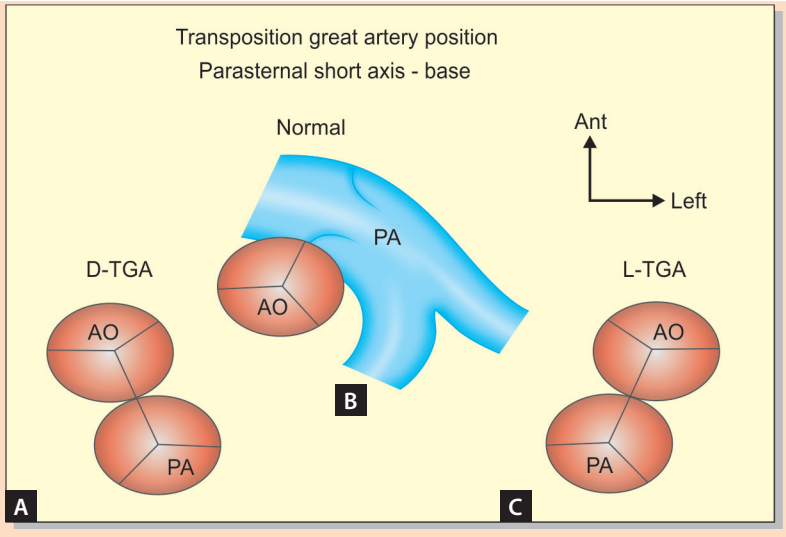


Fig. 14.12

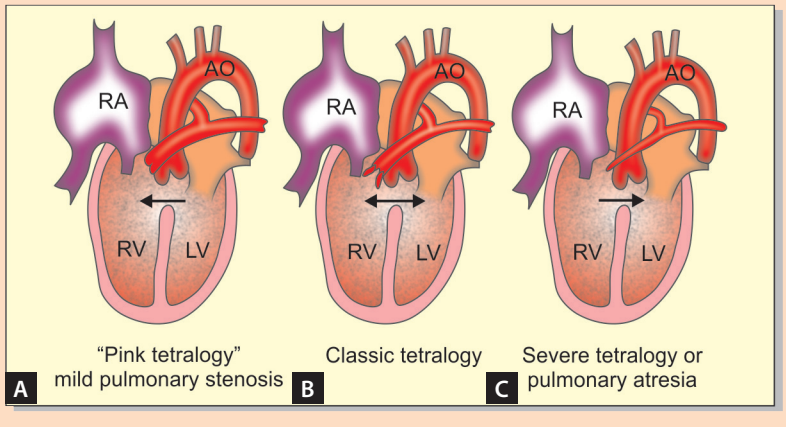
19. c. This patient has D-transposition of great arteries. Transposition is defined as a connection of the aorta to the right ventricle and the pulmonary artery to the left ventricle. This abnormal ventricular arterial connection is also termed "ventriculo-arterial discordance" and probably results from abnormal conotruncal septation. Transposition occurs in approximately 4–8% of children born with congenital heart defects. "D-transposition" is a term which refers to the way the conotruncal septum rotates *in utero* ("D" for dextro) and has been commonly applied to this entity. In transposition, the aorta arises from the right ventricle, usually in a position which is anterior and rightward of the pulmonary valve (Fig. 14.4B in the case). The two great arteries course parallel to one another; a distinctly different arrangement from the normal pulmonary artery crossing over the aortic root (Fig. 14.4A in the case).



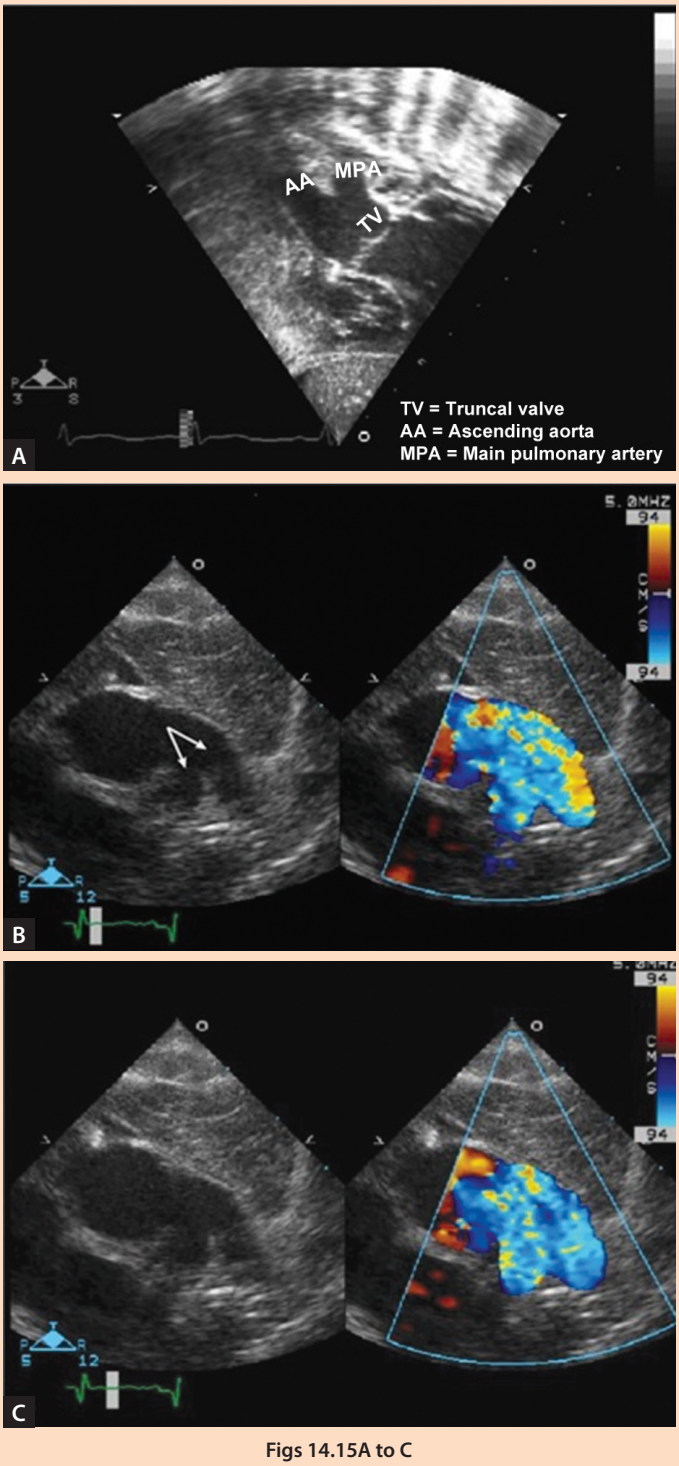
Figs 14.13A to C

Figures 14.13A to C demonstrates the position of the great arteries as commonly seen from the echocardiographic perspective of the parasternal short-axis view. Great artery position is a key to identifying the type of transposition. Normally, the pulmonary artery wraps around the aorta anteriorly as it courses posteriorly (Fig. 14.13B). With D-transposition, the great arteries assume a parallel course, and the aorta is located anterior and rightward of the centrally located pulmonary artery (Fig. 14.13A). In L-transposition, the great arteries are again parallel, but the aorta is anterior and leftward (Fig. 14.13C). It is important to note that in normally related great vessels, the pulmonary valve and aortic valve are not in the same plane while in any form of transposition, they are usually in the same plane as shown in Figure 14.4B as d and c, respectively, because of the generally more parallel course of the great arteries in transposition.

20. a. Figure 14.5A illustrates a malalignment of the VSD with overriding of aorta. Figure 14.5B shows the narrowing of right ventricular outflow tract, hypoplastic pulmonary valve, and hypoplastic main pulmonary artery. This is consistent with the diagnosis of TOF. The oxygen saturation is



Figs 14.14A to C



Figs 14.15A to C

determined by how much blood goes across the right ventricular outflow tract (RVOT) into the pulmonary artery and thereby the degree of RVOT obstruction. It is important to note that RVOT obstruction can be at any level and can be at multiple levels—subvalvar, valvar, and or supravalvar. The degree of aortic override is usually about 50% but has been observed to range from 15 to 95% in one echocardiographic study. However, neither the VSD nor the degree of overriding of the aorta determines the level of saturation in TOF. An ASD/patent foramen ovale is present in most cases of TOF. The presence of an ASD is important to know for surgical purposes, but it does not have any role in the determination of oxygen saturation in TOF.

Based on the severity of right ventricular outflow tract obstruction, TOF can present in mainly three different forms. These clinical/anatomic variables (Figs 14.14A to C) include: (a) "Pink" tetralogy; (b) Classic tetralogy; and (c) Pulmonary atresia/VSD (tetralogy with pulmonary atresia). It is important to recognize that these descriptions refer to a starting point at the time of diagnosis and are helpful in trying to predict the subsequent clinical course. In the "pink" form of TOF, there is minimal narrowing/RVOT obstruction. This infant will have very little or no cyanosis at all and may even exhibit some symptoms of pulmonary overcirculation. The right ventricular outflow obstruction in tetralogy tends to change and worsen with time, causing more severe restriction of pulmonary blood flow. In the classic form of TOF, there is less blood flow to the lungs, the peripheral saturation will be lower than normal, and some infants are cyanotic. These patients may need a shunt surgery (Blalock-Taussig shunt) in the early period of their life to provide adequate pulmonary blood flow. Patients may start life "pink" and progress to a cyanotic stage with time. However, in practical terms, this happens infrequently in the modern age because infant surgery is generally available to address this trend. Early primary repair is often carried out within the first few months of life. Patients with pulmonary atresia are ductal-dependent and represent a very complex spectrum of tetralogy patients. There may be many anatomic variables in this group depending upon the anatomy of the pulmonary blood supply.

21. d. Ebstein's anomaly is a severe deformity of the tricuspid valve which results from failure of the normal development of the septal and posterior leaflets. These leaflets become displaced apically and are adherent to the septum and wall of the right ventricle, respectively. The anterior leaflet becomes enlarged and "sail-like" with variable attachments to the trabecular portion of the right ventricle and outflow area. The apical displacement of the valve reduces the effective volume of the right ventricle available for pumping function. In addition, the Ebstein's valve usually is quite insufficient. All of these factors contribute to tricuspid regurgitation, poor forward flow, and the potential for right-to-left shunt through an ASD or foramen ovale. Thus, patients with severe Ebstein's anomaly may be profoundly cyanotic, particularly as newborns. This cyanosis usually resolves after several weeks once pulmonary resistance starts to drop after the birth of the child. Patients with a less severe form of Ebstein's anomaly may be clinically quite well for many years till young adulthood such as given in the case.

This is not a case of tricuspid atresia as the tricuspid valve is seen displaced apically. Patients with pulmonary hypertension (primary or secondary to Eisenmenger's syndrome) can present with low saturation and limitation of exercise capacity, but they do not have the anatomical abnormality of the tricuspid valve as shown in the Figure. A large ASD can lead to dilation of the right atrium and right ventricle secondary to a large left-to-right shunt. Less than 7–10% of patients with large ASDs can develop Eisenmenger's syndrome in their late adulthood or in old age. Nonetheless, they also will not have such an anatomical abnormality of the tricuspid valve. Uhl's anomaly is an extremely rare congenital heart disease characterized by an almost total absence of the right ventricular myocardium. Less than 20 cases have been reported so far. It was first described in 1980. In Uhl's anomaly, the tricuspid valve is normal.

22. b. Echocardiography shows overriding of the aorta with a malaligned VSD. Although patients with tricuspid atresia present with cyanosis and heart murmur, they do not have such

echocardiographic findings. Patients with truncus arteriosus, D-transposition of great arteries with VSD, and simple VSD might have similar appearing echocardiographic features; but they usually present with the symptoms of pulmonary overcirculation such as respiratory distress, hepatomegaly, and poor weight gain.

This is a typical presentation of a classic form of TOF. TOF is the most common cause of cyanotic congenital heart disease in children. The salient feature of this defect is an anterior deviation of the infundibular septum which narrows the right ventricular outflow tract leading to subpulmonary stenosis. The anterior deviation of the infundibular septum also is responsible for the malalignment of the VSD and the overriding (dextroposition) of the aorta. The VSD in tetralogy is virtually always large and nonrestrictive, leading to systemic pressures in the right ventricle. The pulmonary stenosis in tetralogy is highly variable but usually increases in severity with age. Progressive subvalvular (infundibular) pulmonary stenosis leads to increasing obstruction to pulmonary blood flow. With such an obstruction, two things happen: (1) right-to-left shunting occurs at the ventricular level, (2) relatively less blood gets to the lungs to become oxygenated. The combination of these two effects results in increasing cyanosis. The severity of pulmonary stenosis generally determines the magnitude of the right-to-left shunt. Unlike isolated large VSDs, patients with TOF will be relatively protected from the high-pressure damage to the lung vasculature because the pulmonary stenosis restricts lung flow and pressure and does not present with signs and symptoms of pulmonary overcirculation. Patients with TOF present most often with an asymptomatic heart murmur heard at the first office visit to the pediatrician or family practitioner. Some will also be picked up in the newborn period, but the murmur is often much softer at that time because (1) the subpulmonary stenosis has not developed significantly to produce turbulence and (2) pulmonary resistance is high and flow is decreased in the first day of life as the infant goes through normal transition. The children usually remain asymptomatic early in life, with normal growth and development. Symptoms develop with increasing desaturation and cyanosis.

23. c. This infant has truncus arteriosus. The parasternal long-axis view shows the malalignment VSD and overriding great vessel, similar to many other conotruncal abnormalities. The modified apical view in Figure 14.15A shows that the great artery divides into two segments, typical of truncus arteriosus.

Color flow Doppler can help to illuminate the division of the great artery as shown in Figure 14.15B.

Figure 14.15B the arrows demonstrate the division of the common trunk into the anterior aorta and the more posterior pulmonary artery segment. This is more often better seen from a parasternal short-axis view as shown in Figure 14.15C.

Truncus arteriosus is an uncommon congenital heart defect of the outflow tract of the heart. A single arterial vessel gives rise to the systemic, pulmonary, and coronary arteries. By definition, there is always a large malalignment VSD and the presence of a truncal valve instead of separate pulmonary and aortic valves. During normal embryology, the common arterial trunk undergoes septation to allow the aorta to arise from the left ventricle and the main pulmonary artery to arise from the right ventricle. An absent or abnormal conotruncal septation leads to persistence of truncus arteriosus.

Choices A and B are both incorrect, as in both conditions, the pulmonary artery arises from the right ventricle instead of a single truncal artery. Truncus arteriosus is associated with DiGeorge syndrome not with Trisomy 21 (VSD and complete atrioventricular canal defect are associated with Trisomy 21). There is nothing in the images which suggests the presence of anomalous pulmonary venous return, although the scenario of pulmonary congestion and cyanosis would potentially suggest this entity.

24. b. This example demonstrates pulmonary valve atresia. There is no forward flow or regurgitation in the pulmonary valve region, establishing the atresia. Even though what appears to be a valve seen in the pulmonary position, it never opens.

    Pulmonary valve atresia is divided into two broad categories based on the presence or absence of VSD. These two categories actually describe very different anatomic entities. These are: (1) pulmonary atresia with intact ventricular septum (PA/IVS) and (2) pulmonary atresia with VSD (PA/VSD). PA/IVS is also commonly referred to as the "hypoplastic right heart syndrome," although this is an older terminology, not used commonly. PA/IVS will have varying degrees of right ventricular hypoplasia and will frequently need to be repaired as a single ventricle. PA/VSD is a severe form of TOF. However, because of the wide variety of sources of pulmonary blood flow which may be encountered in PA/VSD, it is often described separately from tetralogy patients.

    Usually, left ventricular size is adequate in all cases of pulmonary atresia. Choice D is incorrect because it is very unlikely to have pulmonary atresia and aortic arch abnormalities, such as coarctation of aorta or interrupted aortic arch. A right aortic arch may be seen more frequently in PA/VSD, but this is unlikely to help clinically in any great way. Evaluation of the atrial septum is useful but the presence or absence of an atrial septal defect will not change the diagnosis, natural history, or future surgical management. The pulmonary veins should always be examined but anomalies in this area are infrequent with any form of pulmonary atresia and are therefore of lesser importance.

25. c. The primary anatomic feature of tricuspid atresia, as shown in Figure 14.10, is the absence of the tricuspid valve, which prevents normal flow of right atrial blood directly into the right ventricle. The resulting membrane is usually muscular but may be fibrous. This membrane is very well seen in Figure 14.10, where the mitral valve is open with a membrane in place of the tricuspid valve. An ASD must be present to allow blood out of the right atrium. Tricuspid atresia provides a good example of the concept of downstream obstruction. When stenosis or atresia occurs at one level (in this case at the tricuspid valve level), obstruction or hypoplasia is often present downstream or in the path where blood would normally have flowed. For this question, it is common to have hypoplasia of the right ventricle, particularly the inlet portion. The development of a trabecular portion of the right ventricle and pulmonary arteries depends upon the presence of a VSD.

    Total anomalous pulmonary venous return will produce an echo picture of right heart enlargement and perhaps relative left heart hypoplasia, with right-to-left shunting at the atrial level. Complete atrioventricular canal defect includes a common AV valve, large inlet VSD, and primum ASD which are not shown in Figure 14.10. Choices (d) and (e) are also incorrect as in these conditions, the tricuspid valve is present.

26. b. The infundibular obstruction found in TOF has been postulated to be a result of the anterior displacement of the bulbotruncal ridges with unequal separation of the developing outflow tracts and anterior deviation of the outlet septum. Anterior deviation of this septum results in misalignment of the outlet and trabecular portion of the ventricular septum causing a malaligned VSD and subsequent straddling of the aorta over the malaligned ventricular septum.

    When stenosis or obstruction occurs at one level (in this case, at the right ventricular infundibular level), hypoplasia is often present downstream or in the path where blood would normally have flowed. In this case, it is common to have hypoplasia of the pulmonary valve and pulmonary arteries. Right ventricular hypertrophy is secondary to right ventricular outflow tract obstruction which has resulted from anterior displacement of the outlet septum. Posterior deviation of the outlet septum is seen in the Taussig-Bing variety of double-outlet right ventricle, not in TOF.

15

Echocardiography for Pulmonary Hypertension

1. Which of the following is an abnormal right ventricular (RV) dimension in an adult 30 years old?
   a. Basal RV diameter of 2.5 cm
   b. Mid RV diameter of 3.8 cm
   c. Right ventricular outflow tract (RVOT) diameter above the aortic valve of 2.6 cm
   d. Base to apex RV length of 7.5 cm

2. Which is an abnormal finding in an adult 30 years old?
   a. Tricuspid annular excursion of 2.0 cm
   b. RV end-diastolic area of 26 cm^2
   c. RV end-systolic area of 19 cm^2
   d. RV fractional area change of 40%

3. Which of the following is true concerning right atrial (RA) dimensions/area?
   a. RA volumes can be measured in low parasternal views
   b. RA minor axis dimension of 4.8 cm is normal
   c. RA volumes can be increased in patients with normal RV filling pressures
   d. A dilated right atrium is an early marker of pulmonary hypertension

4. Which of the following is an abnormal finding pertaining to the inferior vena cava (IVC) diameter?
   a. IVC diameter of 2.3 cm in a 23-year-old swimmer
   b. IVC diameter of 1.1 cm in a 51-year-old woman with pulmonary hypertension
   c. IVC diameter of 1.2 cm with 80% collapse during spontaneous breathing in a 61-year-old woman with systemic hypertension
   d. IVC diameter of 2 cm and 40% collapse in a 35-year-old woman with exertional dyspnea

5. A 46-year-old woman with 3-year duration of primary pulmonary hypertension is expected to have which of the following measurements?
   a. RA volume of 30 mL
   b. D-shaped interventricular septum in diastole
   c. RV free wall thickness of 1 cm
   d. Long acceleration time of systolic flow through the RVOT

1. b 2. c 3. c 4. d 5. c

6. Which of the following is characteristic of RV structure and function in patients with longstanding arrhythmogenic RV dysplasia (ARVD)?
   a. RV regional dysfunction in RVOT and apical segments
   b. RV fractional area change of 50%
   c. Tricuspid regurgitation (TR) jet by continuous-wave Doppler of 3.6 m/s
   d. Left ventricular (LV) ejection fraction (EF) of 26%

7. Which of the following tissue Doppler velocities is expected in a 36-year-old patient with primary pulmonary hypertension of 4-year duration?
   a. Septal mitral annulus systolic ejection velocity of 16 cm/sec
   b. Lateral mitral annulus early diastolic velocity of 14 cm/sec
   c. Septal mitral annulus early diastolic velocity of 13 cm/sec
   d. Tricuspid systolic ejection velocity of 15 cm/sec
   e. Tricuspid early diastolic velocity of 13 cm/sec

8. Which of these is an abnormal finding?
   a. Predominant forward hepatic vein diastolic flow in a 25-year-old man
   b. A hepatic vein atrial reversal velocity of 20 ms duration
   c. A tricuspid *E/A* ratio of 1.8 in a 34-year-old woman
   d. A hepatic vein systolic velocity to diastolic velocity ratio of 0.3 in a 70-year-old man
   e. Hepatic vein midsystolic reversal velocity of 15 cm/sec

9. Which of the following is *not* a limitation for utilizing hepatic venous flow to predict RA pressure?
   a. A 55-year-old man with mid-diastolic rumble/holosystolic murmur at the lower left sternal border
   b. A 61-year-old woman with postoperative dyspnea and paradoxical pulse
   c. A 65-year-old man with a heart rate of 40/min after bypass surgery and cannon "a" waves in his jugular venous pulse
   d. A 53-year-old man with low-voltage EKG, postural hypotension, and LV posterior wall thickness of 18 mm
   e. A 45-year-old man who received a heart transplant 6 months ago

10. Which of the following is compatible with advanced RV disease in patients with cardiac amyloidosis?
    a. RV free wall thickness of 7 mm
    b. Deceleration time of tricuspid E velocity of 260 ms
    c. Tricuspid *E/A* ratio of 1
    d. A hepatic venous systolic velocity to diastolic velocity ratio of 0.6
    e. Inspiratory venous and atrial flow reversals

11. What is the pulmonary artery (PA) systolic pressure in a patient with a peak TR velocity of 3 m/sec and a jugular venous pressure of 15 cm?
    a. PA systolic pressure = 51 mm Hg
    b. PA systolic pressure = 36 mm Hg
    c. PA systolic pressure = 46 mm Hg
    d. PA systolic pressure = 40 mm Hg

12. Which of these patients has the highest pulmonary vascular resistance?
    a. TR jet of 3.6 m/sec and time velocity integral of RVOT systolic flow of 13 cm
    b. TR jet of 3.3 m/sec and time velocity integral of RVOT systolic flow of 13 cm
    c. TR jet of 3.6 m/sec and time velocity integral of RVOT systolic flow of 18 cm
    d. TR jet of 3.5 m/sec and time velocity integral of RVOT systolic flow of 14 cm

6. a 7. b 8. d 9. d 10. e 11. c 12. a

13. What is the mean PA pressure in this patient with TR peak velocity of 3 m/sec, pulmonary regurgitation (PR) end diastolic velocity of 2 m/sec, and RA pressure of 10 mm Hg?
    a. PA mean pressure = 26 mm Hg
    b. PA mean pressure = 21 mm Hg
    c. PA mean pressure = 33 mm Hg
    d. PA mean pressure = 40 mm Hg

14. What is the PA systolic pressure of this patient with pulmonary stenosis, where peak TR velocity is 4 m/sec, peak velocity across pulmonic valve = 3 m/sec, and RA pressure = 10 mm Hg?
    a. PA systolic pressure = 46 mm Hg
    b. PA systolic pressure = 74 mm Hg
    c. PA systolic pressure = 38 mm Hg
    d. PA systolic pressure = 50 mm Hg

15. Which of these supports the diagnosis of increased RV systolic pressure?
    a. Acceleration time of 120 ms in systolic flow recorded at RVOT
    b. PR peak velocity of 1.5 m/sec, and RA pressure of 5 mm Hg
    c. TR peak velocity of 3.5 m/sec
    d. Flat interventricular septum during diastole only

16. Which of the following is most compatible with the hepatic venous flow in Figure 15.1?

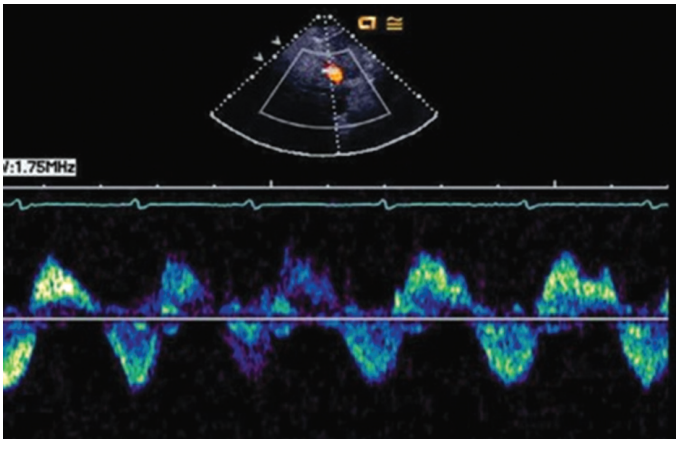
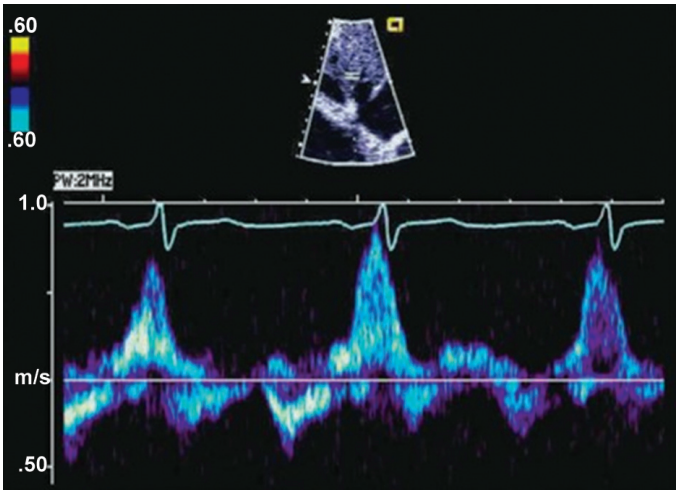


Fig. 15.1

    a. A 56-year-old man with systemic hypertension under control with medical therapy
    b. A 39-year-old woman with hypotension in the setting of acute inferior wall MI
    c. A 25-year-old man with recurrent septic pulmonary embolism
    d. A 63-year-old man in atrial fibrillation

17. Which of the following is compatible with the hepatic venous flow in Figure 15.2?
    a. A 49-year old man with dilated cardiomyopathy and systemic and pulmonary congestion
    b. A 29-year-old woman with pulmonary hypertension and systemic congestion
    c. A 55-year-old man with cardiac amyloidosis and lower extremity swelling
    d. A 65-year-old woman with hypertrophic cardiomyopathy and RV hypertrophy

13. c 14. c 15. c 16. c 17. d



Showing hepatic venous flow

Fig. 15.2

18. Which of the following is the most accurate conclusion about the continuous wave (CW) signal in Figure 15.3?

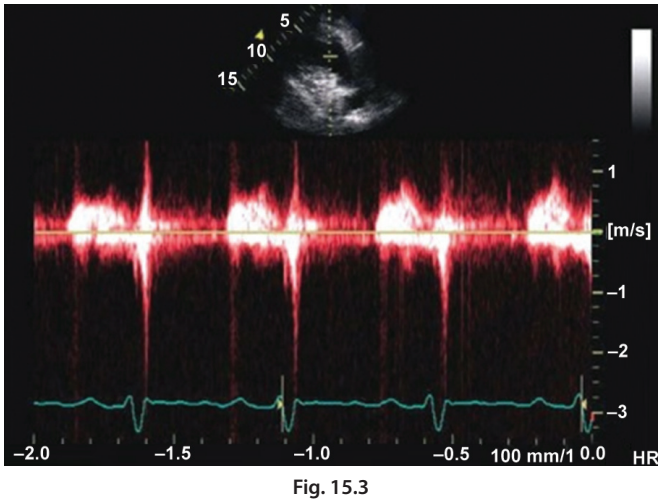


Fig. 15.3

a. PA systolic pressure can be reliably estimated
b. PA systolic pressure is at least 25 mm Hg
c. Intravenous saline is recommended for reliable assessment of PA systolic pressure
d. With normal RV size and septal shape, PA systolic pressure is normal

18. c

19. Which of the following is correct about Figure 15.4?

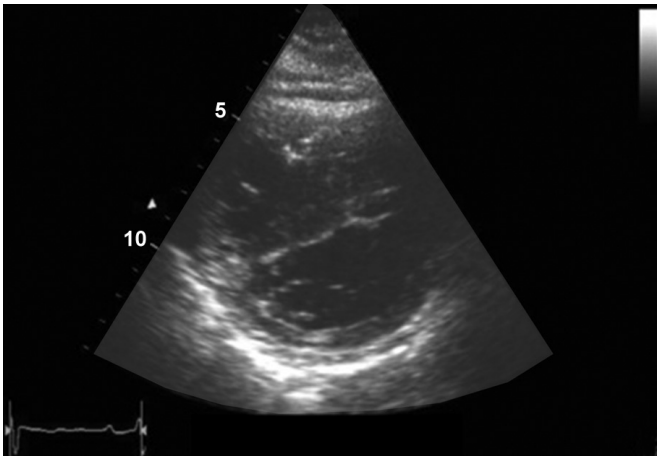


Fig. 15.4

a. It is seen in patients with systemic sclerosis, if noted only at end diastole
b. It is seen in patients with fixed wide splitting of the second heart sound, if noted only at end diastole
c. It is seen in patients with pulmonary embolism, if noted only at end diastole
d. It is seen in patients with pulmonary stenosis, if noted only at end diastole

20. What is the PA diastolic pressure in this patient with dyspnea on exertion (Fig. 15.5)? The IVC is dilated and does not collapse with sniffing:

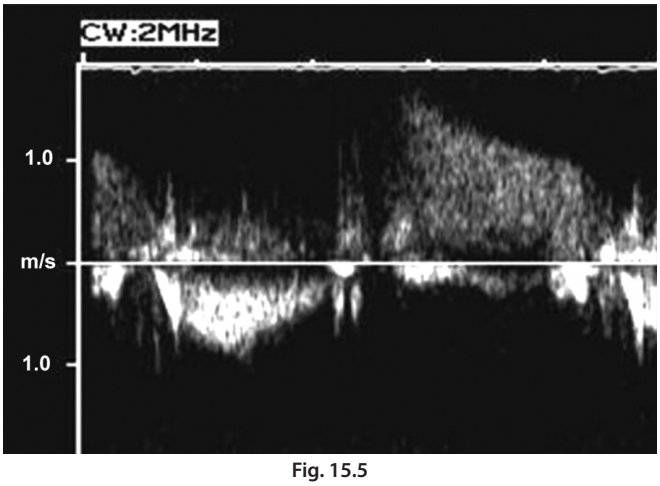


Fig. 15.5

a. PA diastolic pressure = 14 mm Hg
b. PA diastolic pressure = 9 mm Hg
c. PA diastolic pressure = 24 mm Hg
d. PA diastolic pressure = 19 mm Hg

19. b 20. c

21. Which is true about this patient with PR, (Fig. 15.6)?

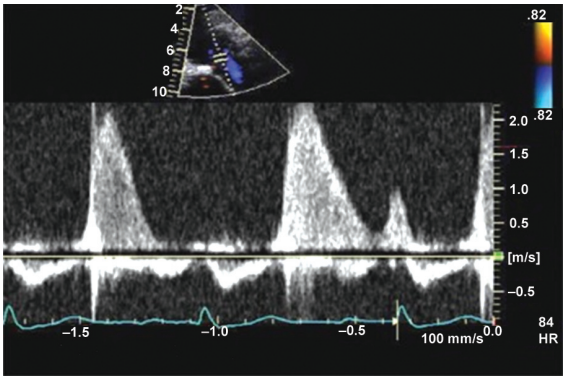
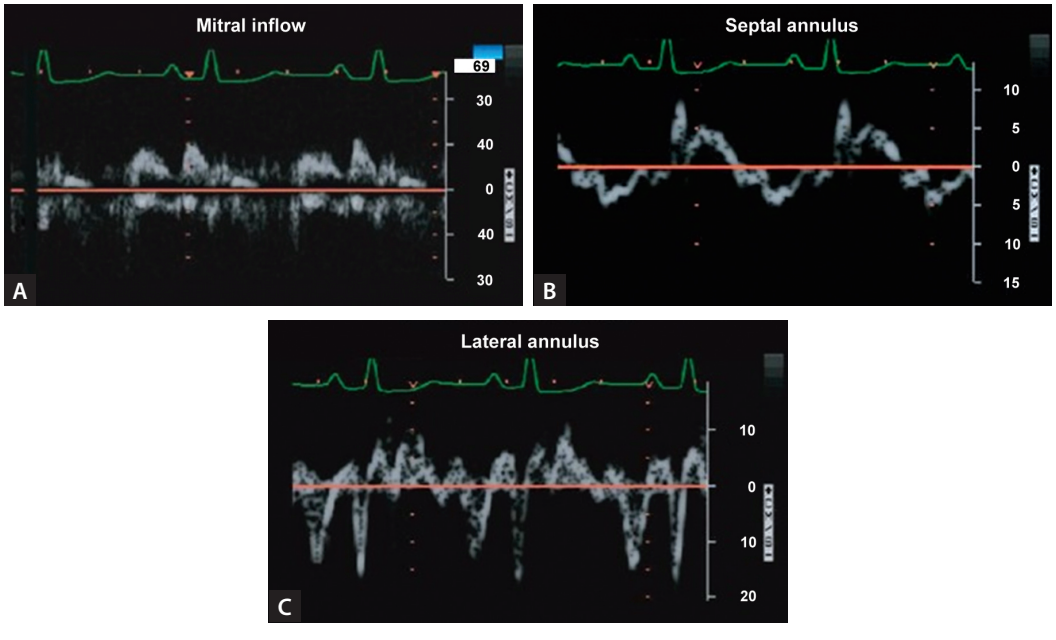


Fig. 15.6

a. Right ventricular end diastolic pressure (RVEDP) is normal
b. RV stiffness is increased
c. Systolic reversal in the hepatic veins is present
d. Tricuspid *E/A* ratio is 0.6

22. Choose the correct conclusion about LV diastolic function in this patient with pulmonary hypertension (Figs 15.7A to C)

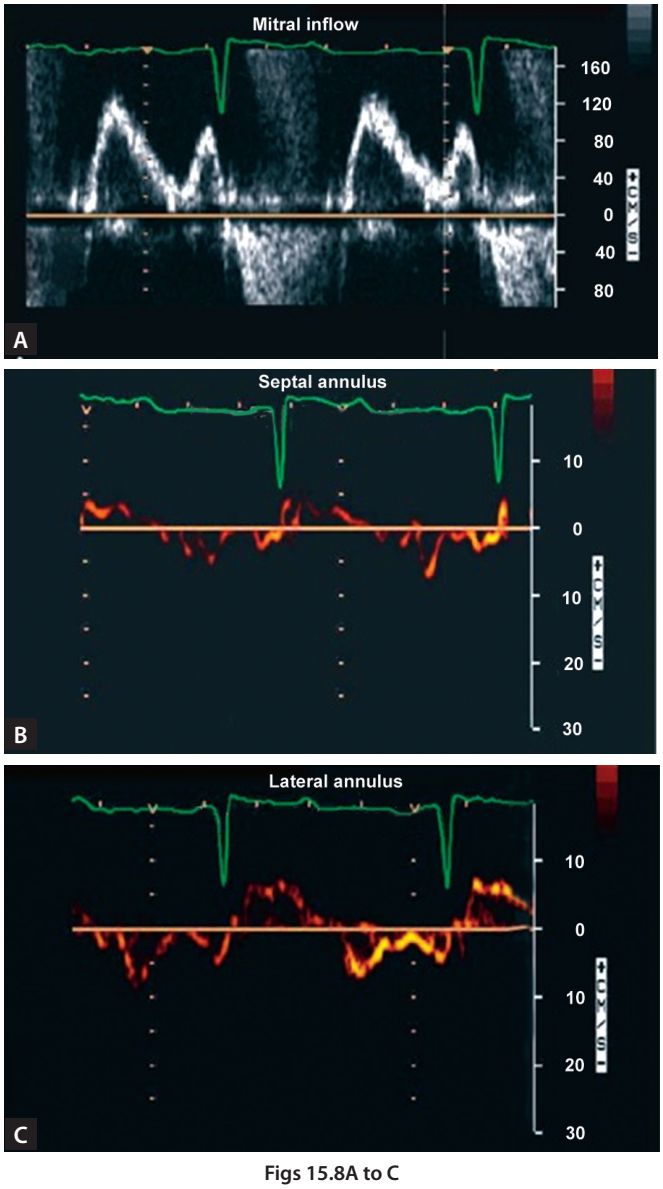


Figs 15.7A to C

21. b

a. Mean left atrial pressure is increased
b. LV relaxation is impaired
c. Successful treatment with Bosentan will lead to an increase in mitral *E/A* ratio
d. Left ventricular end diastolic pressure (LVEDP) is increased

23. Choose the correct conclusion about LV diastolic function in this patient with pulmonary hypertension (Figs 15.8A to C):



Figs 15.8A to C

22. c

a. Mean left atrial (LA) pressure is normal
b. LV relaxation is impaired and LA pressure is increased
c. Treatment with diuretics will lead to an increase in mitral E/A ratio
d. LVEDP is normal

24. Choose the correct conclusion about LV and RV pressures in this patient with a holosystolic murmur at the left sternal border and a blood pressure of 150/80 mm Hg. The Doppler is obtained from VSD flow at the parasternal short-axis view at the level of the aortic valve (Fig. 15.9):

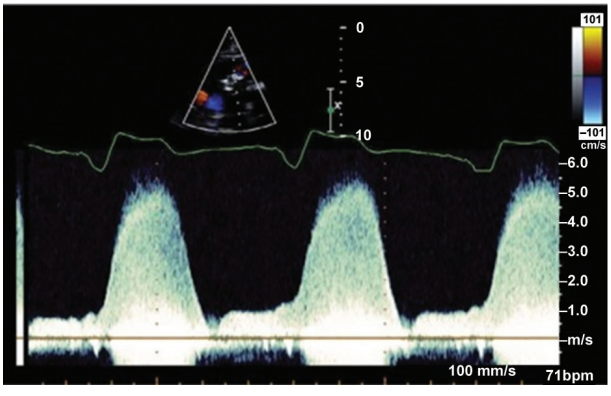


Fig. 15.9

a. RVEDP is higher than LVEDP
b. RV systolic pressure is higher than LV systolic pressure
c. If the peak velocity is approximately 5.5 m/sec, PA systolic pressure is 29 mm Hg in the absence of pulmonary stenosis
d. The findings are compatible with a peak TR velocity of 3.5 m/sec in the absence of pulmonary stenosis

25. What is the PA systolic pressure in this patient, where the TR peak velocity is 2.8 m/sec (Fig. 15.10)? Hepatic venous flow shows an S/D velocity ratio of 0.35:

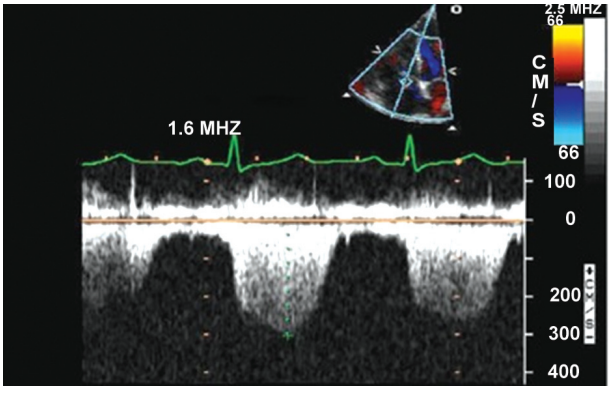


Fig. 15.10

a. PA systolic pressure = 31–36 mm Hg
b. PA systolic pressure = 46–51 mm Hg
c. PA systolic pressure = 41–46 mm Hg
d. PA systolic pressure = 36–41 mm Hg

23. b 24. c 25. c

Answers

1. b. All of the measurements are within the range of normal values except for the mid-right ventricular (RV) diameter, which is consistent with moderate enlargement. The normal range for the latter diameter is 2.7–3.3 cm. For basal RV diameter, the normal range is 2–2.8 cm, and for the RV diameter above the aortic valve level, it is 2.5–2.9 cm. The long axis of the RV is normally between 7.1 and 7.9 cm (Table 15.1). Note that these measurements are obtained at end diastole and require parallel alignment of the septum and the ultrasound beam, and no foreshortening.

Table 15.1 Summary of normal RV dimensions

RV dimensions (cm)	
Basal RV diameter	2.0–2.8
Mid-RV diameter	2.7–3.3
Basal-to-apical length	7.1–7.9
Right ventricular outflow tract diameters (cm)	
Above aortic valve	2.5–2.9
Above pulmonic valve	1.7–2.3

2. c. The tricuspid annular descent is normally in the range of 1.5–2 cm. RV end-diastolic area in normal subjects ranges between 11 and 28 cm^2, whereas end-systolic area is between 7.5 and 16 cm^2. RV fractional area change is normally between 32% and 60%.
3. c. Right atrial (RA) dimensions and volumes can be measured to draw conclusions about RA size. RA volumes should be measured in an apical four-chamber view. The minor axis diameter is measured between RA lateral border and the interatrial septum in a perpendicular direction to RA long axis, and normally ranges between 2.9 and 4.5 cm. Changes in RV myocardial function as detected by myocardial imaging are the earliest abnormalities in patients with pulmonary hypertension; and in early stages, the RA volume is often normal. Similar to left atrial (LA) volumes, RA volumes are not sensitive markers to acute changes in filling pressures. Accordingly, a dilated right atrium can be seen in patients with normal RV filling pressures. In addition, increased flow as seen with athlete's heart or left-to-right shunts may increase RA size without increasing filling pressures. On the other hand, RA volumes are a better reflection of chronic changes of RV filling pressures.
4. d. Inferior vena cava (IVC) diameter is measured in the subcostal views at 1–2 cm from its drainage into the RA. The measurement is performed in a perpendicular direction to its long axis. A diameter <1.2 cm is indicative of normal to reduced RA pressure (RAP) (Table 15.2). Athletes can have a dilated IVC which exceeds 2 cm. In patients with normal RAP, the IVC has a normal diameter which decreases by >50% with inspiration. However, if spontaneous breathing is not accompanied by such a change, sniffing should be performed. The change in IVC diameter with sniffing, in addition to IVC diameter at baseline, should be used to predict RAP. When the RAP is mildly elevated in the range between 5 and 10 mm Hg, the IVC diameter is usually increased (>2.1 cm) with a collapse index, that is at least 50%.

Table 15.2

Mean RAP	IVC% collapse	Hepatic veins
0–5 mm Hg	≥50%	Vs > VD
5 - 10 mm Hg	≥50%	Vs = VD
10 - 15 mm Hg	<50%	Vs < VD
≥20 mm Hg	<50%	Flow only with VD

Abbreviations: IVC = inferior vena cava; RAP = reduced RA pressure; Vs = forward systolic velocity in hepatic venous flow; VD = forward diastolic velocity in hepatic venous flow

5. c. In patients with pulmonary hypertension of 3-year duration, RA and RV enlargement are often present, along with increased RV free wall thickness. With RV enlargement, both long axis and minor dimensions are increased. RV free wall thickness is most reliably measured in the subcostal views and normally is up to 0.5 cm. In pulmonary hypertension, the interventricular septum is D-shaped both in systole and diastole. These patients also have a short acceleration time for systolic flow in the RVOT. Mean pulmonary artery (PA) pressure can be estimated using the regression equation: 80–0.5 (acceleration time).
6. a. In this cardiomyopathy, there are frequent abnormalities in RV regional and global function. The regional dysfunction is commonly noted in the RVOT, apex, and basal RV free wall in the region of the "triangle of dysplasia." RV dilatation and depressed global systolic function also occur, though not in all patients early on. In one study, dilatation of the RVOT was noted in all patients with arrhythmogenic RV dysplasia (ARVD) and may occur as an isolated finding. Other abnormalities include abnormally bright moderator band, RV sacculations (or diastolic outpouchings), aneurysm (systolic outpouchings), and trabecular derangements. left ventricular (LV) ejection fraction (EF) is characteristically normal in most patients with ARVD although infrequently a left-sided cardiomyopathy may occur. Given the presence of RV systolic dysfunction, PA pressures are usually normal and not elevated. Therefore, a peak tricuspid regurgitation (TR) velocity of 3.6 m/sec is not consistent with ARVD.
7. b. RV systolic and diastolic functions are depressed in patients with pulmonary hypertension. Because of the RV contribution to septal function, both septal systolic and diastolic mitral annulus tissue Doppler velocities are reduced. Likewise, tricuspid annulus velocities at the lateral side of the tricuspid annulus are reduced in these patients. On the other hand, LV function is preserved, and early diastolic velocities at the lateral side of the mitral annulus are usually normal.
8. d. The flow in the hepatic veins is largely determined by RAP during the cardiac cycle (Table 15.2). In normal subjects, antegrade flow from the hepatic veins to the RA occurs in systole (S) and diastole (D). With RA contraction, brief retrograde late diastolic flow (Ar), as well as late systole flow (Vr), occurs into the hepatic veins. It is feasible to record high-quality signals by transthoracic imaging from the subcostal window in most ambulatory patients. Hepatic vein flow velocities can be used to asses RAP. In general, a lower proportion of forward systolic flow is indicative of increased RAP, except in healthy young subjects where this finding is normal. Similar to mitral inflow, young subjects have an *E/A* ratio that is >1 with a short DT, and reduced RA contribution to RV filling.
9. d. There is limitations to using hepatic venous flow to predict RAP. These include the presence of tricuspid valve stenosis or regurgitation, pericardial compression syndromes, high-grade AV block, and heart transplants. The presence of a restrictive cardiomyopathy is not a limitation. Option A is consistent with tricuspid stenosis/regurgitation. Option B is consistent with a postoperative pericardial compression syndrome. The patient in option C has high-grade heart block, and option E is a heart transplant. The presentation in D is consistent with amyloid where the patient has cardiac disease and peripheral neuropathy.

10. e. With advance RV disease in patients with cardiac amyloidosis, RV free wall thickness is >7 mm, and tricuspid inflow shows a restrictive filling pattern. Hepatic venous flow at this stage is characterized by reduced forward systolic flow, increased forward diastolic flow, and inspiratory diastolic flow reversal.
11. c. PA systolic pressure is given by $4(V_{TR})^2$ + RAP. A jugular venous pressure of 15 cm water corresponds to 15 × 0.7 or 10–11 mm Hg, since 1 cm water corresponds to 0.7 mm Hg. Accordingly, PA systolic pressure is given by $4(3)^2 + 10$, or 46 mm Hg.
12. a. Pulmonary vascular resistance (PVR) is derived invasively as: (mean PA pressure – wedge pressure)/cardiac output. It can be estimated noninvasively by using the ratio between peak velocity of TR jet (as a surrogate of PA pressure), and time velocity integral of RVOT systolic flow (as a surrogate of cardiac output). Options A and C have the highest peak velocity, while option A has the least time velocity integral of RVOT systolic flow.
13. c. Mean PA pressure is given by PA diastolic pressure + 1/3 pulse pressure. This patient has a PA systolic pressure of $4(3)^2 + 10$ or 46 mm Hg. PA diastolic pressure = $4(2)^2 + 10$ or 26 mm Hg. Pulse pressure is given by 46–26 or 20 mm Hg. Accordingly, mean PA pressure = 26 + (20/3), or 33 mm Hg. Mean PA pressure can also be estimated using the regression equation: 80–0.5 (acceleration time).
14. c. RV systolic pressure is given by $4(V_{TR})^2$ + RAP, where VTR is the peak velocity of the TR jet. Therefore, RV systolic pressure = 64 + 10, or 74 mm Hg. The gradient between RV systolic pressure and PA systolic pressure is given by RV systolic pressure – PA systolic pressure = $4\ (V_{PV})^2$, where V_{PV} is the peak velocity across the pulmonary valve. Therefore, PA systolic pressure = 74 – 36, or 38 mm Hg.
15. c. Mean PA pressure can be estimated using the regression equation: 80–0.5 (acceleration time). Therefore, the patient in A is predicted to have a mean PA pressure of 20 mm Hg, which is normal. Mean PA pressure can also be estimated using the peak velocity of pulmonary regurgitation (PR) to which an estimate of right ventricular end diastolic pressure (RVEDP), or RAP, is added. Therefore, the mean PA pressure in B can be predicted to be: $4(1.5)^2 + 5$ or 14 mm Hg, which is normal. In C, the peak systolic pressure is at least: $4(3.5)^2$, or 49 mm Hg, which is consistent with pulmonary hypertension. With increased RV systolic pressure, a D-shaped septum is present in both systole and diastole, and not only during diastole.
16. c. The hepatic venous flow shows holosystolic reversal compatible with severe TR, as in the setting of infective endocarditis of the tricuspid valve (option C). A patient with controlled blood pressure has normal RA pressure and predominant forward systolic flow, not systolic reversal. In the setting of RV infarction and acute inferior wall MI, RV filling pressures are increased and there is predominant forward diastolic flow in the hepatic veins. Systolic flow is reduced, but not reversed in atrial fibrillation.
17. d. The hepatic venous flow shows large Ar signal compatible with normal RA systolic function in the presence of increased RVEDP. In early stages of RV diastolic dysfunction, RVEDP is increased, whereas mean RAP is normal. This hemodynamic finding is compatible with option D. Systemic congestion occurs with increased RA mean pressure and predominant forward diastolic flow in all other choices.
18. c. This is an incomplete TR jet that should not be used to predict PA systolic pressure. Intravenous saline injection can be used however. Depending on the level of pulmonary hypertension and its duration, RV size and function and septal morphology can appear normal despite an increased PA systolic pressure.
19. b. When the interventricular septum is D-shaped in systole and diastole, RV systolic pressure is increased (options A, C, and D). If the D-shaped septum is noted only during diastole, RV volume overload is present as in patients with an atrial septal defect (option B).
20. c. The PA diastolic pressure is given by $4v^2$ + RA pressure, where v is the end-diastolic velocity of the PR jet. The patient with a dilated IVC that does not collapse with inspiration is consistent

with an RA pressure of 20 mm Hg. Accordingly, the PA diastolic pressure is given by $4(1)^2 + 20$ or 24 mm Hg.

21. b. The PR signal is steep indicating rapid equilibration of pressure between the PA and the RV. When RV stiffness is increased, RV diastolic pressure rises rapidly leading to a PR signal that is similar to that seen in this case. These patients have increased RVEDP and RAP. Tricuspid inflow is characterized by predominant early filling with an *E/A* ratio >1, and a steep deceleration time of tricuspid *E* velocity. Hepatic venous flow shows predominant forward flow in diastole (not systolic reversal).

22. c. The Doppler tracings show a mitral *E/A* ratio <1, a normal lateral *e′* velocity, and a reduced septal *e′* velocity. Collectively, these findings are seen in patients with pulmonary hypertension of a noncardiac etiology. The presence of a lateral *E/e′* ratio <10 is indicative of normal or reduced LV filling pressures. A mitral *E/A* ratio <1 is not due to impaired LV relaxation, but reduced LV filling due to pulmonary hypertension and dilated RV. With the reduction in pulmonary vascular resistance with Bosentan, LV filling increases as well as mitral *E/A* ratio.

23. b. This patient has a pseudonormal LV filling pattern, and a lateral *E/e′* ratio > 10. Collectively, the findings are consistent with pulmonary hypertension secondary to a cardiac etiology. LV relaxation is impaired given the reduction in lateral *e′* velocity. The increase in mitral *E/e′* ratio is consistent with increased LV filling pressures. Treatment with diuretics leads to a reduction in LV filling and the mitral *E/A* ratio.

24. c. The flow is obtained from a ventricular septal defect (VSD) signal showing flow between the LV and the RV during systole and diastole. This is compatible with a higher left ventricular end diastolic pressure (LVEDP) than RVEDP, as well as a higher LV systolic pressure than RV systolic pressure. RV systolic pressure is the same as PA systolic pressure in the absence of pulmonary stenosis. Accordingly, PA systolic pressure can be computed as PA systolic pressure = LV systolic pressure – $4(V_{VSD})^2$, where v is in m/sec and represents the peak velocity of the VSD jet by continuous-wave Doppler. In this case, PA systolic pressure = $150 - 4(5.5)^2 = 29$ mm Hg. This is not compatible with a TR jet of 3.5 m/sec, which indicates an RV/PA systolic pressure of at least 49 mm Hg.

25. c. The PA systolic pressure is given by $4v^2$ + RA pressure, where v is the peak velocity of the TR jet. The patient with predominant forward diastolic flow is compatible with an RA pressure of 10–15 mm Hg. Accordingly, the PA systolic pressure is given by $4(2.8)^2$ + 10–15 mm Hg, or 41–46 mm Hg.

16

Echocardiography for Infective Endocarditis

1. Echocardiography plays a central role in evaluating patients with a clinical suspicion of infective endocarditis (IE). In patients with native valve endocarditis, what is the size of the smallest left-sided vegetation that can be detected by 2D transthoracic echocardiography (TTE)?
   a. 1 mm
   b. 3 mm
   c. 5 mm
   d. 7 mm
   e. 9 mm

2. In patients with native valve endocarditis, what is the size of the smallest left-sided vegetation that can be detected by transesophageal echocardiography (TEE)?
   a. 1 mm
   b. 2 mm
   c. 3 mm
   d. 4 mm
   e. 5 mm

3. A typical vegetation during the acute phase of endocarditis is defined as:
   a. A discrete echogenic mass adherent to native valves or intracardiac prosthetic devices with high-frequency motion independent of the underlying cardiac structure. The mass cannot be imaged in multiple views throughout the cardiac cycle
   b. A highly echogenic dense mass adherent to native valves or intracardiac prosthetic devices with high-frequency motion independent of the underlying cardiac structure. The mass can be imaged in multiple views throughout the cardiac cycle
   c. A discrete echogenic mass adherent to the downstream side of native valves or intracardiac prosthetic devices with high-frequency motion related to the underlying cardiac structure. The mass can be imaged in multiple views throughout the cardiac cycle
   d. A discrete echogenic mass adherent to the upstream side of native valves or intracardiac prosthetic devices with high-frequency motion independent of the underlying cardiac structure. The mass can be imaged in multiple views throughout the cardiac cycle

4. A patient with a membranous ventricular septal defect (VSD) presents with a high likelihood of IE. Where is the vegetation arising from the jet lesion most likely to be located?
   a. Mitral valve
   b. Left ventricular outflow tract (LVOT)
   c. Septal leaflet of the tricuspid valve
   d. Aortic valve
   e. Pulmonic valve

1. c 2. a 3. d 4. c

5. Prosthetic valve dehiscence should be suspected when the following is present:
   a. Vertical motion of prosthetic valve during systole
   b. Rocking motion of prosthetic valve with excursion of >15 degrees in at least one direction throughout the cardiac cycle
   c. The poppet motion is restricted
   d. Vertical motion of prosthetic valve during diastole

6. In native valve IE, which of the following clinical scenarios carries the worst prognosis?
   a. A vegetation of 10 mm of the aortic valve
   b. A vegetation of 10 mm of the mitral valve
   c. A vegetation of 10 mm of the tricuspid valve
   d. A vegetation of 15 mm of the tricuspid valve

7. What is the most frequent location of an abscess in patients presenting with IE?
   a. Mitral valve annulus
   b. Tricuspid valve annulus
   c. Aortic root
   d. Myocardium
   e. Pericardial space

8. Which of the following is more likely to be confused with a mitral abscess on a transthoracic echocardiogram?
   a. Caseous calcification of mitral annulus
   b. Dilated coronary sinus
   c. Descending thoracic aorta
   d. Epicardial fat

9. By TEE, which of the following is the best view to determine the location and extent of an aortic root abscess?
   a. Midesophageal five-chamber view at 0–15 degrees
   b. Midesophageal short-axis view at 45–60 degrees
   c. Midesophageal long-axis view at 120–140 degrees
   d. Deep transgastric five-chamber view at 0–10 degrees

10. Which of the following represents an early sign of aortic root abscess in the setting of native aortic valve IE?
    a. Abnormal flow between aorta and right atrium
    b. An echolucent space at the aortic root without drainage into the aortic lumen
    c. Abnormal thickness of the aortic root (>10 mm)
    d. Abnormal aortic root dilatation (>42 mm)

11. A patient has been found to have a vegetation on the left ventricular aspect of the anterior mitral valve leaflet (AMVL) with a leaflet aneurysm. What other structure should be sought for the presence of vegetation?
    a. Aortic valve
    b. Posterior mitral valve leaflet
    c. Tricuspid subvalvular apparatus
    d. Left atrium (LA)
    e. Myocardium

12. A 49-year-old man presents with IE. The TEE shows a 10 mm × 15 mm vegetation on the left atrial aspect of the posterior mitral valve leaflet. The patient has been given IV antibiotics. He remains stable during his 4 weeks course of therapy. A repeat TEE reveals a persistent vegetation on the mitral valve with similar dimension but without significant mitral regurgitation.

5. b 6. a 7. c 8. a 9. b 10. c 11. a

If the size of the vegetation remained the same after 4 weeks of antibiotics, which of the following statements is true regarding the short-term prognosis of the patient?

a. After 4 weeks of therapy, the size of the vegetation usually remains unchanged
b. After 4 weeks of therapy, an increase in echo brightness of vegetations is associated with an increased risk of complications related to endocarditis
c. After 4 weeks of therapy, persistence of vegetations in the absence of significant valvular regurgitation is associated with no increased risk of complications related to endocarditis
d. After 4 weeks of therapy, rapid reduction of vegetation size has been shown to correlate with an increased risk of embolic events

13. After complete resolution of a vegetation, what proportion of the affected valves retains normal structure and function?

a. 10%
b. 15%
c. 20%
d. 25%
e. 30%

14. IE involving the eustachian valve is a rare entity. Its incidence has been reported as low as 3% in the setting of right-sided endocarditis. Unfortunately, the eustachian valve is not routinely examined to rule out vegetation.

What are the best views to visualize the Eustachian valve during a transthoracic echocardiographic study?

a. Right ventricular (RV) inflow view/parasternal short-axis view
b. Apical four-chamber view/subcostal view
c. Parasternal long-axis view/apical four-chamber view
d. Subcostal view/parasternal long-axis view

15. What are the two features that distinguish a vegetation on the eustachian valve from the normal eustachian valve?

a. Abnormal thickness of >2 mm and high-frequency motion independent of the underlying structure
b. Abnormal thickness of >2 mm and high-frequency motion similar to the underlying structure
c. Abnormal thickness of >5 mm and high-frequency motion independent of the underlying structure
d. Abnormal thickness of >5 mm and high-frequency motion similar to the underlying structure

16. What is the negative predictive value of multiplane TEE?

a. 50%
b. 60%
c. 70%
d. 80%
e. >85%

17. A mitral valve aneurysm has the following characteristics:

a. A localized bulging of mitral leaflet toward the LA with expansion throughout the cardiac cycle
b. A localized bulging of mitral leaflet toward the LA with systolic expansion and diastolic collapse
c. A localized bulging of mitral leaflet toward the left ventricle (LV) with expansion throughout the cardiac cycle
d. A localized bulging of mitral leaflet toward the LV with systolic expansion and diastolic collapse

18. What condition is most likely to be confused with a mitral valve aneurysm?

a. Mitral valve prolapse
b. Mitral valve blood cyst
c. Mitral valve flail leaflet
d. Mitral valve repair with Alfieri stitch

12. c 13. a 14. a 15. c 16. e 17. b 18. a

19. Which abnormality is the result of a satellite lesion in this patient with endocarditis (Fig. 16.1)?

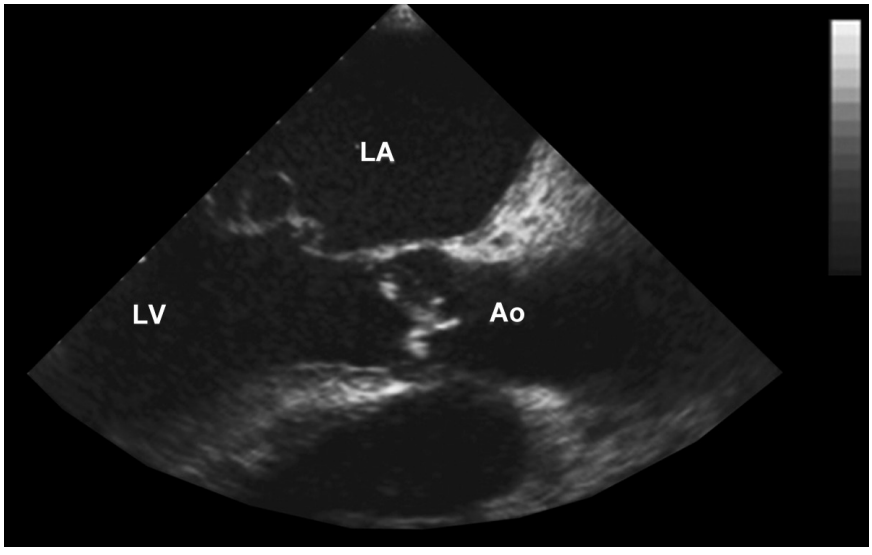


Fig. 16.1

a. Aortic root abscess
b. Anterior mitral valve aneurysm
c. Aortic cusp perforation
d. Aorta to right ventricular outflow tract (RVOT) fistula

20. You suspect severe aortic regurgitation. To confirm your suspicion in this patient, you demonstrate significant diastolic flow reversal by:
a. Pulsed wave (PW) Doppler through the LVOT in its deep transgastric five-chamber view
b. PW Doppler through the descending aorta in its long-axis view
c. PW Doppler through the ascending aorta in its long-axis view
d. PW Doppler through the abdominal aorta in its long-axis view
e. Continuous wave (CW) Doppler through the abdominal aorta in its long-axis view

21. Based on the TEE image, (Fig. 16.1) the vegetation on the aortic valve appears to affect more than one cusp. What is the best view to assess the extent of the lesion on the aortic valve?
a. Short-axis view of the aortic valve (40–60 degrees)
b. Short-axis view of the LVOT (40–60 degrees)
c. Long-axis view of the LVOT and aortic valve (110–140 degrees)
d. Five-chamber view of the LVOT and aortic valve (0 degree)
e. Deep transgastric five-chamber view (0 degree)

22. Based on the TEE findings, what is the prognosis of the patient?
a. Low risk of embolic event, low risk of mortality, high risk of valve replacement
b. High risk of embolic event, low risk of mortality, high risk of valve replacement
c. High risk of embolic event, high risk of mortality, high risk of valve replacement
d. High risk of embolic event, high risk of mortality, low risk of valve replacement

19. b 20. d 21. a 22. c

23. A 25-year-old man, injection drug user, presents with fever and shortness of breath. Two sets of blood culture grew gram-positive cocci in clusters. An echocardiogram is performed and showed a vegetation of 2.5 cm × 3.5 cm on the tricuspid valve (Fig. 16.2).

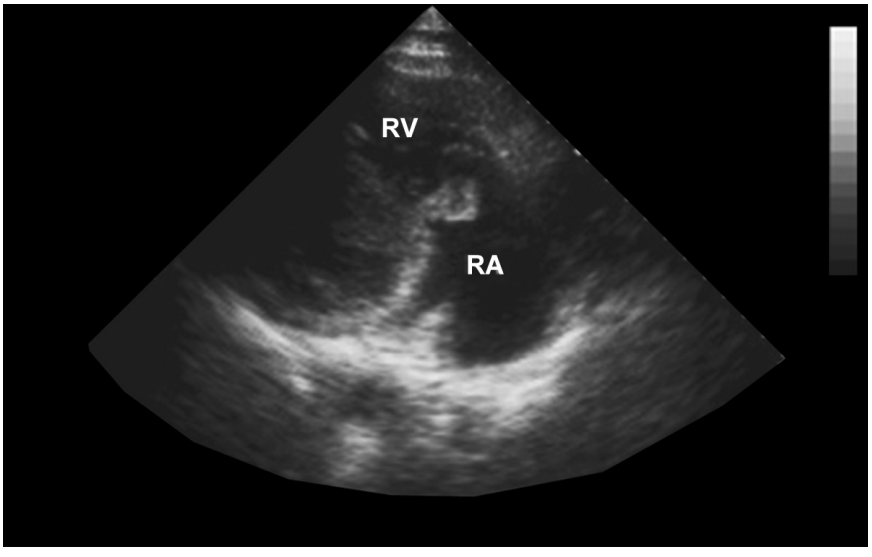


Fig. 16.2

Which leaflet of the tricuspid valve is the vegetation attached to?

a. Anterior leaflet
b. Septal leaflet
c. Posterior leaflet
d. None

24. What is the prognosis of this patient based on the vegetation size?

a. High risk of embolic event, high risk of valve replacement, high risk of mortality
b. Low risk of embolic event, low risk of valve replacement, low risk of mortality
c. High risk of embolic event, high risk of valve replacement, low risk of mortality
d. Low risk of embolic event, high risk of valve replacement, low risk of mortality

25. Where should the presence of a satellite lesion be sought?

a. Vegetation on the right atrial wall
b. Vegetation on the pulmonic valve
c. Vegetation on the tricuspid papillary muscle
d. Vegetation on the RV wall

23. b 24. c 25. a

Answers

1. c. Studies comparing transthoracic echocardiography (TTE) with transesophageal echocardiography (TEE) for the detection of vegetations with TEE as gold standard have shown that the sensitivity of TTE is dependent on vegetation size. It varies from 0% to 25% for vegetations of <5 mm and from 84% to 100% for vegetations of >10 mm. Therefore, vegetations of <5 mm can easily be missed by TTE even with the application of harmonic imaging. The resolution of echocardiography is affected by image quality. A recent meta-analysis showed that the sensitivities of TTE and TEE in detecting vegetations in native valve endocarditis were 62% and 92%, respectively.
2. a. TEE provides high spatial resolution of cardiac structures due to its close proximity to the heart and the high frequency of the transducer. Sachdev et al. showed that TEE can depict a structure as small as 1 mm in diameter.
3. d. Initially, M-mode was used to detect vegetations. With 2D TTE, better spatial definition of vegetations can now be obtained. An active vegetation is an echolucent mass with an irregular shape. It is usually located at the upstream side and near the tips of leaflets with high-frequency motion independent of the underlying cardiac structure. The mass can be associated with valve dysfunction. Chronic healed vegetations become echo-dense masses due to fibrin, collagen, and calcium deposition. According to the modified Duke's criteria, a vegetation is "an oscillating intracardiac mass on valves or supporting structures, or in the path of regurgitant jets, or on implanted material, in the absence of an alternative anatomical explanation." Compared with infective vegetations, noninfective vegetations from marantic or Libman-Sacks endocarditis have similar morphologic features and can only be differentiated from infective vegetations on the basis of the clinical findings.
4. c. Because of its close proximity to the ventricular septal defect (VSD) jet, the septal leaflet of the tricuspid valve is usually affected. However, right ventricular outflow tract (RVOT) and subpulmonic vegetation have also been described in patients with VSD presenting with infective endocarditis.
5. b. Dehiscence of a prosthetic valve is defined as a rocking motion of the prosthetic valve with an excursion of >15 degrees in at least one direction throughout the cardiac cycle. Studies show that only valves with ring dehiscence more than 40% of their annular circumference exhibit excessive rocking motion. Thus, absence of rocking motion does not exclude dehiscence.
6. a. Studies have shown that vegetations of >10 mm in the aortic position are associated with a higher risk of mortality, abscess formation, and valve replacement when compared with mitral valve vegetations, although in the study by Mugge et al. mitral valve vegetations of >10 mm were associated with a higher embolic risk. Tricuspid valve endocarditis carries the best prognosis because the affected patients are usually young. However, the prognosis seems to be worse with bulky tricuspid valve vegetation of >20 mm. No head-to-head comparison study has been reported between right-sided and left-sided endocarditis with respect to short-term and long-term prognosis.
7. c. On echocardiography, an abscess is identified as localized abnormal thickening of the perivalvular tissue or echolucent space within the perivalvular tissue that does not communicate with surrounding cardiac chambers. It is predominantly located at the aortic root and mitral-aortic intervalvular fibrosa. Myocardial abscesses are associated with very high mortality. The development of heart block in this setting is an indication of abscess formation involving the ventricular septum. A pericardial abscess usually represents a fistula formation between an annular abscess and the pericardial space.
8. a. Caseous calcification of the mitral annulus can present as an echolucent space within the calcification of the mitral annulus, simulating a mitral valve annular abscess. To differentiate from an abscess, other echocardiographic features need to be sought, such as a vegetation, perforation of the leaflet, or valve dysfunction.

A dilated coronary sinus, thoracic descending aorta, and epicardial fat can be easily distinguished from an abscess in the presence of normal mitral valve anatomy and function.

9. b. On TEE or TTE, the short-axis view of the aortic valve allows better visualization of the location and extent of an aortic root abscess. This view provides a 360° spatial orientation of the aortic root and aortic valve leaflet.
10. c. Abnormal thickness of the aortic wall of >10 mm is suspicious for an aortic root abscess in native aortic valve endocarditis. If present, serial echocardiograms can follow the evolution of this thickening and identify formation of an echolucent space over time. This criterion cannot be used in patients with recent aortic valve or aortic root replacement, as postoperative inflammation can contribute to thickening of the aortic wall. Prosthetic valvular thrombosis and pannus formation can be differentiated from an abscess by their predilection to involve the sewing ring encroaching onto the prosthetic orifice instead of the surrounding annulus. A pseudoaneurysm can be recognized by the presence of an echolucent cavity with communication with a neighboring cardiac chamber.
11. a. Aortic valve endocarditis usually leads to valve disruption and aortic regurgitation. The regurgitant jet can either be directed anteriorly against the anterior septum or posteriorly against the anterior mitral valve leaflet (AMVL). If aortic regurgitation is directed posteriorly, the jet lesion can seed the AMVL. This localized infection destroys the endothelium and fibrosa of the valve. If the infection is not controlled, aneurysm (diverticulum formation) and perforation of the AMVL ensue.
12. c. Vegetations evolve during successful antibiotic treatment. Reduction in vegetation size and increase in density are common. Persistence of vegetations alone does not predict a worse outcome. Rohmann et al. reported that the lack of regression of vegetation size after 4–6 weeks of antibiotic therapy is associated with an increased risk of mortality and complications related to endocarditis. However, this occurs only in patients with progressive valve disruption and dysfunction. In contrast, in patients with endocarditis but without significant valve dysfunction, the mortality and morbidity rate is not increased despite the lack of reduction in the vegetation size.
13. a. Rohmann et al. have shown that after healing from endocarditis, <10% of affected valves regain their normal structure. The majority of affected valves show nodular changes, thickening, or disruption of the leaflet after healing. No reliable predictors for complete healing have been identified.
14. a. Right ventricular (RV) inflow and parasternal short-axis views are the best views to appreciate the anatomy of the eustachian valve. Sometimes, the apical four-chamber view and the subcostal views can also be used to assess the extent of vegetation, but the eustachian valve is usually not well seen because of the increased image depth necessary for these views. The eustachian valve is an embryonic remnant from the incomplete resolution of the membranous partition between the smooth posterior venous chamber and the anterior trabeculated primitive atrium. When the membranous embryonic remnant is extensive and weblike with attachment to multiple sites, it is referred to as Chiari network.
15. c. San Roman et al. found two specific features of the normal eustachian valve: the valve is thin with a width of <3 mm, and it has predictable oscillating motion. They suggested that abnormal thickness (>5 mm) of a eustachian valve leaflet and a mass with chaotic high-frequency motion are suspicious for an eustachian valve vegetation.
16. e. Multiplane TEE has been reported as a highly diagnostic tool with a negative predictive of value varying from 87% to 98% in IE, depending on the clinical setting and the criteria used to define IE (native valve vs prosthetic valve, modified Duke criteria vs. pathological confirmation). The negative predictive value of TEE can be further increased if a repeat TEE 7–10 days later remains negative.

17. b. Mitral valve aneurysms are usually due to endocarditis. Surgical repair is frequently indicated because of the concomitant presence of perforation involving the aneurysm resulting in significant mitral regurgitation.
18. a. Mitral valve prolapse can sometimes mimic mitral valve aneurysm because of the systolic bulging of the mitral valve leaflet toward the left atrium. However, the absence of vegetation and valve disruption favor the diagnosis of prolapse.
    Mitral valve blood cyst is a very rare condition that can present as an immobile echogenic mass on the mitral valve leaflet. Flail of mitral valve leaflet is usually associated with ruptured chordae that can be identified by the typical "snake-tongue" appearance of the corresponding mitral leaflet into the LA during systole. Mitral valve repair with Alfieri stitch presents as a double orifice mitral valve on the parasternal short-axis view. On the parasternal long-axis view, the mitral valve leaflets appear thickened and restricted.
19. b. Aortic valve endocarditis usually leads to valve disruption and aortic regurgitation. The regurgitant jet can either be directed anteriorly against the septum or posteriorly against the AMVL. If aortic regurgitation is directed posteriorly, a satellite vegetation may form on the AMVL. This localized infection destroys the endothelium and fibrosa of the valve. If the infection is not controlled, aneurysm (diverticulum) formation and perforation of the AMVL ensue.
20. d. The abdominal aorta is easily imaged by turning the probe to either direction when it is in the stomach. Pulsed-wave (PW) Doppler in the long axis can be obtained by rotating the probe to 90°. Diastolic reversal in the abdominal aorta, if present, suggests severe aortic regurgitation. Diastolic reversal in the ascending aorta but not in the abdominal aorta probably suggests moderate to severe aortic regurgitation.
21. a. On TEE, the short-axis view of the aortic valve allows better visualization of the location of a vegetation on its three cusps. This view provides a 360° spatial orientation of the aortic root and aortic valve leaflet on the aorta aspect. To better assess the LVOT aspect of the aortic valve, real-time 3D imaging may be very helpful.
22. c. The patient has double valve lesions, multiple mobile aortic vegetations, and severe aortic valve disruption with severe aortic regurgitation. These findings suggest a poor outcome and high likelihood for surgical intervention and embolic events.
23. b. This is an RV inflow view. We normally see the anterior leaflet (anterior on the screen) and posterior leaflet (posterior on the screen) of the tricuspid valve. However, because of the shallow angle of the transducer, the interventricular septum instead of the RV posterior wall is imaged and thus, the leaflet is in fact the septal leaflet (not the posterior leaflet).
24. c. Studies have shown that vegetations of >2.5 cm on the tricuspid position is significantly associated with an increase risk of an embolic event and a need for valve replacement. However, the mortality rate remains low because most of these patients are young and are without serious comorbidities.
25. a. The tricuspid regurgitation jet, if present can be directed against the right atrial wall. The resultant jet can "seed" the infection on the right atrial wall as a satellite lesion.

17

Echocardiography for Prosthetic Valves

1. A diagnosis of patient prosthesis mismatch (PPM) is made in a 32-year-old woman with prior aortic valve replacement for a congenitally bicuspid aortic valve complicated by severe aortic regurgitation. The basis for this diagnosis is:
   a. A mechanical valve has been selected for a female patient in whom pregnancy is planned
   b. A mechanical valve has been selected for a patient with a history of drug abuse
   c. The valve implanted is too small for this patient
   d. The valve implanted is too large for this patient
   e. A bioprosthesis has been selected for a young patient

2. A 55-year-old man with prior aortic valve replacement presents with dyspnea on exertion, which has been present since his surgery. The PPM is suspected. Which of the following criteria is used to define this syndrome?
   Effective orifice area (EOA) corrected for body surface area:
   a. $\leq 0.55\ cm^2/m^2$
   b. $\leq 0.65\ cm^2/m^2$
   c. $\leq 0.75\ cm^2/m^2$
   d. $\leq 0.85\ cm^2/m^2$
   e. $\leq 0.95\ cm^2/m^2$

3. An 11-year-old boy had a 19 mm bileaflet mechanical aortic valve implanted for severe aortic stenosis on the basis of a congenitally bicuspid valve. On echocardiographic evaluation, the peak transvalvular velocity was 3.5 m/sec. However, at catheterization the left ventricle (reached by transseptal puncture) to aortic gradient was only 25 mm Hg. What is the most likely explanation for this discrepancy?
   a. At catheterization, the aortic valve gradient could not be measured by pullback
   b. The cardiac output was higher at the time of catheterization than at the time of the echocardiogram
   c. The pressure recovery phenomenon has resulted in overestimation of the aortic valve gradients by Doppler
   d. The aortic valve gradients have been overestimated because a mitral regurgitant spectrum was confused with the aortic valve spectrum
   e. The valve is too small for this patient

1. c 2. d 3. c

4. A 72-year-old man who had a ball and cage (Starr-Edwards) mitral valve implanted 20 years ago is followed echocardiographically. In echocardiogram of patients with this type of prosthesis, the size of the ball is:
   a. Overestimated because of faster propagation of sound in the ball relative to that in tissue
   b. Overestimated because of slower propagation of sound in the ball relative to that in tissue
   c. Underestimated because of faster propagation of sound in the ball relative to that in tissue
   d. Underestimated because of slower propagation of sound in the ball relative to that in tissue
   e. Accurately represented
5. A 55-year-old man with a recent aortic valve replacement undergoes postoperative echocardiography to establish baseline values for the valve. A peak velocity of 2.5 m/sec is recorded. This value is:
   a. Abnormally high suggesting PPM
   b. Abnormally high suggesting prosthetic valve stenosis
   c. May be normal depending on the size and type of the valve
   d. Low suggesting that the valve is a homograft valve
   e. Abnormally low suggesting that the patient has a reduced cardiac output
6. A 63-year-old patient with prior bioprosthetic mitral valve replacement undergoes an echocardiographic evaluation. The mean transvalvular gradient is 10 mm Hg. To interpret this result, which of the following patient information is most important?
   a. Height
   b. Weight
   c. Heart rate
   d. Blood pressure
   e. Gender
7. A 71-year-old patient with a bileaflet mitral valve prosthesis undergoes a transthoracic echocardiographic evaluation with harmonic imaging. In the apical views, microcavitations (spontaneous microbubbles) are seen in the left ventricle. This finding is most consistent with:
   a. Hemolysis
   b. Paravalvular regurgitation
   c. Imaging artifact
   d. A patent foramen ovalis
   e. Normal prosthetic function
8. An 82-year-old man with a bioprosthetic aortic valve prosthesis undergoes an echocardiographic evaluation. Which of the following is the formula for calculating EOA?
   a. Stroke volume/prosthetic velocity-time integral (VTI)
   b. (Stroke volume × heart rate)/peak transvalvular velocity
   c. Subvalvular VTI/prosthetic VTI
   d. Subvalvular peak velocity/peak transvalvular velocity
   e. (Subvalvular VTI × stroke volume)/prosthetic VTI
9. A 12-year-old boy with a history of aortic valve replacement undergoes an echocardiographic evaluation. The peak velocity across the prosthesis is 3.5 m/sec. In which of the following valves is pressure recovery most likely to be a consideration?
   a. Bileaflet
   b. Tilting disc
   c. Homograft
   d. Bovine stented bioprosthesis
   e. Stentless bioprosthesis

4. b 5. c 6. c 7. e 8. a 9. a

10. A 15-year-old boy who had bioprosthetic aortic valve replacement for a congenitally bicuspid aortic valve undergoes an echocardiographic evaluation. The peak velocity across the prosthesis is 3.5 m/sec. Which of the following is most supportive of the diagnosis of prosthetic valve stenosis?
    a. The bioprosthetic cusps are thickened with reduced mobility
    b. The size of the valve is 19 mm
    c. The aortic root is dilated
    d. The patient's hematocrit level is 45%
    e. The patient's left ventricular ejection fraction is 32%

11. A 72-year-old woman with a bioprosthetic mitral prosthesis undergoes an echocardiographic evaluation. Which of the following statements is true?
    a. EOA calculated as 220/pressure half time provides the best single measurement of functional valve area
    b. EOA calculated as 270/pressure half time provides the best single measurement of functional valve area
    c. EOA calculated as 1.5 × (220/pressure half time) provides the best single measurement of functional valve area
    d. EOA calculated as 150/pressure half time provides the best single measurement of functional valve area
    e. EOA calculated by the pressure half time method is inaccurate in patients with mitral prostheses

12. A 63-year-old patient with prior bioprosthetic mitral valve replacement undergoes an echocardiographic evaluation. In which of the following valves is a large central jet most consistent with normal valve function?
    a. Starr-Edwards ball and cage valve
    b. St. Jude bileaflet valve
    c. Medtronic-Hall single-disc valve
    d. Bovine pericardial bioprosthesis
    e. Porcine bioprosthesis

13. A 63-year-old patient with prior aortic valve replacement undergoes an echocardiographic evaluation for new symptoms of dyspnea. In addition to recording peak and mean gradients, the dimensionless index is calculated as:
    a. (Stroke volume × heart rate)/peak transvalvular velocity
    b. Subvalvular VTI/prosthetic VTI
    c. (Subvalvular VTI × stroke volume)/prosthetic VTI
    d. Calculated EOA/factory-specified normal EOA

14. An 81-year-old woman with prior bioprosthetic mitral valve replacement is noted to have a new systolic murmur and evidence of congestive heart failure. Transthoracic echocardiographic evaluation reveals only trace central mitral regurgitation. Which of the following statements is correct?
    a. Transesophageal echocardiography (TEE) is essential to evaluate the patient for paravalvular regurgitation
    b. A peak transmitral velocity of 2 m/sec argues against undetected paravalvular regurgitation
    c. A mean transmitral gradient of 10 mm Hg argues against undetected paravalvular regurgitation
    d. Normal (S dominant) pulmonary venous flow excludes the possibility of paravalvular regurgitation
    e. Paravalvular regurgitation is best detected in the apical three-chamber view

10. a 11. e 12. b 13. b 14. a

15. A 22-year-old man presents for echocardiographic follow-up 10 years after a Ross procedure. A 3/6 murmur is heard. What complication is the echocardiogram most likely to demonstrate?
    a. Aortic homograft stenosis
    b. Aortic autograft stenosis
    c. Aortic autograft regurgitation
    d. Aortic homograft regurgitation
    e. Pulmonary autograft regurgitation

16. A 72-year-old woman with prior mitral valve replacement is noted to have a new systolic murmur. An echocardiogram is obtained. Based on Figure 17.1, what is the diagnosis?

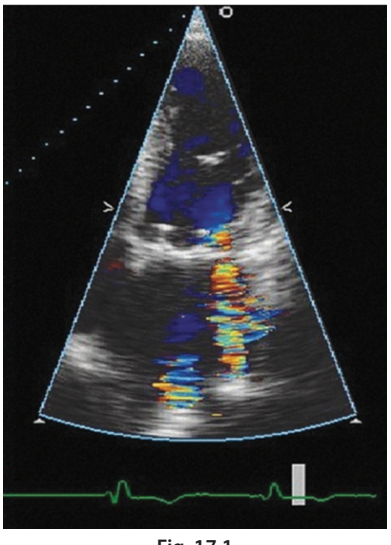
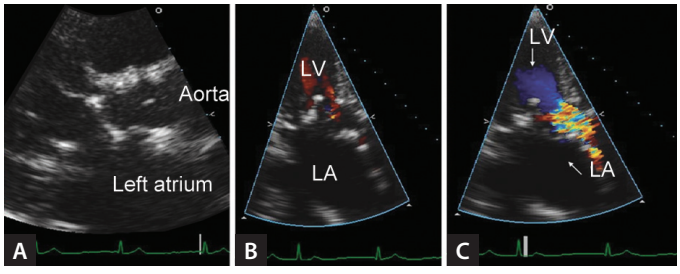


Fig. 17.1

    a. Bioprosthesis with paravalvular mitral regurgitation
    b. Bileaflet prosthesis with paravalvular mitral regurgitation
    c. Bioprosthesis with valvular mitral regurgitation
    d. Bileaflet prosthesis with normal closure jets
    e. Bileaflet prosthesis with valvular regurgitation

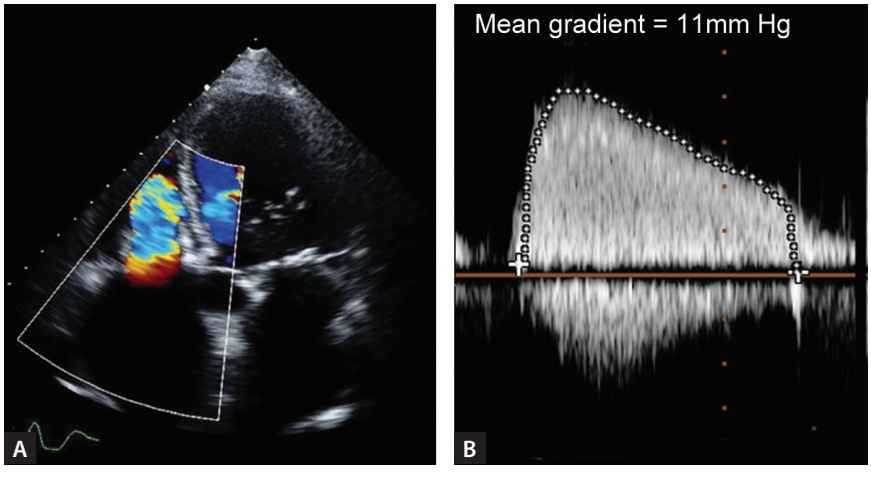
17. A patient with recent bioprosthetic mitral valve replacement for endocarditis undergoes echocardiographic evaluation because of persistent fatigue and a loud murmur. Based on these parasternal (A) and apical long-axis views (B and C) in Figure 17.2, what is the most likely diagnosis?
    a. Severe paravalvular mitral regurgitation
    b. Severe valvular mitral regurgitation
    c. Left ventricular outflow tract (LVOT) obstruction due to mitral systolic anterior motion
    d. LVOT obstruction due to malalignment of the prosthesis
    e. Prosthetic mitral stenosis

15. c 16. a 17. d



Figs 17.2A to C

18. A 65-year-old woman underwent tricuspid valve replacement for traumatic flail tricuspid valve caused by acceleration-deceleration injury in a car accident. Two years later, she presented with peripheral edema. Transthoracic echocardiography was performed. The images in Figures 17.3A and B were recorded at a heart rate of 55 bpm and a blood pressure of 120/75 mm Hg. With which of the following diagnoses are these most consistent?



Figs 17.3A and B

a. *Normal tricuspid prosthetic function:* High output state
b. *Normal tricuspid prosthetic function:* Pressure recovery
c. Mild tricuspid prosthetic stenosis
d. Moderate tricuspid prosthetic stenosis
e. Severe tricuspid prosthetic stenosis

19. A 52-year-old man with prior mitral valve surgery undergoes three-dimensional (3D) transesophageal echocardiogram (TEE) following a suspected neuroembolic event (Fig. 17.4). What type of procedure has the patient undergone?
a. Mitral ring annuloplasty
b. Alfieri stitch valvuloplasty
c. Tilting disc mitral valve replacement
d. Bileaflet mitral valve replacement
e. Mitral homograft replacement

18. e 19. d

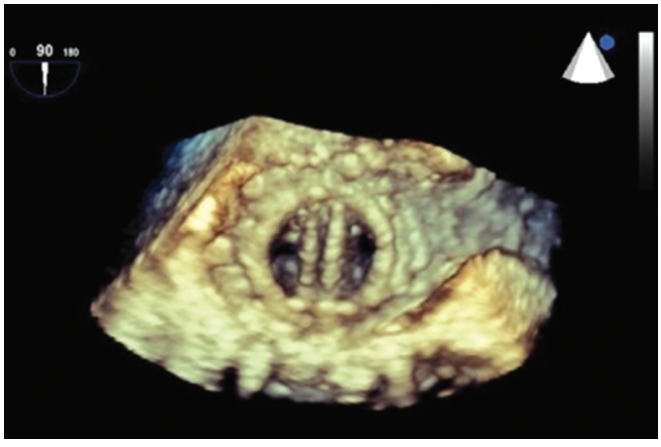


Fig. 17.4

20. A 67-year-old man has undergone prior valve surgery. Based on the echocardiogram (ECG) in Figure 17.5, what is the most likely diagnosis?

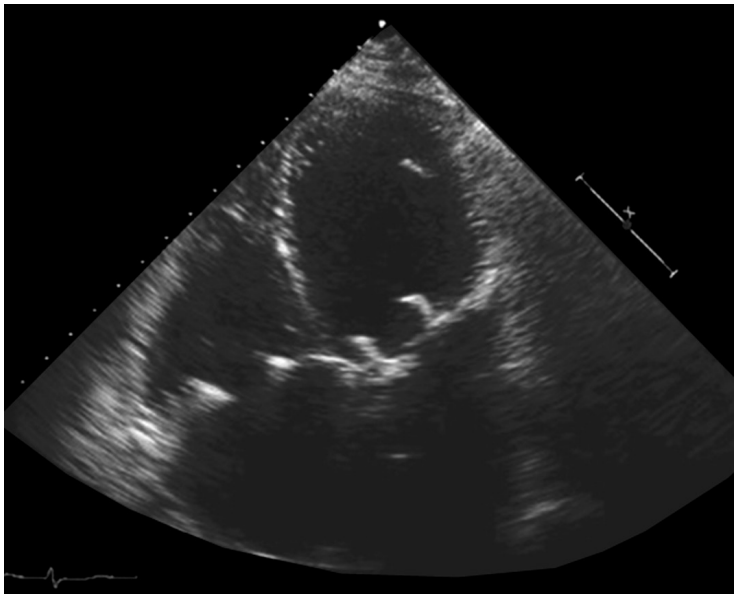


Fig. 17.5

a. Normal mitral and tricuspid ring repair
b. Normal mitral bioprosthesis, tricuspid ring dehiscence
c. Normal mitral bioprosthesis and tricuspid ring
d. Normal mitral bioprosthesis, pacer lead in the right ventricle
e. Normal mitral bioprosthesis, tricuspid vegetation

20. b

21. A 21-year-old man with recent aortic homograft valve replacement experiences a headache preceded by visual field deficits and undergoes a TEE to rule out a cardiac source of embolus. He has been afebrile and Doppler evaluation reveals only trace aortic regurgitation. Based on the echocardiographic image in Figure 17.6, what would be an appropriate next step in management?

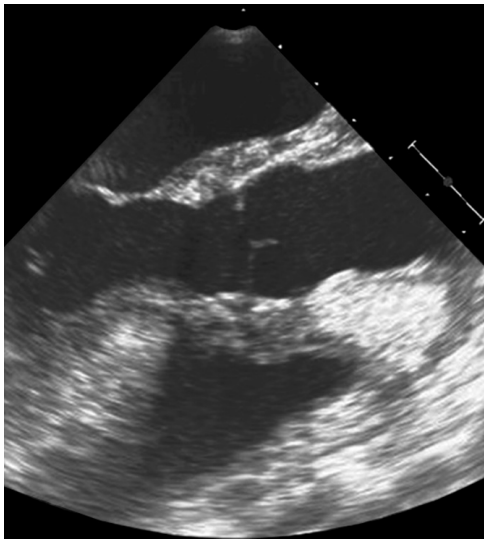


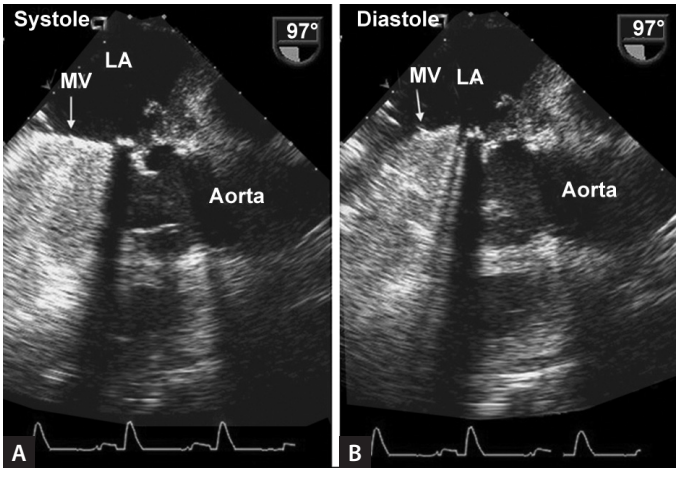
Fig. 17.6

a. Initiate broad-spectrum antibiotics
b. Urgent reoperation
c. Refer for computed tomography evaluation
d. Refer for coronary angiography
e. Provide reassurance that the appearance of the valve is normal

22. A 62-year-old woman undergoes mitral valve surgery. What type of prosthesis is shown on the perioperative transesophageal echocardiogram (TEE) in Figures 17.7A and B?
a. Tilting disc
b. Bileaflet
c. Trileaflet
d. Ball and cage
e. Disc and cage

23. A 75-year-old man with prior aortic valve replacement undergoes an echocardiographic evaluation because of dyspnea on exertion (Fig. 17.8). The pulsed Doppler spectrum recorded in the LVOT yields a peak modal velocity of 1.1 m/sec. Continuous-wave Doppler recorded across the LVOT (and valve) yields a peak velocity of 3.3 m/sec. The LVOT diameter is 2.0 cm. The calculated dimensionless index is?
a. 3.0
b. 1.05
c. 0.75
d. 0.5
e. 0.33

21. e 22. a 23. e



Figs 17.7A and B

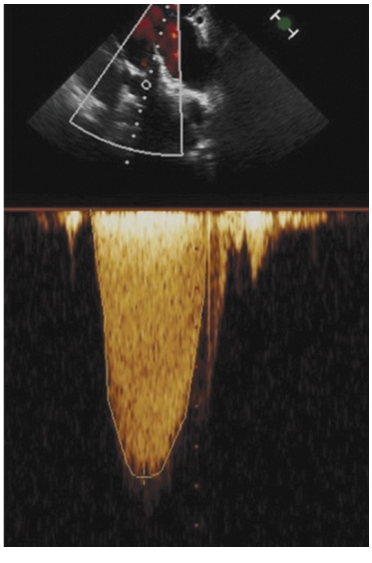


Fig. 17.8

24. A 32-year-old man with a prior history of aortic valve surgery undergoes TEE because of suspected aortic dissection. Based on the echocardiographic image in Figure 17.9, what type of procedure was performed?
    a. Stentless bioprosthesis replacement
    b. Aortic homograft replacement
    c. Aortic autograft replacement
    d. Stented bioprosthesis replacement
    e. Aortic valve repair

24. d

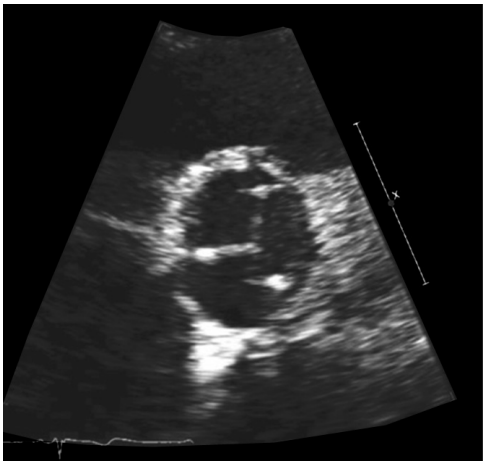


Fig. 17.9

25. A 66-year-old woman undergoes a resting transthoracic echocardiographic evaluation following an episode of chest pain. What is the most likely explanation for the echodensity identified by the arrow in Figure 17.10?

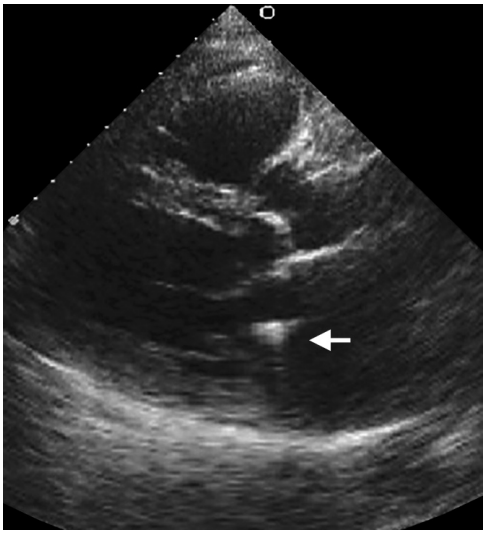


Fig. 17.10

a. Aortic prosthesis reverberation artifact
b. Aneurysm of the interatrial septum
c. Biventricular pacing lead
d. Alfieri stitch
e. Dehisced mitral ring

25. e

Answers

1. c. The term patient prosthesis mismatch (PPM) refers to the situation in which the effective orifice area (EOA) of a prosthesis is too small relative to the patient's body size resulting in abnormally high postoperative gradients. Although bioprostheses rather than mechanical valves are generally selected for women anticipating pregnancy as well as for patients with a prior history of drug abuse, these situations are not considered PPM. Children with prosthetic valves may outgrow their valves and develop PPM but this may be unavoidable regardless of whether a mechanical versus a bioprosthetic valve is implanted.
2. d. PPM refers to the situation in which the EOA of a prosthesis is too small relative to the patient's body size resulting in abnormally high postoperative gradients. The cut off for PPM has been established to be a body surface area (BSA)-indexed EOA of ≤0.85 cm^2/m^2 on the basis of the observation that at smaller areas there is a rapid increase in transvalvular gradients. BSA-corrected EOA ≤0.65 cm^2/m^2 is considered severe PPM. The major adverse outcomes associated with PPM are reduced short-term and long-term survival, particularly if associated with left ventricular (LV) dysfunction. The high gradients associated with PPM may be distinguished echocardiographically from prosthetic valve dysfunction by comparing the echocalculated EOA with published normal values for individual valves and by excluding imaging evidence of valve dysfunction.
3. c. Pressure recovery refers to the situation in which there is a localized pressure drop at the central orifice of a bileaflet mechanical valve that is partially recovered distally as flow from the lateral two orifices merges with the central flow jet. Since Doppler records the maximal pressure drop, it will yield a gradient higher than that measured at catheterization with catheters placed proximal and distal to the valve. Clinical significant pressure recovery is most often encountered in the setting of small bileaflet valves in the aortic position particularly when the cardiac output is increased.
   a. is incorrect because the direct measure of left ventricle to aorta gradients used in this patient is superior to the pullback approach. It would be dangerous to attempt to cross this valve retrograde.
   b. is incorrect because a relatively higher cardiac output at catheterization would result in a relatively higher (not lower) transvalvular gradient.
   d. Although it is may be possible to mistake a mitral regurgitant for a transaortic Doppler spectrum, the peak MR velocities are typically much higher than 3.5 m/sec (49 mm Hg) reflecting large gradients from the left ventricle to left atrium.
   e. In the case of PPM, elevated gradients are noted both by echocardiography and by catheterization.
4. b. Echocardiographic displays are calibrated on the basis of the velocity of sound through tissue, assuming that only tissue will be encountered by the ultrasound beam. The speed of sound in a Starr-Edwards valve ball is slower than that in tissue. Consequently, the ball is misrepresented echocardiographically as being larger than it actually is.
5. c. Although there is significant variability in the normal values reported for aortic prosthetic valves depending on size and valve type, a peak velocity of 2.5 m/sec is well within the normal range for many valves, and as such, would not be helpful in determining the type of prosthesis that has been implanted. In general, velocities of >3.0 m/sec prompt concern about pathologic elevation due to a variety of causes including PPM and intrinsic valve pathology although velocities of >3 m/sec may be normal for some valves. Stroke volume as an index of cardiac output is measured by the velocity-time integral (VTI) of the pulsed Doppler spectrum of the left ventricular outflow tract (LVOT).
6. c. Gradients across mitral and tricuspid prostheses are very heart rate dependent. Although a mean gradient of 10 at a heart rate of 60 bpm would be abnormal, the same gradient at a heart rate of 120 bpm would be "normal" for most mitral prostheses. While height and weight

(choices A and B) and calculated BSA are important in evaluating patients for PPM (BSA-indexed EOA <1.15 cm^2/m^2), this assessment requires the calculation of EOA, which is not possible with only mean gradient. It is important to record blood pressure (choice D) at the time of echocardiography for patients with mitral disease. However, its major impact is on regurgitation rather than stenosis. Gender has no direct impact on valve gradients.

7. e. With harmonic imaging, microcavitations are frequently seen with normally functioning mechanical valves. Although their origin is uncertain, they are not imaging artifacts. In the era of fundamental imaging, microcavitations were reported as markers of hemolysis, which may be a feature of paravalvular regurgitation. In the absence of intravenously injected microbubbles, a patent foramen ovalis and associated right-to-left shunt will not result in left-sided microbubbles.
8. a. EOA is calculated using the continuity equation and is equivalent to the calculation of valve area in native valves. Thus Choices B and C represent formulae that can be used to calculate the dimensionless index. By comparing calculated EOA with published norms, the diagnosis of prosthetic stenosis can be established.
9. a. See also discussion of question 3. Pressure recovery is typically encountered in small bileaflet or ball and cage valves.
10. a. Imaging features of restricted thickened cusps support the diagnosis of prosthetic stenosis as the basis for the elevated gradients. A small valve (19 mm Hg) as in choice B may be associated with elevated gradients even in a structurally normal valve if there is PPM (the valve is too small for the patient). The aortic root may be dilated (Choice C) in patients with native aortic valve disease and does not regress following aortic valve replacement in the absence of aortic reconstructive surgery. Choice D: The normal hematocrit excludes anemia-associated high output, which may be associated with elevated gradients in structurally normal valves. Choice E: Reduced LV ejection fraction is typically associated with low gradients and provides no explanation for the elevated gradients noted here.
11. e. The pressure half time should not be used to calculate EOA in patients with prosthetic valves.
12. b. All mechanical prosthetic valves have physiologic "regurgitation" that consists of a closing volume (a displacement of blood caused by the motion of the occluder) and leakage at the perimeter of or at hinge points of the occluders. Studies have shown bileaflet mechanical valves (St. Jude) to have the largest degree of physiologic regurgitation with central as well as peripheral jets. While Medtronic-Hall valves also have central and peripheral jets, the total amount of regurgitation is less compared to St. Jude valves.
13. b. The dimensionless index is defined as the ratio of subvalvular VTI or peak velocity to prosthetic VTI or peak velocity, respectively. It is particularly useful when image quality precludes accurate measurement of the LVOT as is needed to calculate EOA.
14. a. Because of acoustic shadowing and the eccentricity of paravalvular jets, transthoracic echocardiography is relatively insensitive for paravalvular regurgitation. Thus, transesophageal echocardiography (TEE) is indicated whenever paravalvular regurgitation is suspected. Elevated mitral gradients B and C favor mitral regurgitation. When jets are eccentric, normal (S dominant) flow may be preserved in pulmonary veins remote from the jet. All apical views should be used to assess for paravalvular regurgitation but no single view is ideal.
15. c. The Ross procedure consists of a moving the patient's pulmonary valve to the aortic position (aortic autograft) and placing a homograft (cadaveric) valve in the pulmonic position (pulmonary homograft). Of the possible correct answers (aortic autograft stenosis or regurgitation), aortic regurgitation is the most common.
16. a. The prosthesis is identifiable as a stented bioprosthesis by the presence of clearly demarcated stents. There is a mitral regurgitant jet that clearly originates outside the sewing ring and extends to the back of the left atrium: this is paravalvular regurgitation. Although the image has not been optimized for proximal isovelocity surface area (PISA) based quantitation,

note the clearly demarcated PISA shell. Although spontaneous valve dehiscence may occur, hemodynamically significant new paravalvular jets raise the possibility of endocarditis as the cause.

17. d. In the parasternal long-axis view and in the diastolic frame from the apical long axis, the mitral struts are seen abutting the interventricular septum. The systolic frame shows turbulent flow in the LVOT at the level of the mitral struts. Although rare, such malpositioning of high-profile mitral prostheses may cause significant LVOT obstruction. Patients at greatest risk are those with small hypertrophied ventricles. Mitral systolic anterior motion and LVOT obstruction may be a complication of mitral repair but not mitral valve replacement. Notably in patients with mitral valve replacement for active endocarditis, the mitral chords and leaflets are typically not preserved. Mitral stenosis would be associated with high-velocity flow in diastole not systole. There is no evidence of mitral regurgitation (high-velocity flow is in the LVOT not left atrium).
18. e. Although there are no large series of published normal values for tricuspid prosthetic gradients, the existing literature supports the diagnosis of prosthetic tricuspid stenosis whenever the mean gradients are more than 6 mm Hg. The mean gradient of 11 mm Hg at a slow heart rate is consistent with severe prosthetic stenosis. It is unlikely that this patient has a high output state with a heart rate of 55 bpm and even a significantly elevated cardiac output would unlikely be associated with gradient elevation of this degree. Pressure recovery does not occur with large bioprosthetic valves in the tricuspid position. Note that the pressure half time method has not been validated for prosthetic tricuspid valves and should not be used.
19. d. This is the typical three-dimensional (3D) view of a bileaflet mechanical mitral prosthesis as seen from the left atrial perspective. Two orifices are identified in this diastolic frame with the occluders in the open position. For 3D images of other prosthesis see the study of Sugeng et al as shown in the Suggesting Readings at the end of this chapter.
20. b. Mitral struts are clearly seen, identifying this valve as a bioprosthesis. On the right side, the septal leaflet of the tricuspid valve is seen in the open position with the dehisced portion of a tricuspid ring seen floating in the tricuspid inlet. The ring is appropriately attached laterally, identifying the normally attached portion of the ring. This helps prevent mistaking the dehisced portion for either a vegetation or pacer lead. This patient had severe tricuspid regurgitation.
21. e. Aortic homografts are treated cadaveric aortic roots and valves to which the native coronary arteries are implanted. The native aorta may be used to wrap the homograft aorta (the inclusion technique) or resected. Particularly when the inclusion technique is used, the normal postoperative appearance is one of a variably thickened root that may be in part due to hematoma. Over time, this resorbs and the appearance of the valve resembles that of the native aortic valve. In a clinical scenario suggestive of endocarditis, it may be impossible to differentiate a normal homograft from abscess. However, the postimplantation perioperative TEE can be very helpful in resolving this dilemma. In the absence of clinical features of infection, the appearance shown here can be interpreted as normal.
22. a. This is a typical appearance for a tilting disc mechanical mitral prosthesis. The disc pivots from an eccentric pivot point and closure is associated with a prominent central jet. This valve should not be confused with bileaflet or ball/disc and cage valves examples of which are provided elsewhere in this chapter. There are no trileaflet mechanical valves.
23. e. The dimensionless index is the ratio of subvalvular VTI or peak velocity to prosthetic VTI or peak velocities respectively (= 1.1/3.3). It is easily performed and an alternative to EOA when the LVOT diameter is difficult to measure.
24. d. This short-axis image shows three stents and cusps in the closed position. This appearance is typical of a stented bioprosthesis. Stents are not elements of homografts or autografts, which

are human valves or stentless heterograft bioprostheses. Aortic repairs are also not associated with stents. Stented valves are the most common type of bioprosthesis.

25. e. The arrow indicates a dehisced mitral ring. The anterior rim of the ring is seen in a normal position adjacent to the aortic root. This patient had severe posteriorly directed mitral regurgitation. Alfieri stitches are seen in the left ventricle, tying together the A2 and P2 scallops. The LV lead of biventricular pacing is placed in the coronary sinus. The aortic valve in this patient is a native valve. Although atrial septal aneurysms may project into the left atrium and be visible from this window, they do not appear as discrete echodensities as is seen here.

18

Echocardiography for Left-sided Valves

1. A 72-year-old man is referred for a cardiology evaluation after his primary care physician noted presence of a loud ejection murmur. There is no history of angina, syncope, or exertional dyspnea. Clinical examination shows presence of a loud ejection murmur (3/6) over the aortic area, radiating to the neck vessels. There are no ejection clicks. The second heart sound is single. There are no other murmurs or gallops. Lung examination is unremarkable. Transthoracic echocardiogram shows normal left ventricular (LV) size with an ejection fraction (EF) of 65%. The left ventricular outflow tract time-velocity integral (LVOT TVI) is 15 cm with a velocity of 0.8 m/sec. The peak aortic velocity is 4.8 m/sec, and the aortic valve TVI is 100 cm. The LVOT area is 4 cm^2. Your interpretation of the echocardiogram is:
   a. Severe aortic stenosis because valve area is <1 cm^2
   b. Severe aortic stenosis because the LVOT/aortic velocity ratio is <0.3
   c. Severe aortic stenosis because peak aortic velocity is >3.5 m/sec
   d. The severity of the aortic stenosis cannot be determined from the data presented
2. In this asymptomatic patient, your further recommendation is:
   a. Inform patient that the chance of developing symptoms in the next 5 years is 20%
   b. Recommend coronary angiography in anticipation of surgical intervention
   c. Recommend transesophageal echocardiography (TEE)
   d. Recommend oxygen consumption treadmill test
   e. Recommend repeat echocardiogram in 2 years
3. A 60-year-old man with a history of chronic renal insufficiency, arterial hypertension, and history of moderate aortic stenosis is admitted to the hospital for worsening dyspnea on exertion. His previous echocardiogram obtained 2 years ago showed concentric LV hypertrophy with an EF of 55%. The aortic valve gradient was 30 mm Hg and the calculated valve area was 1.1 cm^2. Clinical examination shows a patient in mild respiratory distress. The apical impulse is laterally displaced. There is a 2/6 systolic ejection murmur over the aortic area, which does not radiate to the carotid vessels. The second heart sound is diminished in intensity. Peripheral arterial pulsations are reduced in volume. There is significant peripheral edema. Laboratory work-up shows a creatinine level of 3.2 mg/dl. Overnight, the patient is started on a furosemide infusion by the on-call resident, but this has to be stopped due to development of hypotension. Initial echocardiogram shows an enlarged left ventricle (64 mm) with severely reduced systolic function with an EF of 20% and global hypokinesis. The mean aortic gradient is 30 mm Hg, with an aortic valve TVI of 66 cm, and an LVOT TVI of 15 cm. Your recommendation is:

1. a 2. d

a. Recommend adenosine sestamibi
b. Recommend exercise echocardiogram
c. Recommend full-dose dobutamine echocardiogram
d. Recommend low-dose dobutamine echocardiogram
e. Findings are probably related to end-stage renal disease, no further cardiac workup is required. Initiate dialysis

4. Which of the following statements referring to an echocardiographic evaluation of aortic stenosis is are accurate?
   a. Echocardiographic assessment of maximum aortic gradient is usually higher than the pullback gradient obtained during left heart catheterization. This is due to overestimation of the true gradient by echocardiography
   b. Echocardiographic assessment of mean aortic gradient correlates well with the mean gradient obtained in the catheterization laboratory
   c. The usual echocardiographic measurement of the mean aortic gradient cannot overestimate the true gradient
   d. The assessment of mean aortic gradient with a nonimaging probe is more accurate because these probes allow for better Doppler software processing

5. A patient is evaluated for aortic stenosis. Doppler measurements from all available windows show a highest peak aortic velocity of 5 m/sec and a TVI of 125 cm. The LVOT velocity is 2 m/sec, and the TVI is 25 cm. The LVOT diameter is 2 cm. Which of the following calculations is correct?
   a. Aortic valve area 0.78 cm^2, peak gradient 100 mm Hg
   b. Aortic valve area 0.63 cm^2, peak gradient 100 mm Hg
   c. Aortic valve area 0.78 cm^2, peak gradient 84 mm Hg
   d. Aortic valve area 0.63 cm^2, peak gradient 84 mm Hg

6. A 72-year-old woman is referred for surgical intervention for severe aortic stenosis. She has a long-standing history of dyspnea on exertion, which has recently worsened. She has hypertension requiring multiple medications, hyperlipidemia, and diabetes. She quit smoking last year after a 40-pack-year history. On clinical examination, there is a 2/6 systolic ejection murmur over the aortic area. The second heart sound is split at the base. Pulsations are 2/4 in the upper and lower extremities. There is a left carotid artery bruit. Lung examination shows prolonged expiratory phase but is otherwise unremarkable. The echocardiographic report from the referring physician shows a normal LV size, EF of 70%, normal cardiac output, and severe aortic stenosis with a valve area of 0.68 cm^2 and a mean gradient of 30 mm Hg. The best recommendation at this stage is:
   a. Proceed with surgical intervention
   b. Perform coronary angiography then proceed with surgical intervention
   c. Repeat transthoracic echocardiogram
   d. Perform transesophageal echocardiogram
   e. Perform cardiac computed tomography (CT) for aortic valve calcium score

7. A 30-year-old woman is referred for management of a newly diagnosed subaortic stenosis. She presented at an outside institution with complaints of mild dyspnea on exertion. Echocardiogram demonstrated a subaortic membrane with a gradient of 44 mm Hg and concomitant presence of moderate aortic valve regurgitation. The left ventricle is mildly enlarged, with an EF of 57%. At TEE, the aortic valve does not appear to be significantly calcified. Which of the following statements is correct?

3. d 4. b 5. c 6. c

a. This type of lesion responds well to balloon dilatation
b. Presence of moderate aortic regurgitation is not an indication for surgical intervention
c. Careful inspection of the pulmonary artery should be carried out during TEE
d. Doppler interrogation of the abdominal aorta provides no information in this case

8. Which of the following statements regarding aortic regurgitation is correct?
   a. A proximal isovelocity surface area (PISA) radius of 0.8 cm with an aliasing velocity of 40 cm/sec and a peak aortic regurgitant velocity of 4 m/sec is consistent with severe aortic regurgitation
   b. A pressure half time in excess of 250 milliseconds is consistent with severe aortic regurgitation
   c. Vena contracta is best evaluated from the apical long-axis view
   d. The use of the suprasternal notch window is not useful in the assessment of aortic regurgitation

9. Which of the following echocardiographic findings is important in predicting the outcome of mitral balloon valvuloplasty?
   a. Presence of significant valvular calcification
   b. Presence of significant valvular thickening
   c. Presence of significant subvalvular calcifications
   d. All
   e. A and B

10. During routine assessment of a patient with known valvular disease, the sonographer measures a mitral inflow deceleration time of 758 milliseconds. Which of the following is a reasonable estimate of the mitral valve area?
   a. 1 cm^2
   b. 0.3 cm^2
   c. 3 cm^2
   d. 1.5 cm^2
   e. 2 cm^2

11. Which of the following mitral stenosis patients are likely to benefit from mitral balloon valvuloplasty?
   a. Asymptomatic 29-year-old woman with mitral gradient of 9 mm Hg and resting tricuspid regurgitation velocity of 4 m/sec
   b. A 49-year-old man complaining of dyspnea and a mitral pressure half time of 110 milliseconds
   c. A 62-year-old woman complaining of dyspnea and evidence of heavily calcified mitral commissures and a mitral gradient of 12 mm Hg
   d. Asymptomatic 35-year-old woman with a mitral valve gradient of 12 mm Hg and a loud apical systolic murmur

12. A comprehensive echocardiogram is obtained for the assessment of mitral regurgitation. The mitral annulus measures 4 cm in diameter, and the TVI of the Doppler signal obtained from the plane of the mitral valve is 10 cm. The LVOT diameter is 2 cm, with a TVI of 25 cm. The mitral regurgitant volume is:
   a. 125 ml
   b. 47 ml
   c. 78.5 ml
   d. 30 ml
   e. The regurgitant volume cannot be calculated on the basis of presented data

13. A cardiac surgeon calls you regarding an echocardiogram from an outside institution. He noticed the presence of significant mitral regurgitation by color Doppler and asks you to help with formal quantification of the degree of regurgitation. The study shows clips for mitral regurgitant PISA (aliasing velocity 40 cm/sec, PISA radius 1 cm), but there is no continuous wave (CW) Doppler interrogation of the mitral regurgitant signal. You tell him that an exact measurement cannot be done without knowing the exact mitral regurgitant velocity and TVI; however, with some reasonable assumptions you can say that:

7. c 8. a 9. e 10. a 11. a 12. b

a. Mitral regurgitation is severe because mitral effective regurgitant area is approximately 0.50 cm^2
b. Mitral regurgitation is nearly severe because the effective regurgitant area is approximately 0.38 cm^2
c. Mitral regurgitation is severe because the regurgitant volume is approximately 75 ml
d. Mitral regurgitation cannot be quantified on the basis of existing data
e. A and C

14. Mitral valve prolapse is best diagnosed from which of the following imaging planes?
a. Apical four-chamber view
b. Apical two-chamber view
c. Apical long-axis view
d. Parasternal short-axis view
e. Parasternal long-axis view

15. A 54-year-old man is hospitalized with an acute myocardial infarction. He is taken emergently to the catheterization laboratory, where a completely occluded right coronary artery is found. He undergoes successful stenting. On the third day of hospitalization, he becomes acutely dyspneic and appears diaphoretic. There are no murmurs on clinical examination. An emergency bedside echocardiogram shows hyperdynamic LV function; there is no pericardial effusion. The mitral CW interrogation shows a dense dagger-shaped signal in systole. The most likely explanation for the patient's symptoms is:
a. LV free wall rupture
b. Ventricular septal rupture with large ventricular septal defect
c. Acute severe mitral regurgitation due to papillary muscle rupture
d. Acute thrombosis of the coronary stent

16. A patient is referred for further evaluation of a systolic murmur. The echocardiographic finding in parasternal short axis in Figure 18.1 is most suggestive of:
a. Degenerative aortic stenosis
b. Rheumatic aortic stenosis
c. Bicuspid aortic stenosis
d. Unicuspid aortic stenosis

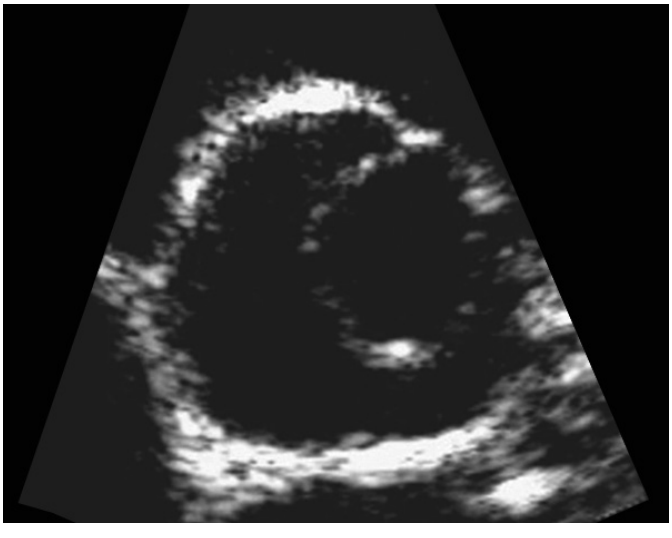
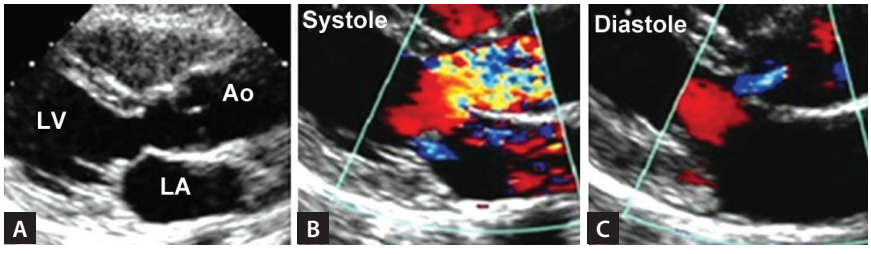


Fig. 18.1

13. e 14. e 15. c 16. d

17. A 42-year-old woman presents with complaints of palpitations. She has no history of cardiac disease. She is otherwise completely asymptomatic. Clinical examination reveals presence of a moderate ejection murmur over the aortic area. There is a soft diastolic murmur along the left sternal border. Heart sounds are normal. A transthoracic echocardiogram is shown in Figures 18.2A to C. The best answer regarding the patient's condition is:



Figs 18.2A to C

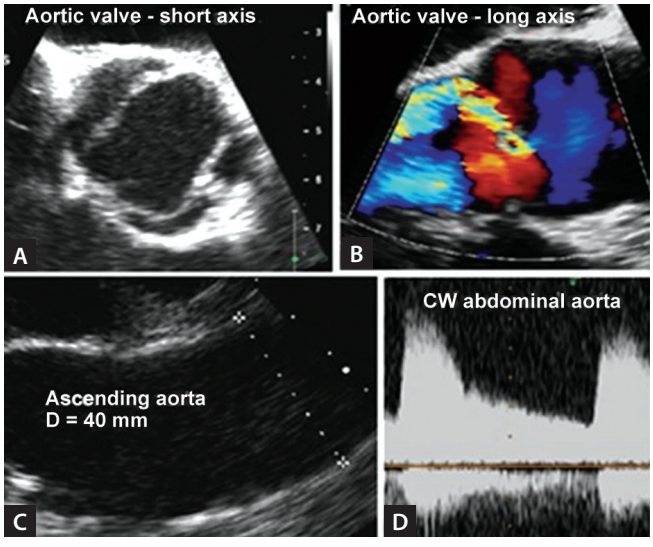
a. Patient has an indication for surgery for severe aortic stenosis
b. Patient's condition is benign, no further evaluation is necessary
c. Patient's condition would be completely resolved with surgical intervention; there is no need for long-term follow-up
d. TEE may be useful in deciding whether surgical intervention is required

18. A 36-year-old man is referred for further evaluation of a cardiac murmur. He has noticed some decrease in his ability to exercise. He used to be an avid jogger but now is able to go only 15 minutes on a treadmill at moderate speed. Clinical examination shows a blood pressure of 164/68 mm Hg with a heart rate of 82 bpm. The cardiac impulse is laterally displaced. There is a loud diastolic murmur, and an ejection click is present. The echocardiogram is shown in Figures 18.3A to D. The best statement regarding the patient's condition is:
    a. The only surgical option is aortic valve replacement
    b. A valve sparing intervention is unlikely to be successful
    c. Ascending aortic graft repair is indicated only when the aortic diameter is >5.5–6 cm
    d. Chest CT will be required for surgical planning

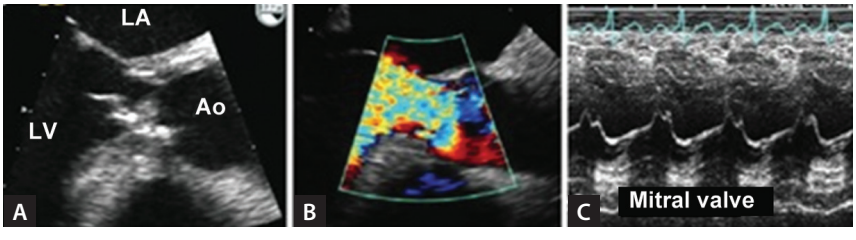
19. A 45-year-old man is transferred for recurrent fevers, weight loss, and rapidly worsening dyspnea. The two-dimension and color Doppler echocardiographic diastolic frames and a mitral valve M mode are shown in Figures 18.4A to C. The most likely clinical finding is:
    a. Marked v waves on the jugular venous contour
    b. Loud continuous murmur over the left sternal border and in the back
    c. Systolic click at the apex
    d. Diastolic rumble at the apex

20. A 60-year-old man without a history of cardiac disease presents with new complaints of palpitations and dyspnea on exertion for the last 10 days. The electrocardiogram demonstrates atrial fibrillation with rapid ventricular response. A TEE-guided cardioversion is performed; a mobile 1.5 cm echodensity is noted on the aortic valve (Figs 18.5A and B). Which of the following statements is correct?

17. d 18. d 19. d

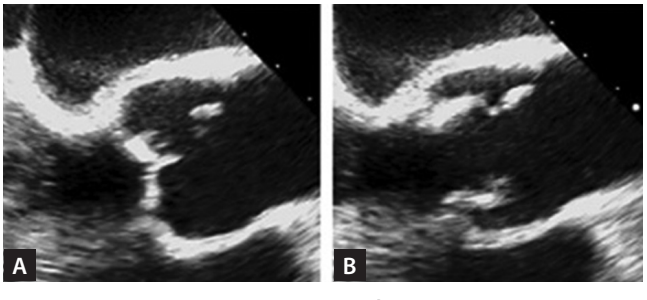


Figs 18.3A to D



Figs 18.4A to C

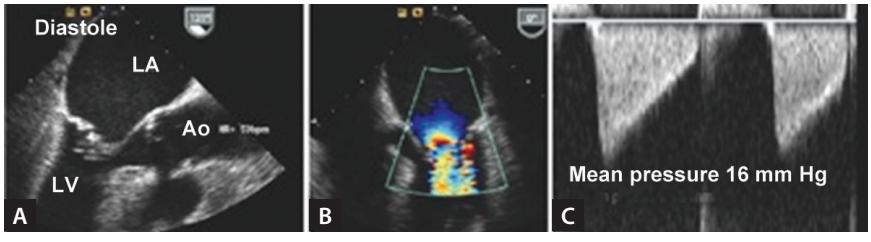
a. Patient should take lifelong anticoagulation
b. Surgical intervention may be required to reduce the risk of embolic events
c. Aortic valve replacement is the most recommended surgical intervention
d. If surgery is performed, there is no risk of recurrence
e. Aspirin has no role in this condition



Figs 18.5A and B

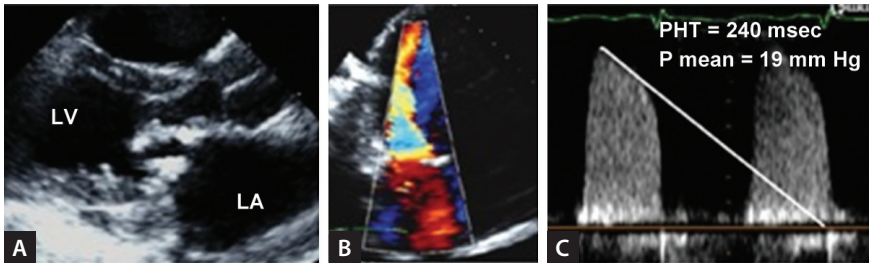
20. b

21. A 49-year-old woman presents with a history of progressively worsening dyspnea. She remembers having frequent throat infections as a child. Echocardiogram shows atrial fibrillation with an average heart rate of 85 bpm. An echocardiographic examination is performed (Figs 18.6A to C). Chest X-ray shows normal heart size. Clinical examination is most likely to show:
    a. Laterally displaced apical impulse
    b. Opening snap occurring late after A2
    c. Opening snap occurring early after A2
    d. Apical diastolic rumble decreasing with leg exercise



Figs 18.6A to C

22. A 67-year-old patient with a history of mitral valve repair 6 years ago for severe mitral regurgitation presents now with worsening dyspnea on exertion over the last 6 months. She also complains of cough with occasional blood-tinged sputum. An echocardiogram is performed and shown in Figures 18.7A to C. Which of the following statements is correct?

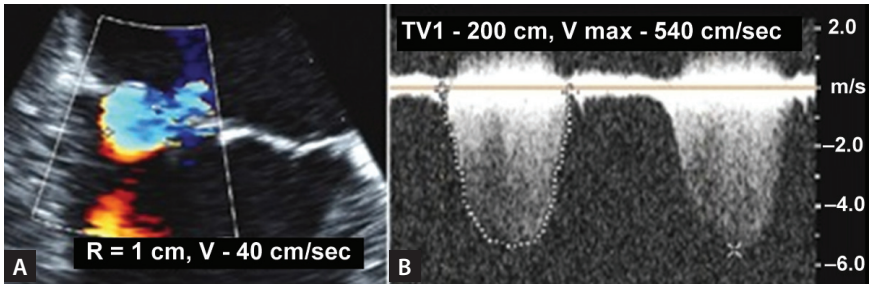


Figs 18.7A to C

    a. Patient's symptoms are likely due to development of secondary pulmonary hypertension
    b. In this situation, accurate diagnosis can only be made by left and right heart catheterization
    c. Supine bicycle echocardiography is the next step in evaluation
    d. Mitral balloon valvuloplasty is likely to result in clinical improvement
    e. All statements are correct

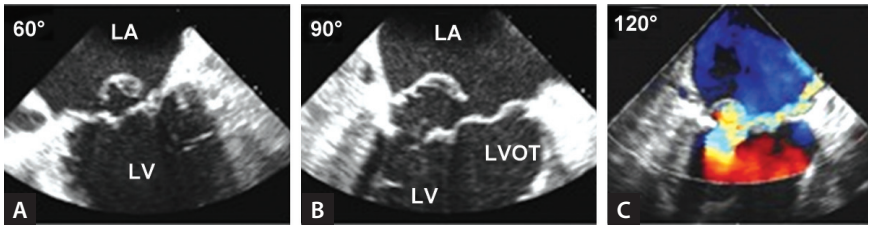
23. A 39-year-old woman is referred for evaluation of mitral regurgitation due to a very eccentric jet. The TEE findings shown in Figures 18.8A and B are consistent with:
    a. Eccentric jets are not reliably quantified by PISA
    b. The mitral regurgitation is moderate
    c. The mitral regurgitation is severe
    d. The regurgitant volume is <60 ml
    e. The only definitive proof of severe regurgitation in the case of eccentric jets is a demonstration of systolic flow reversal in the pulmonary veins

21. c 22. a 23. c



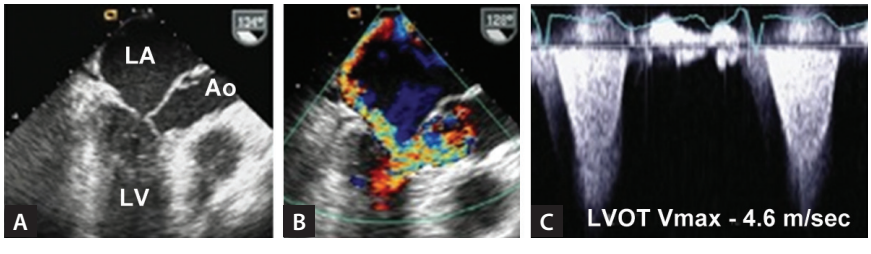
Figs 18.8A and B

24. The TEE images in Figures 18.9A to C are obtained for evaluation of a newly diagnosed mitral regurgitation. The imaging plane angles are provided. You advise the surgeon that:
    a. There is a flail segment in the P1 scallop
    b. There is a flail segment in the P2 scallop
    c. There is a flail segment in the P3 scallop
    d. There is a flail segment in the A2 scallop
    e. There is bileaflet prolapse



Figs 18.9A to C

25. You are called to assist with an intraoperative transesophageal echocardiogram. Images are shown in Figures 18.10A to C. You advise the surgeon that:
    a. The mitral regurgitation is severe; he will need to perform a posterior leaflet repair
    b. The mitral regurgitation is severe; he will need to perform an anterior leaflet repair
    c. The mitral regurgitation is severe and the patient will need to be reassessed intraoperatively after coming off cardiac bypass
    d. The mitral regurgitation is moderate and does not require intervention
    e. Medical therapy is unlikely to have an effect on the mitral regurgitation in this type of disease



Figs 18.10A to C

24. b 25. c

Answers

1. a. The Doppler findings are consistent with severe aortic stenosis. Valve area can be calculated with the continuity equation. The basic formula is:
Left ventricular outflow tract (LVOT) flow = Aortic valve flow
LVOT area × LVOT time-velocity integral (TVI) = Aortic valve area (AVA) × Aortic TVI 4 × 15 = AVA × 100
In the example, the AVA is 0.6 cm^2. Answer B refers to the dimensionless index (LVOT/aortic TVI or velocity ratio), which has been shown to accurately predict presence of severe aortic stenosis when the ratio is <0.25 (rather than 0.3). This measurement avoids the use of LVOT diameter, which is the largest source of errors in AVA calculations. This is due to the inherent difficulty associated with the measurement in the presence of a heavily calcified valve; any error is further increased by using the squared value in the valve formula. Answer C is false; typical severe aortic stenosis has aortic velocities in excess of 4 m/sec. Echocardiographic criteria used in classification of the severity of valvular disease have been summarized in the latest AHA/ACC Guidelines.
2. d. The evolution of completely asymptomatic aortic stenosis is not benign. Several studies have shown that once the stenosis is severe patients will inexorably develop symptoms. Rosenhek et al. have shown that among 128 patients with asymptomatic severe aortic stenosis, only 47% were free of death or aortic valve replacement after 2 years. Pellikka et al. have shown that among patients with asymptomatic aortic stenosis with aortic velocities >4 m/sec at baseline, only 33% remain free of symptoms after 5 years. Therefore, answer A is obviously false.
Available information in this question suggests presence of severe asymptomatic aortic stenosis. Although the patient is likely to require surgery, a decision cannot be made based solely on the information presented so far, and thus answer B is false.
Transesophageal echocardiography (TEE) can be used in the evaluation of aortic stenosis. Indeed, planimetry of the AVA at TEE correlates well with AVA by catheterization laboratory evaluation. However, this test is typically used as an incremental step only when the transthoracic study fails to establish disease severity (answer C is false).
Exercise studies are useful in clinical decision making for asymptomatic aortic stenosis. Current AHA/ACC guidelines for management of valvular heart disease suggest their use in asymptomatic aortic stenosis. Development of symptoms or a decrease in blood pressure at peak exercise would suggest a more advanced disease state, and aortic valve replacement should be considered. We are using the oxygen treadmill consumption test. In our experience, this test allows better quantification of patient's physical limitation; serial studies are also easier to compare to assess disease progression (answer D is correct). Current AHA guidelines recommend yearly echocardiographic evaluations in patients with severe asymptomatic aortic stenosis who are not undergoing aortic valve replacement (answer E is false).
3. d. Based on the Doppler data, the mean gradient is 30 mm Hg and the dimensionless index is less than 0.25. These findings are worrisome for severe aortic stenosis, low-gradient, low-output type. The hypotensive response to diuretics is also suggestive of severe aortic stenosis. The substantial decrease in systolic function could represent end-stage valvular heart disease, but the question of an ischemic etiology is obvious. However, a vasodilator stress test is contraindicated when severe aortic stenosis is suspected (answer A is false); exercise and full-dose dobutamine stress echocardiogram are also contraindicated in the presence of acutely decompensated heart failure (answers B and C are false). A low-dose dobutamine echocardiogram will allow assessment of aortic stenosis and provide prognostic information for surgical intervention. Indeed, in low-output, low-gradient aortic stenosis, the gradient is low because of the left ventricular (LV) systolic failure. With the inotropic support provided by low-dose dobutamine, one can distinguish between true severe aortic stenosis (gradient increases, similar valve area) and pseudo-severe aortic stenosis (the calculated valve area is

low due to low stroke volume; with dobutamine, the mean gradient remains the same, but the calculated valve area increases). In addition, patients demonstrating presence of contractile reserve (defined as an increase in stroke volume of >20%) have better outcome after aortic valve replacement.

4. b. The peak-to-peak gradient typically evaluated at pullback in the catheterization laboratory does not reflect a true event, as the peak aortic pressure occurs after peak LV pressure when aortic stenosis is present. Echocardiographic estimation of the peak aortic gradient is more accurate as it reflects instantaneous pressure differences between the aorta and left ventricle (answer A is false). Statement B is correct in the vast majority of situations and established echocardiography is the main diagnostic tool in valvular disease. A number of assumptions are, however, made in echocardiographic assessment of valvular stenosis. If these are not accurate, Doppler-based estimations can be erroneously high (answer C is false). The simplified Bernoulli equation estimates the pressure gradient according to the formula $\Delta_p = 4v2$; this in turn is a simplification of the convective acceleration term ½r(v22 – v12) is the original Bernoulli equation. The number 4 in the simplified formula is the approximation of the $½_p$ converted for expressing pressure in mm Hg units; it assumes a blood mass density of 1,060 kg/m^3. However, blood mass density is lower when significant anemia is present, which would lead to overestimation of the pressure gradient if the same formula is applied. In addition, conditions with increased cardiac output (anemia, fever, subvalvular aortic stenosis, and significant valvular regurgitation) will increase the inflow velocity v1, which is usually considered negligible. This also leads to overestimation of pressure gradients (answer C is false). The use of nonimaging probes is required in the assessment of aortic stenosis not because of hardware or software properties, but because the smaller footprint allows ultrasound interrogation from deeper position and better alignment of the Doppler signal with the direction of blood flow.
5. c. Based on the continuity equation, the aortic valve area is:
$\pi \times$ LVOT diameter $2/4 \times$ LVOT TVI/aortic TVI = 0.78 cm^2
Since the aortic valve inflow velocity (LVOT velocity) is 2 m/sec, the term v12 cannot be ignored in the Bernoulli equation. The full formula $\Delta_p = 4(v22 - v12)$ has to be used. The pressure gradient is 84 mm Hg (answer C is correct).
6. c. Clinical examination argues against severe aortic stenosis (preserved A2 component, normal peripheral pulsations, and unimpressive murmur). On the echocardiographic report, there is a discrepancy between the estimated aortic valve gradient (consistent with moderate stenosis) and the calculated valve area (consistent with severe stenosis). This cannot represent a low-output, low-gradient aortic stenosis type, as the ejection fraction (EF) and cardiac index are normal. Obviously, a decision for surgery cannot be made immediately (answers A and B are false). Although both TEE (valve planimetry) and aortic valve calcium score can be useful in decision making, the most reasonable next step is to repeat the transthoracic study. The most common cause for the overestimation of the AVA is an erroneously low measurement of the LVOT diameter. Careful assessment at transthoracic echocardiography usually rectifies the mistake.
7. c. Subaortic stenosis does not respond to balloon dilatation. The only treatment is surgical resection (answer A is false). Presence of moderate aortic regurgitation is an indication for surgery, as further valve deterioration is expected because of the jet lesion from the subaortic acceleration (answer B is false). Associated lesions must be evaluated. The most common are patent ductus arteriosus and pulmonary valve stenosis (which both can be diagnosed during TEE examination of the pulmonary artery and bifurcation-answer C is correct); coarctation of the aorta (which can be diagnosed by pulsed Doppler of the abdominal aorta-answer D is false); and ventricular septal defect.
8. a. This question uses the proximal isovelocity surface concept in calculating the effective regurgitant orifice (ERO). According to the continuity equation, the flow converging to the

valve must be equal to the flow through the valve. As blood flow accelerates toward a narrowing orifice (in this case the regurgitant orifice), the spatial distribution of points in which the fluid has the same velocity (isovelocity surface) is approximated by a hemisphere.
Based on this concept, one can transcribe the continuity equation as:

- Isovelocity flow = regurgitant flow
- Isovelocity area × aliasing velocity = ERO × regurgitant velocity
- $2\pi R2$ × aliasing velocity = ERO × regurgitant velocity
- Replacing the numbers, this becomes:

A pressure half time of <250 milliseconds is consistent with severe aortic regurgitation. The vena contracta is best measured on the parasternal long axis view (best axial resolution); in the apical long-axis view, the vena contracta will be typically perpendicular to the ultrasonic beam, reducing the spatial resolution (answer C is false). The suprasternal notch window allows Doppler evaluation of flow reversals in the descending thoracic aorta; holodiastolic flow reversals are suggestive of severe aortic regurgitation (answer D is false).

9. e. The score used for predicting the outcome of mitral balloon valvuloplasty takes into account valve leaflet mobility, thickness (answer B), calcification (answer A), and subvalvular thickening. Each is given a score of 1 to 4. When the total score is 8 or less, the valve is considered amenable to balloon valvuloplasty. Subvalvular calcifications are not included in this score (answer C is false). The correct answer is E.

10. a. This question refers to mitral valve area (MVA) calculation based on the pressure half time. Commonly in the echocardiography board examination, the candidate is not presented with the actual pressure half time measurement, but rather with a still image of a continuous wave (CW) signal or in this case with the measured deceleration time. The relationship between pressure half time and deceleration time is constant.
    - Pressure half time = 0.29 × deceleration time
    - Furthermore, the MVA is estimated according to the formula
    - MVA = 220/pressure half time

    Using the numbers provided, MVA is 220/0.29 × 758 milliseconds = 1 cm^2 (answer A).

11. a. This question addressed the indications and contraindications for mitral balloon valvuloplasty. Case A is consistent with moderate mitral stenosis. Although asymptomatic, a tricuspid regurgitation velocity of 4 m/sec is suggestive of pulmonary artery systolic pressure in excess of 70 mm Hg; therefore, the patient has a clear indication for balloon valvuloplasty (correct answer). In case B, the MVA is estimated at 2 cm^2 (220/pressure half time), and therefore the etiology of dyspnea must be sought elsewhere. The mechanism of successful mitral valvuloplasty is commissural separation; presence of heavy calcification is associated with lower procedural success and higher incidence of significant mitral regurgitation (answer C is false). Presence of significant mitral regurgitation (suggested by clinical examination) is a contraindication for valvuloplasty (answer D is false).

12. b. This question uses the continuity equation for estimating the mitral regurgitant volume (MRV). In the absence of significant aortic regurgitation, the net flow through the aortic valve must equal the net flow through the mitral valve:
    - Aortic flow = mitral forward flow – mitral regurgitant flow
    - Therefore, MRV can be estimated by the formula.

13. e. There are several simplified calculations that are commonly used in proximal isovelocity surface area (PISA) evaluation of mitral regurgitation. They are all based on some presumptions, but their simplicity makes them attractive for rapid calculations. Two simplified methods are commonly used for ERO calculation. In the first one, the aliasing velocity is set at 40 cm/sec. If the mitral regurgitant velocity is considered 500 cm/sec (a reasonable assumption when systemic blood pressure is normal), calculation of the ERO is:
    PISA surface × aliasing velocity = ERO × regurgitant velocity
    Using this simplification, the ERO is 0.5 cm^2.

A second simplification for ERO is using an aliasing velocity of 30 cm/sec and assuming again that the mitral regurgitant velocity is 500 cm/sec. With these numbers:
ERO = $2 \times 3.14 \times R^2 \times 30/500 = 0.38 \times R^2$
So that if PISA radius is more than 1 cm, the ERO is more than 0.38 cm^2, that is, the regurgitation is severe.
There is also a simplification for estimating the regurgitant volume (RV). This takes advantage of the observation that the ratio between mitral regurgitant TVI and velocity is relatively constant approximately 1/3.25.
RV = ERO × regurgitant TVI
RV = ($2 \times 3.14 \times R^2$ × aliasing velocity/mitral velocity) × regurgitant TVI
Using the numbers provided, the RV is 75 ml (correct answer E).

14. e. Mitral valve annulus has a saddle shape. Mitral valve prolapse is considered to be present when a prolapse of 2 mm or more above the mitral annulus plane is found in the parasternal long-axis view of the mitral valve. Other views (especially the apical four-chamber view) can overestimate presence of prolapse.
15. c. Although all listed complications may occur early after a myocardial infarction and percutaneous intervention, the presence of a hyperdynamic ventricle excludes in-stent thrombosis. There is no evidence of pericardial effusion (free wall rupture). A ventricular septal defect is typically associated with a loud systolic murmur, even when acute. The murmur of acute severe mitral regurgitation due to papillary muscle rupture is unimpressive. This is due to rapid equalization of LV and atrial pressures, with little pressure gradient. The typical CW Doppler finding is a dagger-shaped mitral regurgitant signal (correct answer C).
16. d. The systolic frame is typical of the appearance of a unicuspid aortic valve. Unlike bicuspid valves, which typically have two commissures and a variable presence of a raphe, the unicuspid valves have only one commissure (Fig. 18.1) or even no commissure (central orifice).
17. d. The case is a typical presentation of subaortic stenosis, with flow acceleration visible well below the aortic valve plane. The diastolic frame also shows presence of aortic regurgitation. These can exist either as an isolated ridge/membrane in the LVOT, or as longer narrowing of the LVOT (tunnel). The status of the aortic valve is not certain at this stage, although significant stenosis can be suspected from the intense aliasing seen in the LVOT; however, no clear recommendation can be made in terms of surgical intervention (answer A is false). The condition is not benign, the status of the native valve must be established (answer B is false). Surgical intervention with resection of the ridge/membrane is usually successful but recurrence can be seen and regular follow up is recommended (answer C is false). TEE is ideal in imaging both the subaortic area and the native aortic valve (answer D is correct).
18. d. Echocardiographic images are diagnostic of a bicuspid aortic valve and severe aortic regurgitation. Valve repair techniques have become a reasonable alternative to valve replacement, especially in younger patients in whom the valve is not heavily calcified (answers A and B are false). Valve repair is suitable in patients who do not have restricted leaflet mobility; the freedom from reoperation is approximately 85% after 7 years. Patients with bicuspid aortic valve have a higher risk of progression of aortic aneurysm due to coexisting aortopathy, and therefore the current recommendation is to consider aortic repair when the diameter exceeds 4.5–5 cm (similar to patients with Marfan syndrome; answer D is false). The Doppler signal in the abdominal aorta is highly suggestive of coarctation of the aorta. A computed tomography (CT) scan will be required for further diagnosis and surgical planning (answer D is correct).
19. d. The echocardiographic pictures are diagnostic of severe aortic regurgitation, in this case, due to bacterial endocarditis. The mitral anterior leaflet is pushed by the aortic regurgitant jet. Note in the M mode that the anterior leaflet is displaced posteriorly, and the separation of the mitral valve leaflets is minimal. This will result in functional mitral stenosis and will be the cause of the diastolic apical rumble (Austin-Flint murmur; correct answer D). The

other clinical findings would be consistent with severe tricuspid regurgitation (answer A), coarctation of the aorta or patent ductus arteriosus (B), and mitral valve prolapse (C).

20. b. This is the typical presentation of papillary fibroelastoma of the aortic valve. This benign tumor consists of a narrow stalk with numerous small frond-like excrescences. Anticoagulation is usually not recommended (answer A is false). The tumor is friable and has the potential for embolization, especially when larger than 10 mm or highly mobile; surgical intervention is usually recommended under these circumstances (answer B is correct). Surgery consists of shaving the tumor from the attachment point; sometime valve repair with pericardial patch is necessary (answer C is false). Recurrence is rare, but well described in the literature (answer D is false). Most authors would suggest use of an antiplatelet agent (answer E is false).

21. c. The echocardiographic images are diagnostic of rheumatic mitral stenosis. Note the hockey stick deformity of the anterior mitral leaflet and incomplete opening of the posterior leaflet. There is visible mitral inflow acceleration, and CW Doppler is consistent with severe mitral stenosis (pressure gradient is 16 mm Hg). This condition in isolation is associated with a normal LV size (answer A is false). The interval between the second heart sound A2 and the opening snap reflects the isovolumic relaxation time and is typically shorter with higher left atrial pressure (the shorter the A2-opening snap interval, the more severe is the stenosis; answer C is correct). The mitral gradient is significantly increased with increasing heart rates; presence of a diastolic rumble can be brought out with some physical activity at the time of examination (answer D is false).

22. a. The echocardiographic images show the hockey-stick deformity with limited excursion of the anterior mitral leaflet. In this case, this is occurring after surgical repair with a posterior reduction annuloplasty. Although uncommon, this is a known complication after mitral valve repair. The pathophysiologic mechanisms are similar to mitral stenosis of any other etiology, with left atrial hypertension leading to secondary pulmonary hypertension (answer A is correct); hemoptysis is in this case a direct reflection of elevated postcapillary pulmonary pressure. Estimation of the left atrial pressure (and indirectly of the mitral gradient) by catheterization with the use of pulmonary capillary wedge pressure is usually inaccurate. The echocardiographic assessment of the mitral gradient is the preferred technique. An accurate transmitral gradient can be obtained at catheterization only by transseptal approach with direct measurement of the left atrial and LV pressures (answer B is false). Patient has evidence of symptomatic severe mitral stenosis; an exercise echocardiogram will not provide additional information (answer C is false). Mitral balloon valvuloplasty cannot be used in patients who underwent mitral valve repair (answer D is false).

23. c. The PISA method is excellent in quantification of mitral regurgitation. The strength of the method is particularly important in eccentric jets, when the color Doppler aspect of the jet is less impressive due to the loss of kinetic energy by contact with the atrial wall (Coanda effect). The concept is similar to the one described previously for aortic regurgitation.
    - Isovelocity area × aliasing velocity = effective regurgitant orifice × regurgitant velocity
    - RV = ERO × regurgitant TVI

    Substituting the numbers, the ERO is 0.46 cm^2 and the RV 91 ml. Correct answer is C.

24. b. The echocardiographic images are typical of a flail P2 scallop. We typically start with the four-chamber view on TEE, which helps identify the location (anterior vs. posterior) based on 2D appearance and direction of the color jet (posteriorly directed for anterior flails and anteriorly directed for posterior flails). Imaging in the commissural view of the mitral valve (as shown in Figs 18.9A to C) helps further locate the scallop (lateral/central/medial). Real-time 3D TEE is rapidly emerging as an excellent tool in the assessment of mitral valvular disease.

25. c. Images are typical of mitral regurgitation secondary to systolic anterior motion. This is typically seen in dynamic LVOT obstruction in hypertrophic cardiomyopathy but can also occur in hypertensive heart disease with prominent basal septum, acute anterior infarcts with hyperdynamic compensatory function, or apical ballooning syndrome with hyperdynamic

base. Usually surgical correction of the dynamic outflow obstruction with myectomy results in nearly complete resolution of the mitral regurgitation (answers A and B are false). This needs to be confirmed on postbypass images, when a decision can be made for additional mitral valve surgery (answer C is correct). Presence of an eccentric jet extending all the way to the posterior atrial wall is consistent with severe regurgitation (answer D is false). Agents with negative chronotropic and inotropic effects have been used for medical management (beta-blockers, calcium channel blockers, disopyramide); mitral valve replacement is usually not required (answer E is false).

19

Echocardiography for Right-sided Valves

1. In which of the following clinical scenarios is transesophageal echocardiography (TEE) usually indicated in addition to transthoracic echocardiography (TTE) in the diagnostic assessment?
   a. Pulmonary artery (PA) pressure in primary pulmonary hypertension
   b. Inferior vena cava (IVC) thrombus
   c. Suspected pacemaker endocarditis
   d. Right ventricular (RV) function

2. A patient is undergoing an examination of the heart following a heart transplant. Severe tricuspid regurgitation (TR) is present but no turbulence in the jet is appreciated. RV function is moderately reduced. The tricuspid regurgitant velocity is 1 m/sec. What other finding is most likely to be evident in this patient?
   a. McConnell's sign
   b. Flail tricuspid valve leaflet
   c. Tricuspid stenosis
   d. Atrial septal defect (ASD)
   e. Severe pulmonary insufficiency

3. In the patient in question 2, the estimated RV systolic pressure from the tricuspid regurgitant velocity is:
   a. Low (<30 mm Hg)
   b. Mildly increased (30–50 mm Hg)
   c. Moderately increased (51–70 mm Hg)
   d. High (>70 mm Hg)
   e. Cannot be accurately estimated by this technique

4. A young man with mild pulmonary valve stenosis is seen. He has a peak gradient across the pulmonary valve of 20 mm Hg. His tricuspid regurgitant velocity is 3 m/sec and his right atrial size is normal. His IVC is not enlarged and decreases further on sniffing. Which of the following is true?
   a. His PA systolic pressure is normal
   b. His PA systolic pressure is moderately elevated
   c. His PA systolic pressure cannot be estimated when pulmonic stenosis is present
   d. He has severe PA hypertension that will require treatment
   e. None of the above

1. c 2. b 3. e 4. a

5. The tricuspid valve consists of the following leaflets:
   a. Anterior, lateral, medial
   b. Anterior, posterior, septal
   c. Left, right, posterior
   d. Moderator, anterior, posterior
   e. Moderator, posterior, septal
6. A Gerbode defect is:
   a. Atrialization of the right ventricle in Ebstein's anomaly
   b. An unroofed coronary sinus with resultant bidirectional ASD at the level of the AV groove
   c. A left-sided superior vena cava entering and enlarging the coronary sinus
   d. A communication between the right atrium and left ventricle that may encompass the tricuspid valve leaflets
   e. A sinus of Valsalva aneurysm that communicates with the right atrium
7. A patient with prior rheumatic disease is seen. An echocardiogram is performed. Which of the following is true about the Doppler echocardiographic assessment of tricuspid stenosis in this condition?
   a. Doming and thickening of the valve in systole are seen
   b. The mean pressure gradient is at least 10 mm Hg in severe stenosis
   c. The valve area may be estimated by dividing 190 by the pressure halftime
   d. Planimetry of the valve area is readily obtained
   e. Tricuspid stenosis is clinically significant in 25% of patients with rheumatic mitral stenosis
8. Severe TR is associated with all of the following except:
   a. Paradoxical motion of the interventricular septum
   b. Regurgitant orifice area by proximal isovelocity surface area of 0.25 cm^2
   c. Flow reversal in the hepatic veins in systole
   d. A color flow jet area of >10 cm^2 in the right atrium
   e. A vena contracta dimension of 0.8 cm
9. The most common cause of significant TR is:
   a. Myxomatous change or prolapse
   b. Rheumatic disease
   c. Endocarditis
   d. Secondary to pulmonary hypertension and/or RV dilatation
   e. Trauma
10. Which of the following is consistent with the diagnosis of severe pulmonic stenosis?
    a. Peak velocity of >4 m/sec across the valve
    b. Normal RV systolic pressure
    c. RV wall thickness of 0.3 cm
    d. Normal size of the PA
11. A 25-year-old asymptomatic man presents with a systolic murmur at the second right interspace. An echocardiogram is performed and he is found to have pulmonic stenosis. A peak pressure gradient is measured and is 20 mm Hg. Which of the following statements about his condition is most likely to be true?
    a. He is likely to require surgical or balloon valvuloplasty in the next decade
    b. He should undergo yearly examination and echocardiography and a baseline transesophageal echocardiogram
    c. Cardiac catheterization is indicated to more accurately determine his pulmonic pressure gradient
    d. Systolic doming of the pulmonary valve is present

5. b 6. d 7. c 8. b 9. d 10. a 11. d

12. Which of the following statements about pulmonary insufficiency is correct?
    a. Pulmonary insufficiency detected by Doppler of any degree is abnormal
    b. Severe pulmonary insufficiency leads to a highly turbulent jet on color flow Doppler
    c. Severe pulmonary insufficiency most commonly occurs in the setting of prior treatment of congenital heart disease
    d. Pulmonary insufficiency may be used to measure the PA systolic pressure

13. Which of the following is the most likely cause of a mobile tricuspid valve mass?
    a. Sarcoma
    b. Fibroelastoma
    c. Myxoma
    d. Chiari network
    e. Carcinoid syndrome

14. Which of the following conditions may not cause hemodynamically significant lesions at both the tricuspid and pulmonary valve?
    a. Carcinoid syndrome
    b. Staphylococcal infection
    c. Rheumatic fever
    d. Ebstein's anomaly

15. Which of the following statements about infundibular pulmonic stenosis is correct?
    a. Infundibular pulmonic stenosis is always part of a congenital syndrome
    b. Infundibular stenosis may cause a high-velocity jet that impinges on the pulmonary valve causing pulmonary insufficiency
    c. The site of stenosis is usually discrete
    d. Doppler estimation of the pressure gradient across the infundibular stenosis is inaccurate except when valvar stenosis coexists
    e. Infundibular stenosis is most easily assessed from a parasternal short-axis imaging plane

16. A young man presents with fatigue and a history of occasional near syncope with onset of a fast heart rhythm. Based on the apical four-chamber image in Figure 19.1, which is the least likely finding in this patient?
    a. Wolff-Parkinson-White pattern on electrocardiogram
    b. Intracardiac shunt
    c. Parchment-like RV wall
    d. Severe TR
    e. Atrialization of a portion of the right ventricle

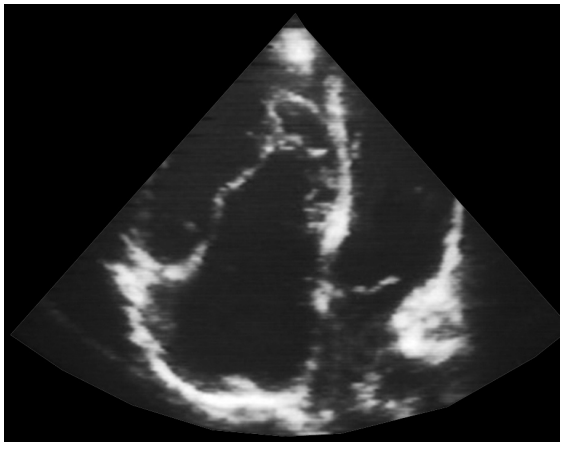


Fig. 19.1

12. c 13. b 14. d 15. b 16. c

17. You see a young man with prior open heart surgery for the first time. He is unaware of what surgery he had performed in the past. He has significant RV dilatation and some RV dysfunction. Based on the accompanying parasternal short-axis image of the pulmonary valve in Figure 19.2, which of the following statements is most likely to be correct?
    a. Mild pulmonary regurgitation is present. No further work-up is indicated
    b. He likely has an ASD with RV overload and high flow through the pulmonary circuit
    c. He has severe pulmonary regurgitation likely as a result of prior surgery on his pulmonary valve or RV outflow tract
    d. This represents a patent ductus arteriosus and requires reoperation
    e. If replacement of the pulmonic valve is required, a mechanical valve should be contemplated

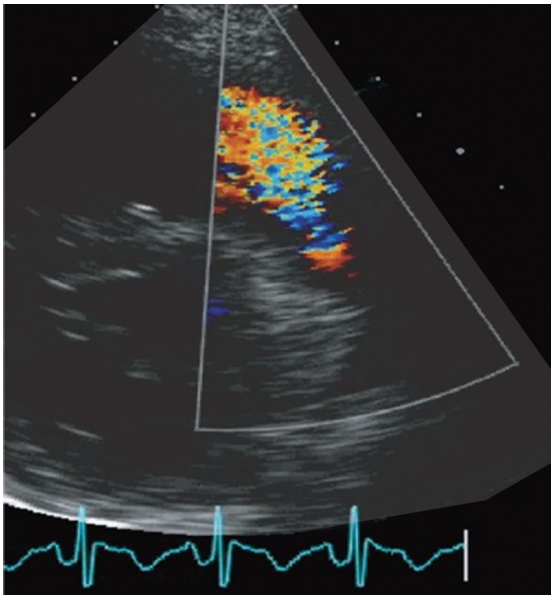


Fig. 19.2

18. A 57-year-old man is undergoing mitral valve repair for severe mitral regurgitation from mitral valve prolapse. He has an intraoperative TEE before the surgical repair and you are asked to consult regarding the image of the TR and tricuspid valve in the midesophageal four-chamber view (Fig. 19.3). Which of the following is correct?
    a. The TR detected intraoperatively will likely overestimate that detected on routine ambulatory examination and should not be used in the decision making regarding concomitant tricuspid valve surgery
    b. Surgical intervention on the tricuspid valve is rarely required in this situation as it always improves after surgical correction of the mitral valve
    c. Surgical correction of the tricuspid valve should be considered as the regurgitation appears severe with a significant flow convergence area, and TR is more likely underestimated in the operative setting
    d. The most likely cause of severe TR in this situation is a flail tricuspid valve
    e. TR only occurs in this situation in the presence of severe pulmonary hypertension

17. c 18. c

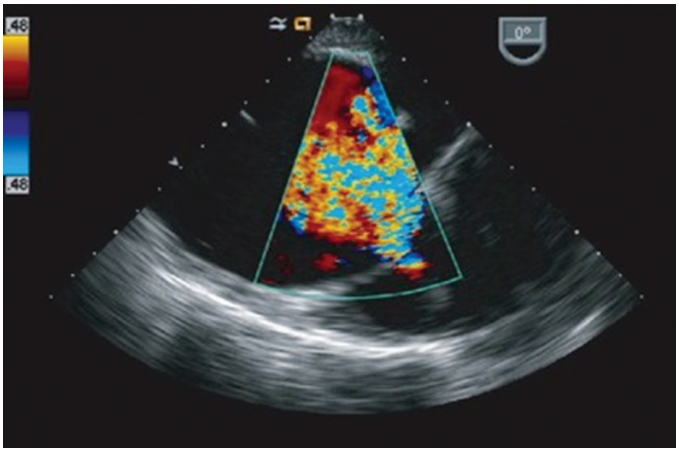


Fig. 19.3

19. A 35-year-old woman has a history of recurrent fever of unknown origin and fleeting pleuritic chest pain. Multiple blood cultures have been negative, and a transthoracic echocardiogram of reasonable quality has been unremarkable. A chest X-ray has shown a small pleural effusion but an ultrasound has shown that this is too small to aspirate. She undergoes TEE. A representative image of the RV outflow tract is shown in Figure 19.4 and constitutes the only abnormality detected. Which of the following would be the most appropriate next step in managing this patient?

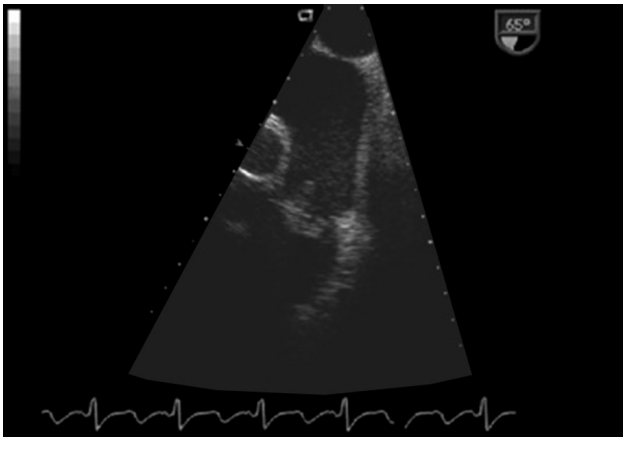


Fig. 19.4

a. Hypercoagulability work-up
b. Venous duplex of lower limbs to exclude venous thrombosis
c. CT scan with contrast of the chest to exclude pulmonary emboli
d. Noncontrast chest CT
e. Broad spectrum antibiotic treatment including antifungal coverage

19. d

20. The hepatic vein pulsed Doppler profile shown in Figure 19.5 is most likely associated with which of the following clinical profiles?
    a. Large "v" waves in the jugular venous profile
    b. Pulsus paradoxus
    c. Kussmaul's sign
    d. Pulsus alternans
    e. Pulsus bisferiens

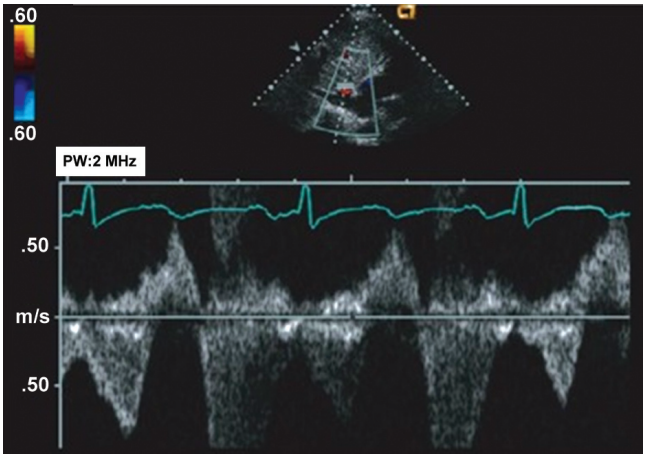


Fig. 19.5

21. The pulmonary valve M-mode in Figure 19.6 is most likely associated with which of the following clinical scenarios?
    a. Endocarditis of the pulmonary valve
    b. Infundibular pulmonic stenosis in a young man with prior repair of tetralogy of Fallot
    c. A young woman with primary pulmonary hypertension being considered for therapeutic intervention
    d. A retained PA catheter remnant in an elderly man with a prolonged hospital course
    e. Severe pulmonic insufficiency

22. Which of the following statements concerning the condition shown in the image of the tricuspid valve in Figure 19.7 is correct?
    a. It may require tricuspid valve replacement
    b. It does not respond to medical therapy
    c. The prognosis is excellent
    d. It frequently involves left-sided valves but rarely the pulmonic valve
    e. Infection is a major predisposing cause

20. a 21. c 22. a

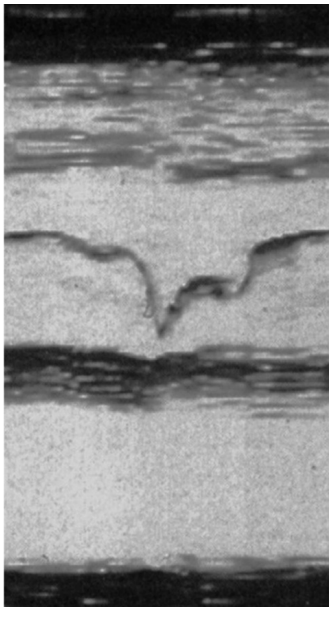


Fig. 19.6

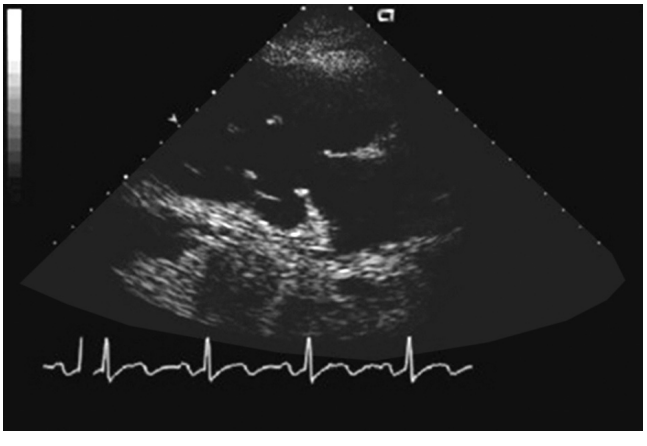


Fig. 19.7

23. The Doppler velocity in Figure 19.8 is through the pulmonary valve in the parasternal short-axis view of an 18-year-old man with chest pain. Which of the following statements is correct?
    a. In the absence of chest pain, there is no indication for any intervention
    b. He will likely benefit from a balloon valvuloplasty
    c. Based on the Doppler profile, he has associated subvalvular stenosis
    d. He most likely has a bicuspid pulmonic valve
    e. His chest pain is unrelated to the valve lesion

23. b

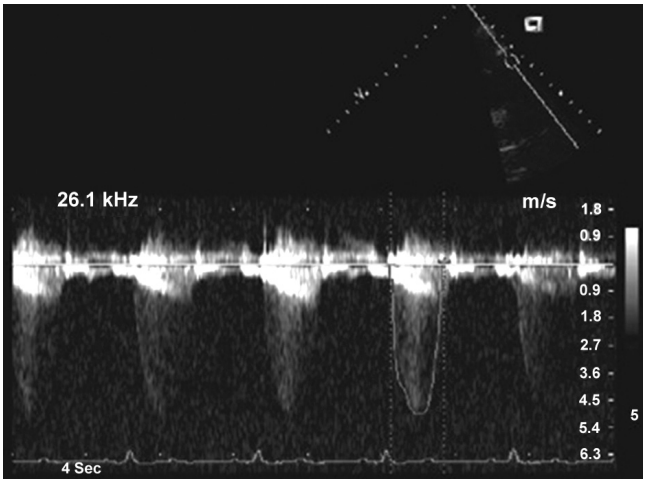


Fig. 19.8

24. Figure 19.9 illustrates a TEE transgastric view of the right atrium and right ventricle with the tricuspid valve open in diastole. The patient has been recently admitted with fevers 6 weeks after permanent pacemaker implantation with a DDD system. No obvious infection is evident at the site of the pacemaker insertion. Mild central TR is present. Which of the following statements is true about this case?
    a. The tricuspid valve will need to be replaced
    b. Only antibiotic therapy is required
    c. Surgical removal of the pacing wires followed by antibiotics is all that is required
    d. Percutaneous removal of the pacing wires and antibiotic therapy is required
    e. The patient will most likely require antibiotic treatment as well as surgical removal of the pacemaker wires and the pacemaker system including the generator

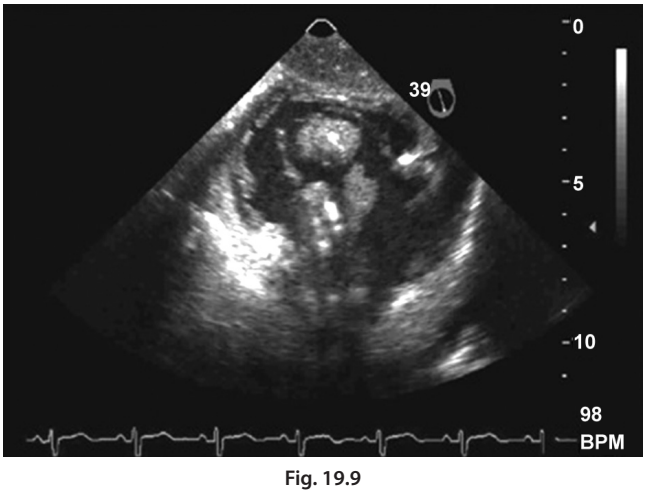


Fig. 19.9

24. e

25. A 22-year-old man is transferred from an outside hospital with endocarditis involving the tricuspid valve. A representative image of the tricuspid valve lesion as seen on TEE is shown in Figure 19.10. Based on the findings, which of the following is correct?
    a. He requires immediate surgery because of the size of vegetation
    b. He may do well with medical therapy
    c. The most likely cause of the infection is *Enterococcus*
    d. The lesion represents a fungal infection
    e. The most likely complication is systemic embolization

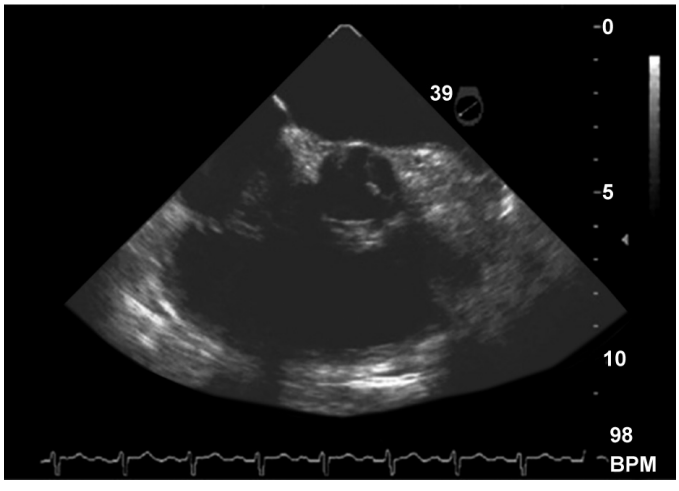


Fig. 19.10

25. b

Answers

1. c. Right-sided valve lesions are usually well identified by transthoracic imaging as these structures lie anterior in the chest and in the near field of the chest wall transducer. However, better resolution of pulmonary valve endocarditis or mass, embolus in transit in the right heart, and of vegetations involving a pacer wire have been reported with transesophageal echocardiography (TEE) than with transthoracic echocardiography (TTE) alone. TEE is not usually indicated in the assessment of pulmonary artery (PA) pressures in primary pulmonary hypertension. When the tricuspid regurgitant velocity is difficult to measure by TTE, injection of agitated saline contrast has been shown to improve the spectral display of the regurgitant jet and is more likely to be helpful than a TEE in this situation.
2. b. A flail tricuspid valve is common with repeated endomyocardial biopsies following transplantation and leads to severe tricuspid regurgitation (TR) often with laminar rather than turbulent flow. McConnell's sign or apical sparing of right ventricular (RV) function is seen in acute pulmonary embolism but is not characteristic of this patient's scenario. Pulmonary insufficiency, tricuspid stenosis, and atrial septal defect (ASD) are usually not seen in transplanted hearts.
3. e. In the presence of severe TR with laminar flow through the valve, the right atrium and right ventricle operate more as a common chamber and Bernoulli's equation ($4 \times \text{velocity}^2$) is not operational. Severe TR, such as that due to a flail valve, is one of the few instances where Bernoulli's equation may not be used to accurately estimate the RV systolic pressure. If RV systolic pressure is required, recourse to invasive pressure recording may be needed.
4. a. His PA systolic pressure is normal. The estimated RV systolic pressure from his tricuspid regurgitant velocity is 36 mm Hg + 5 mm Hg = 41 mm Hg assuming a normal right atrial (RA) pressure (a reasonable assumption given normal RA size and inferior vena cava [IVC] size). The peak systolic pressure across the pulmonary valve is 20 mm Hg. Therefore, the PA systolic pressure is approximately 41 mm Hg – 20 mm Hg = 21 mm Hg or normal. PA systolic pressure can be estimated in pulmonary stenosis as long as the pressure gradient across the pulmonary valve is known.
5. b. Using TTE, the anterior leaflet and either the septal or posterior leaflet are imaged in the parasternal long-axis (RV inflow) view depending on the plane and the presence of the septum in the image. The posterior leaflet is imaged in the parasternal short-axis view at the level of the aortic valve, and is the leaflet adjacent to the RV free wall. The leaflet imaged adjacent to the aortic root can be either the septal or the anterior leaflet. The anterior and septal leaflets are also imaged in the apical four-chamber view, with the anterior leaflet adjacent to the RV free wall and the septal leaflet adjacent to the interventricular septum.
6. d. A Gerbode defect is a communication between the right atrium and left ventricle, often iatrogenic after surgery on the AV valves or following endocarditis of these valves. As the tricuspid valve is more apically situated under normal conditions in the heart than the mitral valve, the right atrium abuts the left ventricle over a small area. If a defect develops in this area, communication occurs between the right atrium and left ventricle.
7. c. The constant used to estimate the valve area in tricuspid stenosis is 190 not 220. Doming of the valve is seen in tricuspid stenosis but this is seen in diastole not systole. The mean gradient expected across the tricuspid valve in severe stenosis may be 5 mm Hg. Planimetry of the valve is difficult in tricuspid stenosis as it is difficult to get a true short-axis view of the valve. Although rheumatic involvement of the tricuspid valve occurs with some frequency, hemodynamic significant stenosis is relatively uncommon and is reported in about 5 percent of patients with rheumatic involvement of the mitral valve.
8. b. The severity of TR is assessed with a semiquantitative approach. Jet area, proximal flow acceleration, and the width of the vena contracta are used to quantify the severity of TR. If the tricuspid regurgitant jet is central, the Nyquist limit should be set at 50–60 cm/sec. A jet area

of <5 cm^2 suggests mild TR, 5–10 cm^2 suggests moderate TR, and >10 cm^2 suggests severe TR. An effective regurgitant orifice (ERO) of ≥0.40 cm^2 is a criterion of severe regurgitation in both TR and mitral regurgitation. A vena contracta dimension of >0.7 cm is diagnostic of severe TR.

9. d. Secondary pulmonary hypertension and/or RV dilatation is the most common cause of significant TR. All of the other conditions may lead to significant TR.
10. a. Normal RV systolic pressure should not occur with severe pulmonic stenosis as the RV systolic pressure will exceed the PA systolic pressure by the gradient across the pulmonary valve. RV hypertrophy (wall thickness of >0.4 cm) and post-stenotic dilatation are common in severe pulmonic stenosis. Severe pulmonic stenosis is defined by Doppler echocardiography as a peak velocity across the valve of 4 m/sec or higher. PA systolic pressure is usually normal in the setting of severe pulmonic stenosis.
11. d. Mild stenosis is considered present when the Doppler velocity is <3 m/sec or pressure of 36 mm Hg. The prognosis is excellent and intervention is rarely necessary. It is appropriate to follow with yearly echocardiography, but cardiac catheterization or TEE is not indicated. Doming of the valve in systole is a common echocardiographic feature of pulmonic stenosis.
12. c. Severe pulmonary insufficiency is usually seen in the setting of prior surgery on the RV outflow tract or pulmonary valve as part of the treatment of a congenital heart lesion. Pulmonary insufficiency is detected to be a trivial or mild degree normally. Severe pulmonary insufficiency is associated with a high end-diastolic pressure and a reduced pressure gradient across the pulmonic valve thus is more often associated with laminar rather than turbulent velocity. The pulmonary end-diastolic velocity (V) may be used to estimate the PA diastolic pressure as $4V^2$ + estimated RA pressure but is not used to estimate the PA systolic pressure.
13. b. A fibroelastoma is the most common cause of a mobile mass on the tricuspid valve among the choices provided. Myxoma and sarcoma of the valve are much less common. Chiari network is a fenestrated membranous structure, which originates at the orifice of the IVC and is an embryological remnant. It may rarely float through the tricuspid valve but is usually confined to the right atrium. It is not attached to the tricuspid valve. Carcinoid syndrome causes immobility of the valve leaflets such that they may remain in a partially open condition throughout the cardiac cycle.
14. d. Ebstein's anomaly involves the apical displacement of the septal leaflet of the tricuspid valve but does not involve the pulmonary valve. Carcinoid syndrome, staphylococcal endocarditis, and rheumatic involvement may involve both the tricuspid and pulmonic valve. Rheumatic involvement may be primary or more commonly secondary to pulmonary hypertension from left-sided valve lesions that produce tricuspid and pulmonary regurgitation.
15. b. Infundibular stenosis may give rise to a high-velocity jet that causes damage to the pulmonary valve leaflets and pulmonary insufficiency in a manner similar to subaortic stenosis. Infundibular stenosis may be either congenital or acquired. It occurs in congenital heart disease syndromes such as tetralogy of Fallot but also in hypertrophic cardiomyopathy, in tumors of the RV outflow tract or in infiltrative disorders. It may be discrete or consist of a more extensive region of fibromuscular thickening. It is often best imaged and evaluated from a parasternal short-axis view or from the subcostal window. Pressure gradients measured by Doppler across the infundibular stenosis are reasonably accurate. When concomitant pulmonic valvar stenosis is present, it is usually impossible to isolate the precise contribution of the pulmonic valve and infundibulum to the total gradient measured by continuous-wave Doppler across the RV outflow tract.
16. c. The image is characteristic of Ebstein's anomaly of the tricuspid valve with displacement of the septal leaflet into the right ventricle so that a portion of the right ventricle is "atrialized." Ebstein's anomaly is associated with accelerated conduction, severe TR but not with a parchment-like RV wall. This is seen in dysplastic RV or Uhl syndrome, which may be associated with ventricular arrhythmias.

17. c. This is severe pulmonary regurgitation with evidence of a proximal flow convergence on the PA side of the valve. It is consistent with RV dilatation and RV dysfunction. The most common cause of severe pulmonary regurgitation is prior surgery for congenital heart disease involving the pulmonary valve or RV outflow tract. Patent ductus arteriosus will give rise to continuous flow into the PA above the valve. A homograft is usually the valve replacement of choice at the pulmonic position. Mechanical valves are associated with higher rates of thrombosis at right-sided valve positions because of the lesser pressure gradient across them and are usually avoided.
18. c. There is severe TR present with a flow convergence area and dilatation of the right atrium. Intraoperative TEE is more likely to underestimate the degree of regurgitation compared with the ambulatory setting due to optimization of intravascular volume and change in loading consequent to anesthesia and mechanical ventilation. Severe TR occurs in mitral valve prolapse as a result of prolapse of the tricuspid valve or secondary to pulmonary hypertension from severe mitral regurgitation but rarely due to flail of the tricuspid valve leaflet. Severe pulmonary hypertension is not necessary to cause this degree of TR; prolapse or secondary changes in the tricuspid annulus or valve may alone cause it. TR may improve after surgical repair of the mitral valve especially if the pulmonary pressures fall but this is less likely when the TR is severe preoperatively as here and concomitant tricuspid valve repair should be considered. This adds relatively little to the operative risk or the duration of the case in experienced centers.
19. d. This patient has a thickened pulmonary valve and pleuritic symptoms. Either endocarditis of the pulmonary valve or a pulmonary fibroelastoma is possible. The pleuritic symptoms suggest embolization to the lungs. A chest CT scan to look for septic emboli is the test of choice now. A chest CT scan was performed in this patient and showed abscess formation in the pulmonary parenchyma. Blood cultures were negative as the patient took oral antibiotics early in the course of treatment. Endocarditis was diagnosed and it transpired that the patient had an occult IV drug abuse habit.
20. a. High-velocity systolic reversal in the hepatic veins is seen in severe TR which also gives rise to large "v" waves in the jugular venous profile (Fig. 19.11). Pulsus paradoxus, a reduction in systolic blood pressure on respiration, is most characteristic of cardiac tamponade. Kussmaul's sign with an increase in the venous pressure on inspiration is most characteristic of constrictive pericarditis. Pulsus alternans, alternating strong and weak peripheral pulses, is seen in end-stage LV systolic dysfunction. Pulsus bisferiens is a characteristic pulse felt in the setting of both significant aortic stenosis and regurgitation.

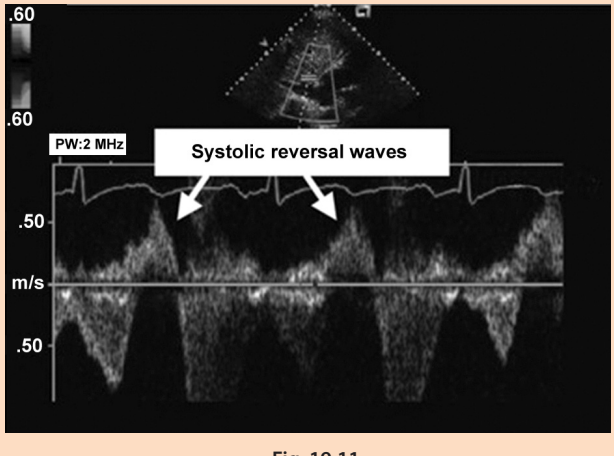


Fig. 19.11

21. c. Pulmonary hypertension is associated with abrupt midsystolic closure of the pulmonary valve in about 50% of cases especially when severe. The appearance is thought to occur from transient reversal of the PA–RV outflow tract gradient due to impaired PA compliance. This appearance is occasionally seen in severe TR and with a dilated PA. It is not associated with the other lesions previously described.
22. a. The condition illustrated is carcinoid, manifested by thickening and shortening of the tricuspid leaflets. Severe TR may result requiring tricuspid valve replacement. Carcinoid is thought to be due to the production of serotonin by a tumor that is inactivated in the lungs so that in the absence of right-to-left shunting, left-sided lesions are uncommon. The pulmonary valve is frequently involved. Medication to reduce the production of serotonin may be helpful in reducing the symptoms of flushing. However, survival is usually significantly reduced with carcinoid and thus prognosis is guarded.
23. b. The ACC/AHA guidelines suggest that balloon valvuloplasty is indicated when the peak pressure gradient across the pulmonary valve is 330 mm Hg with symptoms or 40 mm Hg in the absence of symptoms. Subvalvular stenosis may be present but is not evident on the Doppler profile. Two systolic velocity spectral displays are evident. A low-velocity (~1 m/sec) jet with a dense spectral pattern is consistent with flow in the RV outflow tract. This suggests a relatively low velocity in the RV outflow tract but does not entirely exclude some degree of subvalvar stenosis. The high-velocity (~4.5 m/sec) jet reflects the stenosis at the valve itself. Dysplastic unicuspid or trileaflet valves are a more common cause of pulmonic stenosis than a bicuspid valve. Chest pain is common in severe pulmonic stenosis and likely reflects reduced cardiac outflow and flow to the coronaries and/or subendocardial ischemia in the hypertrophied right ventricle.
24. e. The patient has large mass lesions consistent with vegetations involving the pacing wires, although sparing the tricuspid valve in this view. Given the size of the apparent vegetations, the risk of pulmonary embolism is high and an open surgical approach will likely be needed. Antibiotic coverage will be required and removal of the whole system including the generator is indicated to remove all potential sources of infection. Unless the tricuspid valve has been destroyed in the infective process, tricuspid valve replacement is not indicated.
25. b. There is a large vegetation on the septal leaflet of the tricuspid valve. The size of the vegetation and embolic risk is less of a consideration with tricuspid endocarditis where embolization to the lungs rather than the systemic vasculature is the norm. The exception is when a right-to-left shunt exists. The initial therapy should be appropriate antibiotic therapy and watchful management. If blood cultures fail to clear or there is evidence of severe tricuspid valve destruction, then tricuspid valve surgery may be necessary. Fungal infection may give rise to very large vegetations but staphylococcal infection is by far the most common cause of this particular scenario.

20

Echocardiography for Ischemic Heart Disease

1. A false-positive stress-induced wall motion abnormality is most commonly seen in which of the following myocardial segments?
   a. Basal inferior
   b. Apical septum
   c. Mid lateral
   d. Mid septum

2. Which one of the following is not a high-risk feature on a dobutamine stress echo?
   a. Stress-induced wall motion abnormalities in more than one coronary territory
   b. Dilation of the left ventricular (LV) cavity with stress
   c. Dobutamine-induced ventricular arrhythmias
   d. Decrease in global LV systolic function with stress

3. A 40-year-old man is referred for two-dimensional echocardiography for evaluation of an incidentally found left bundle branch block (LBBB) on ECG. Global LV function is normal. Which of the following is true concerning wall motion abnormalities due exclusively to LBBB?
   a. There is absent myocardial thickening
   b. Wall motion abnormalities are most prominent in the proximal and mid anterior septum
   c. Wall motion abnormalities frequently involve the apex and anterior wall
   d. Two-dimensional imaging provides the most accurate information for recognition of LBBB wall motion

4. The false-negative rate for dobutamine stress echocardiography is higher for patients who have:
   a. Multivessel coronary disease due to balanced ischemia
   b. Concentric LV remodeling
   c. Hypertensive blood pressure response to stress
   d. Eccentric LV hypertrophy

5. A 65-year-old patient presented with an inferior ST elevation and right ventricular (RV) myocardial infarction. Angioplasty of a proximally occluded right coronary artery (RCA) was unsuccessful. The patient received generous intravenous fluid for hypotension, which eventually resolved. Later that night, the patient developed progressive shortness of breath and worsening hypoxia not responding to oxygen supplementation. Cardiovascular examination revealed a faint apical systolic murmur

1. a 2. c 3. b 4. b

and marked jugular venous distention. A stat echocardiogram was ordered. Which of the following needs to be performed?

a. Color Doppler interrogation of the mitral valve
b. Agitated saline contrast to rule out right-to-left shunt
c. Color Doppler interrogation of the interventricular septum
d. Color Doppler interrogation of the tricuspid valve

6. Which of the following is true about a pseudoaneurysm?
   a. It is most frequently located in the apex
   b. It is characterized by a small neck communicating with the LV cavity
   c. It has a lower risk of rupture compared with a true aneurysm
   d. It has a thin wall of myocardium

7. Commercially available echo contrast agents pass through the pulmonary circulation into the left atrium and left ventricle providing image enhancement of these structures. An accurate statement about the use of echo contrast agents is:
   a. They are approved for evaluation of myocardial perfusion in acute infarction and are useful in identifying no-reflow phenomenon
   b. Contrast agents can be used in patients with intracardiac right-to-left shunts
   c. Contrast agents persist longer in the circulation if low power, low mechanical index imaging techniques are used
   d. They can be safely used in any patient with decompensated congestive heart failure

8. Tissue Doppler imaging is a newer technology that enables quantitative assessment of longitudinal systolic function of segments of the right and left ventricle. A true statement regarding assessment of segmental myocardial velocity by tissue Doppler imaging using the apical views is:
   a. In normal individuals, basal LV lateral wall velocity typically exceeds basal RV free wall velocities
   b. In normal individuals, LV apical segment velocities exceed LV basal segment velocities
   c. LV twist or torsion can be assessed by tissue Doppler imaging using the apical views
   d. In normal individuals, there is a base-to-apex gradient in velocities whereby apical segment velocities are significantly lower than basal segment velocities

9. Resynchronization therapy has been shown to promote reverse remodeling and improve symptoms in patients with ischemic cardiomyopathy who have dyssynchrony and severely reduced global LV systolic function. Which of the following group of patients is likely to have the highest frequency of improvement from resynchronization therapy?
   a. Patients with ischemic myopathy with QRS duration of >130 milliseconds and dobutamine echo evidence of viability in both the septal and lateral walls
   b. Patients with ischemic myopathy with QRS duration of <130 milliseconds and Ts-SD (standard deviation of time to peak ejection tissue Doppler velocity of 12 segments) of <32 milliseconds
   c. Patients with ischemic myopathy with QRS duration of >130 milliseconds and nonviable inferolateral wall by dobutamine echo
   d. Patients with ischemic myopathy with QRS duration of >130 milliseconds and M-mode septal to posterior wall delay <130 milliseconds

10. After an acute interruption of coronary blood flow, which sign of ischemia will appear first?
    a. ECG changes
    b. Wall motion abnormality by visual assessment
    c. Angina
    d. Diastolic dysfunction

5. b 6. b 7. c 8. d 9. a 10. d

11. A 67-year-old patient presents with new-onset chest pain. A two-dimensional echocardiogram showed akinesis of the septum, anterior wall, and apical inferior segment. This distribution of wall motion abnormalities is most often the result of obstruction of:
    a. The RCA
    b. The left anterior descending (LAD) and RCAs
    c. The left circumflex (LCX) and LAD arteries
    d. The LAD artery

12. A 45-year-old man presents with worsening shortness of breath. A two-dimensional echocardiogram shows reduced LV systolic function with an ejection fraction of 35%. Which of the following echocardiographic parameters best differentiates ischemic from idiopathic dilated cardiomyopathy?
    a. Presence of regional wall motion abnormalities
    b. LV generalized hypokinesis
    c. Apical dilatation
    d. Extensive transmural myocardial scar

13. A failure to decrease LV end-systolic volume during stress may be a normal finding in which one of the following stress echo modalities?
    a. Dobutamine stress echo
    b. Treadmill stress echo
    c. Bicycle stress echo
    d. Vasodilator stress echo

14. In patients who cannot perform exercise, various stress methods have been used in combination with echocardiography for the detection of coronary artery disease. Of the stress methods listed below, which is the least effective when employed in stress echocardiography?
    a. Dobutamine-atropine
    b. High-dose dipyridamole
    c. Adenosine
    d. Transesophageal atrial pacing

15. Which of the following is an appropriate indication for performing stress echocardiography?
    a. Asymptomatic patient <2 years postpercutaneous revascularization
    b. Asymptomatic patient <1 year after normal noninvasive study scheduled to undergo high-risk nonemergent surgery
    c. Asymptomatic patient with a low to moderate coronary artery disease risk by Framingham Score
    d. New-onset atrial fibrillation in a patient with moderate to high coronary artery disease risk

16. A 60-year-old woman suffered an anterior ST elevation myocardial infarction. She underwent percutaneous revascularization of the LAD artery. The patient presents for follow-up 2 months later without symptoms. A late systolic frame of an apical four- and two-chamber view obtained at follow-up is shown in Figure 20.1. A 12-lead ECG showed ST elevation in the anterior leads. The most likely reason for this finding is:
    a. Recurrent infarction due to acute stent thrombosis
    b. The ECG finding is consistent with the normal evolutionary changes of an anterior infarction
    c. The ECG finding is due to an apical aneurysm
    d. The ECG finding is due to Dressler's syndrome

11. d 12. d 13. c 14. c 15. d 16. c

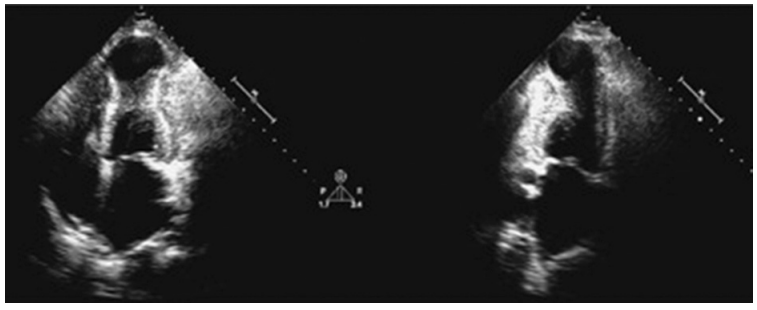


Fig. 20.1

17. A 75-year-old patient with a transmural anterior myocardial infarction and ischemic heart disease is seen in clinic 3 weeks after his event. His current medical regimen includes aspirin, metoprolol, simvastatin, and lisinopril. A routine two-dimensional echocardiogram is performed (Fig. 20.2). What is the most appropriate next step?

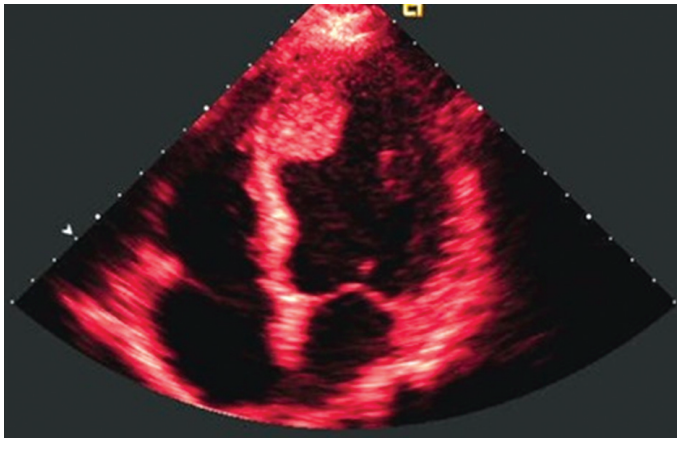
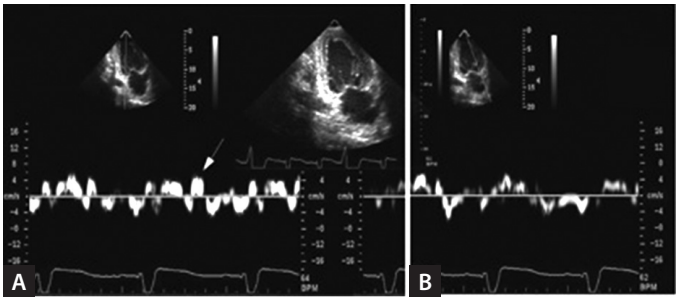


Fig. 20.2

a. Warfarin needs to be added to the medical regimen with a goal INR of 2–3 with a repeat echocardiogram in 3 months
b. Clopidogrel needs to be started for at least 1 year
c. Commercial contrast is needed for better assessment of the LV apex
d. Continue current medical regimen

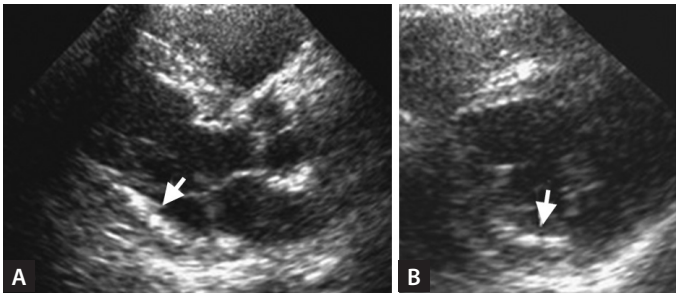
18. An echocardiogram in a 60-year-old man is performed because of dyspnea. The two-dimensional image is an end-systolic frame. Pulsed-tissue Doppler recordings from the basal inferior (Fig. 20.3A) and basal anterior (Fig. 20.3B) walls. A true statement about the tissue Doppler recordings is:
a. Both the inferior and anterior wall signals are normal
b. There is too much artifact to render an interpretation
c. There is evidence for postsystolic shortening of the inferior wall
d. There is prominent inferior and anterior wall dyssynchrony

17. a 18. c



Figs 20.3A and B

19. A 65-year-old man with no history of heart disease had a two-dimensional echocardiogram performed for palpitations. The finding of interest in the parasternal long- and short-axis end-diastolic image in Figures 20.4A and B is:



Figs 20.4A and B

a. Mitral annular calcification
b. Rheumatic mitral valve disease with subvalvular calcification
c. Subendocardial scar due to prior silent myocardial injury
d. Pericardial calcification

20. A transesophageal echocardiogram (TEE) is obtained to evaluate LV function in a 66-year-old man with obesity scheduled for colon resection. He walks 2 miles a day and denies any symptoms. Long-axis images show normal LV systolic function and no regional wall motion abnormalities. Additional short-axis images at the midesophageal level are shown in Figure 20.5. The cardiologist should inform the surgery team that:
    a. The patient has minimal risk and no measures to decrease perioperative cardiac risk have to be considered
    b. The patient has significant coronary disease and medical measures to decrease cardiac risk are needed
    c. Urgent coronary angiography is needed
    d. The patient should be referred for coronary computed tomography (CT) scanning

19. c 20. b

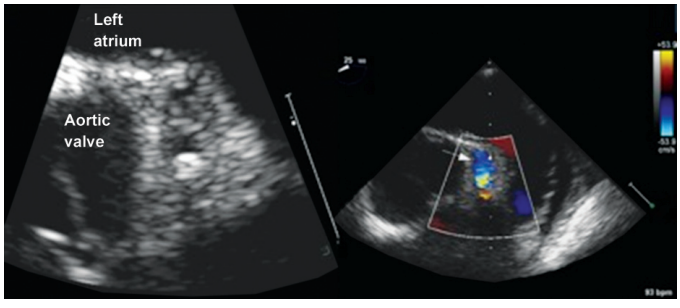
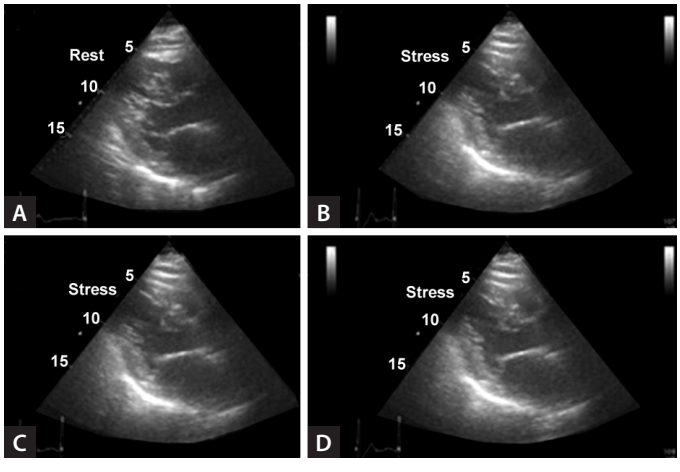


Fig. 20.5

21. A 55-year-old man presents to his primary care physician with a 3-month history of exercise-induced chest pain. A treadmill stress echocardiogram was performed. A baseline long-axis image at end systole (Fig. 20.6A) and three immediate end-systolic poststress images (Figs 20.6B to D) are shown. End-systolic cavity dimension is increased poststress.



Figs 20.6A to D

Which of the following is true?

a. The patient is unlikely to have significant coronary disease
b. The patient has significant disease of the LCX artery
c. The patient has significant left main disease
d. The patient has significant stenosis of the midportion of the LAD artery

22. An 80-year-old male patient with chronic obstructive pulmonary disease presents with an inferior ST elevation myocardial infarction. He has an occluded proximal RCA and an attempt at percutaneous revascularization is unsuccessful. The patient develops progressive hypotension. A repeat ECG showed no reoccurrence of ST elevation. A stat echocardiogram was performed. (Fig. 20.7). What is the most appropriate treatment?

21. d

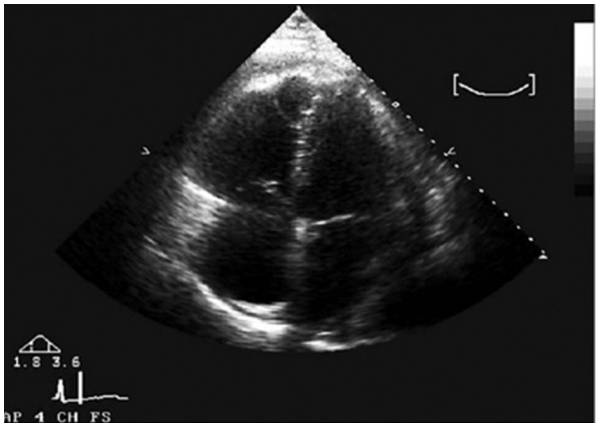
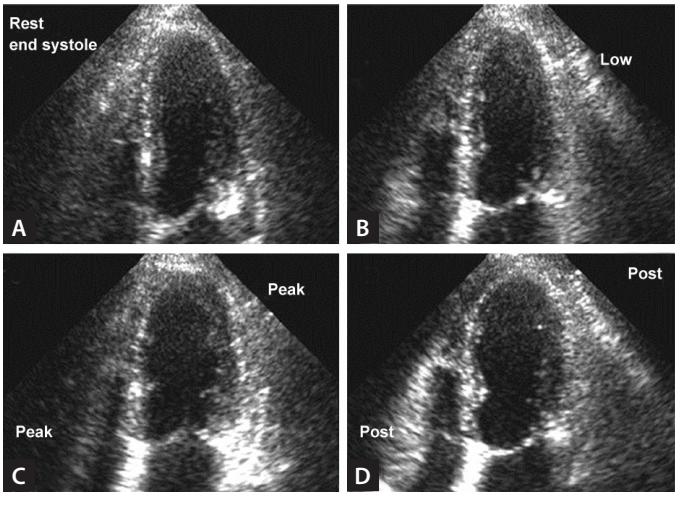


Fig. 20.7

a. Repeat angiography
b. Pelvic CT scan to assess for retroperitoneal bleeding
c. Aggressive fluid administration and an intravenous inotrope if necessary
d. Anticoagulation with heparin and chest CT scan
e. Intra-aortic balloon counterpulsation

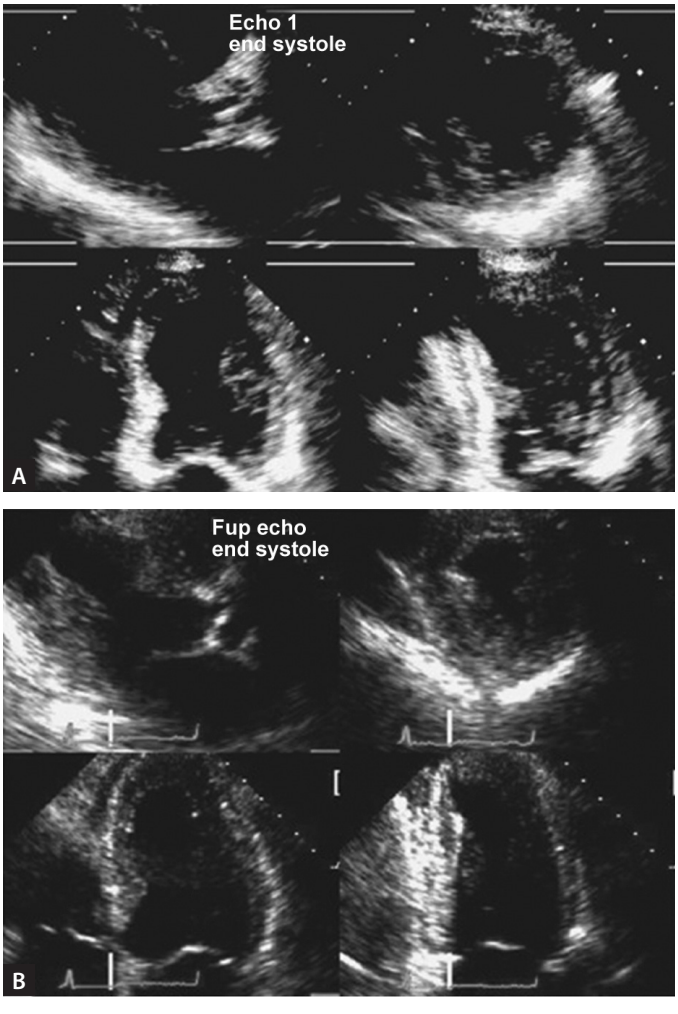
23. A 58-year-old man with a history of stable coronary disease had a dobutamine stress echocardiogram performed for risk stratification prior to noncardiac surgery. End-systolic frames at each stage of stress are shown in Figures 20.8A to D. He most likely has:
a. Severe, multivessel coronary disease
b. Significant stenosis of the mid-LAD artery
c. A hypertensive response to dobutamine and no coronary obstruction
d. Worsening of ischemic mitral regurgitation during dobutamine infusion



Figs 20.8A to D

22. c 23. a

24. A 78-year-old patient with known coronary disease presented with 3 hours of chest pain and shortness of breath. On admission, an echocardiogram is obtained (Fig. 20.9A). Stenting of a stenosis in the proximal LAD artery was performed. Troponin I peaked at 3.0 during admission. Follow-up echocardiogram is performed 1 week later (Fig. 20.9B). End-systolic frames of the admission and follow-up echocardiograms are shown with the endocardial borders outlined. The most likely explanation for the findings on the initial and follow-up echocardiograms is:

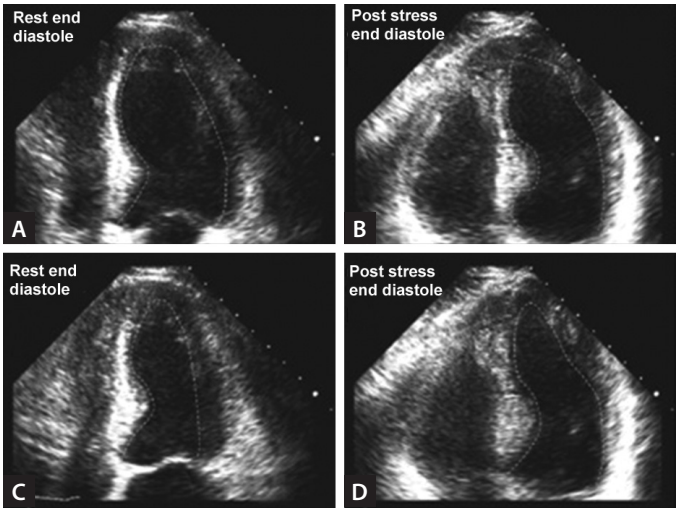


Figs 20.9A and B

a. Volume overload treated with diuretics
b. Myocardial stunning with recovery
c. Myocardial hibernation with recovery
d. Preconditioning

24. b

25. A 55-year-old woman with hyperlipidemia and hypertension was referred for treadmill stress echocardiography after a single episode of chest pain 3 weeks before. She exercised to 10 METs but stopped because of fatigue and mild chest discomfort (Figs 20.10A to D). The most likely cause of the patient's chest pain is:
    a. Diffuse small vessel disease from hypertension
    b. Noncardiac chest pain
    c. Myocardial bridging of the LAD artery
    d. Significant stenosis of the LCX artery



Figs 20.10A to D

25. d

Answers

1. a. False-positive findings on a stress echocardiogram are most frequently encountered in the basal segments of the posterior myocardial circulation. Tethering of the basal inferior segment to the mitral annulus may contribute to a relative reduction in motion of this segment compared with other segments that are not attached to stationary structures. Increased translational motion of the heart with stress towards the inferior wall in systole may lead to the appearance of reduction of excursion of the basal inferior wall.
2. c. Dobutamine-induced ventricular arrhythmias are not closely correlated with myocardial ischemia induced during the test. In addition, the occurrence of ventricular arrhythmia is not predictive of late cardiac events, including mortality, nonfatal acute myocardial infarction, and revascularization. Ischemia in multiple coronary territories, left ventricular (LV) cavity dilatation, and reduction in peak ejection fraction are indicators of increased risk.
3. b. Wall motion abnormalities due exclusively to left bundle branch block (LBBB) are most prominent in the proximal and mid anterior septum and are less often manifested in the anterior wall or apex. They typically do not result in alteration of LV geometry. Myocardial thickening is usually preserved. M-mode echocardiography is often a better method for identification of LBBB wall motion because of its high temporal resolution (Fig. 20.11). A classic downward 'beak' is seen at the onset of ventricular depolarization, followed by anterior motion of the septum but with preserved myocardial thickening.

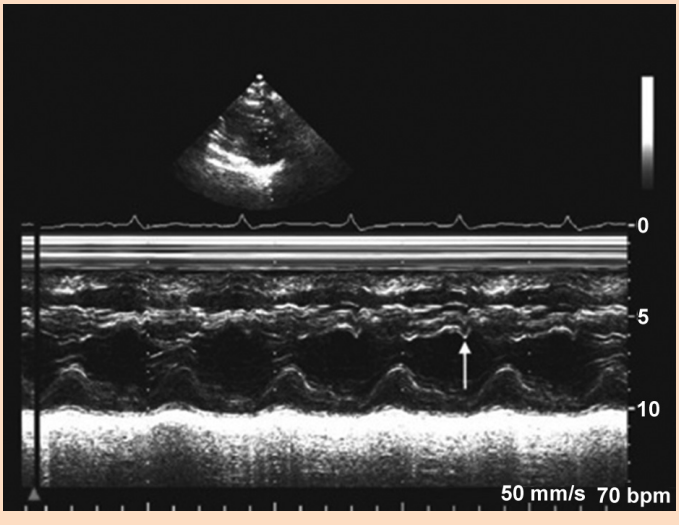


Fig. 20.11

4. b. Patients with concentric remodeling (increased relative wall thickness and small LV cavity) have a higher rate of false-negative dobutamine stress examinations. Wall stress decreases with smaller cavity dimension and increasing wall thickness. Consequently, patients with concentric remodeling have lower wall stress. The vasodilating effects of dobutamine may further result in a decline in wall stress and a more limited increase in oxygen demand than desired. The end result is a lower frequency of stress-induced ischemia. In addition, detection of abnormal wall motion in ischemic segments is more difficult in the setting of hyperdynamic contraction of nonischemic segments and a small LV cavity.
5. b. A rare complication of a right ventricular (RV) infarction is the development of an acute right-to-left shunt through a pre-existing atrial septal defect or persistent foramen ovale.

Shunting occurs because of abnormal RV compliance and markedly elevated right atrial pressure. It should be suspected in patients who develop acute cyanosis and hypoxemia that is not responsive to administration of high flow oxygen. The diagnosis can be confirmed with contrast echocardiography using peripherally injected agitated saline. Acute ischemic mitral valve regurgitation and ventricular septal rupture present with harsh murmurs and pulmonary congestion. Tricuspid regurgitation, which can be due to ventricular dilation in the setting of RV infarct, does not manifest with hypoxia.

6. b. A pseudoaneurysm forms after a free wall rupture is contained by the pericardium. It most frequently occurs in the posterior wall, followed by the lateral walls and apex. It is usually characterized by a neck that is smaller than the diameter of the pseudoaneurysm. A ratio of <0.5 of the diameter of entry and the maximal diameter of the pseudoaneurysm has been shown to have fair accuracy for distinguishing pseudoaneurysm from true aneurysms. Pseudoaneurysm can harbor significant quantities of thrombi, some of which can dislodge and cause arterial emboli. It is generally accepted that pseudoaneurysms have a higher risk of rupture compared with true aneurysms.

7. c. Myocardial contrast echocardiography utilizes gas-filled microbubbles that are inert, remain entirely within the vascular space, and possess an intravascular rheology similar to that of red blood cells. Numerous studies have shown that myocardial contrast agents can be used to qualitatively and quantitatively assess myocardial perfusion including in the setting of acute infarction. However, there is no agent yet approved for the evaluation of myocardial perfusion in the United States. The current recommendations for contrast agent use state that the products are contraindicated in patients known to have fixed right-to-left, bidirectional, or transient right-to-left cardiac shunts. The agents should be cautiously used in patients with unstable cardiopulmonary conditions with the recommendation that monitoring of vital signs and oxygen saturation is performed during and for at least 30 minutes following the administration of a microbubble contrast agent.

8. d. The complex arrangement of myocardial fibers in the ventricles results in active contraction in multiple planes. Longitudinal movement results from longitudinally oriented fibers, whereas radial movement results from circumferential and radial fibers. In the longitudinal plane, the motion of the atrioventricular plane is toward a fixed apex. The end result is a gradient of velocities from base (highest) to apex (lowest). Because of its higher longitudinal fiber content, a normal right ventricle will always have higher longitudinal peak velocities than the left ventricle. Tissue Doppler imaging is an angle-dependent ultrasound technique used for the assessment of longitudinal movement of cardiac structures. Measurement of twist and torsion of the left ventricle is not feasible by tissue Doppler interrogation from the apical window.

9. a. Currently, one-third of patients treated with cardiac resynchronization therapy (CRT) do not respond. Several echocardiographic measures of mechanical dyssynchrony have been applied in an attempt to distinguish responders from nonresponders. Ts-SD (standard deviation of time to peak ejection tissue Doppler velocity of 12 segments) was proposed as a potential LV dyssynchrony index. Myocardial Doppler velocities are obtained in 6 basal and mid-LV segments. Using the QRS complex as the reference point, the time to peak myocardial systolic contraction can be measured, from which the standard deviation of the 12 LV segments is calculated. The earlier clinical trials using Ts-SD of >32 milliseconds showed some correlation with response to CRT in patients with a wide QRS. The septal to posterior wall delay on M mode is another dyssynchrony parameter. The maximum displacement of the septal and posterior walls is first measured from the onset of the QRS; the QRS to septal wall deflection value is then subtracted from the QRS to posterior wall deflection value. A value of 3130 milliseconds has been proposed as threshold value for defining a positive response to CRT. The PROSPECT trial, the largest multicenter trial to date, showed that both Ts-SD and M-mode

septal to posterior wall delay had relatively poor predictive value (sensitivity and specificity of Ts-SD for prediction of clinical composite score response were 74% and 35%, respectively; sensitivity and specificity of M-mode septal to posterior wall delay for prediction of clinical composite score response were 55% and 50%, respectively) for predicting the response to CRT. The presence of contractile reserve on dobutamine stress echo identifies patients with a favorable clinical and reverse LV remodeling response to CRT. Nonviability of the inferolateral wall in the region of the coronary sinus (LV) lead is frequently associated with a poor response to CRT.

10. d. There is a well-defined hierarchy of functional abnormalities that occurs as a consequence of interruption of coronary blood flow. This is known as the ischemic cascade (Fig. 20.12). The earliest manifestation is diastolic dysfunction, followed by abnormal wall motion, ECG changes, and then angina.

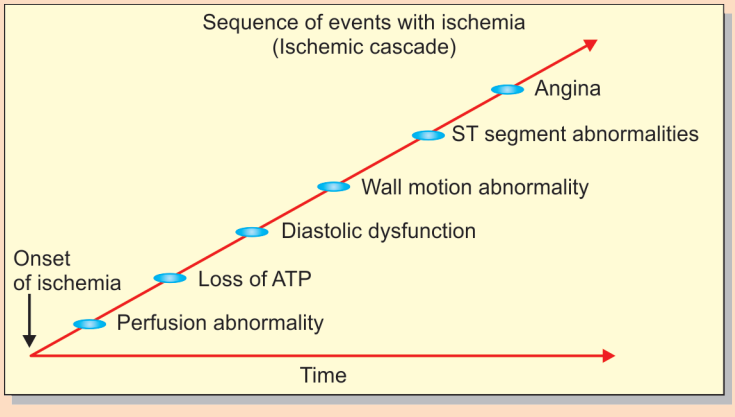


Fig. 20.12

11. d. The standard approach for representation of the left ventricle uses a 16- or 17-segment model. Myocardial segments are grouped according to their coronary supply (left anterior descending [LAD], right coronary [RCA], and left circumflex [LCX]) with the recognition that there is variability in the coronary supply of various segments including the apical lateral (LAD or LCX territory) and apical inferior (LAD or RCA territory) segments that are considered "overlap" segments. Detection of an apical inferior abnormality in the presence of anterior and septal wall motion abnormalities is usually due to occlusion of an LAD that wraps around the apex and supplies the apical portion of the inferior wall. On the other hand, when basal and mid inferior abnormalities are present without anterior and apical abnormalities, abnormal apical inferior wall motion is usually due to RCA disease (Fig. 20.13).

12. d. Distinguishing between ischemic and idiopathic dilated cardiomyopathy may be very challenging in those with advanced disease with severe LV systolic dysfunction and LV dilatation. However, in those with less advanced disease, large areas of scar involving two or more contiguous segments are highly specific for an ischemic etiology. Transmural scar will be manifested as a highly echo-reflective region, which is significantly thinner (<70% thickness of a normal wall). Gradual LV remodeling results in ventricular dilatation in both ischemic and idiopathic cardiomyopathy. Dilatation is often more severe in the apex in both conditions because of higher wall stress in this region. Regional wall motion at rest might be abnormal in as many as two-thirds of patients with nonischemic cardiomyopathy, whereas patients with ischemic cardiomyopathy might have uniform hypokinesis.

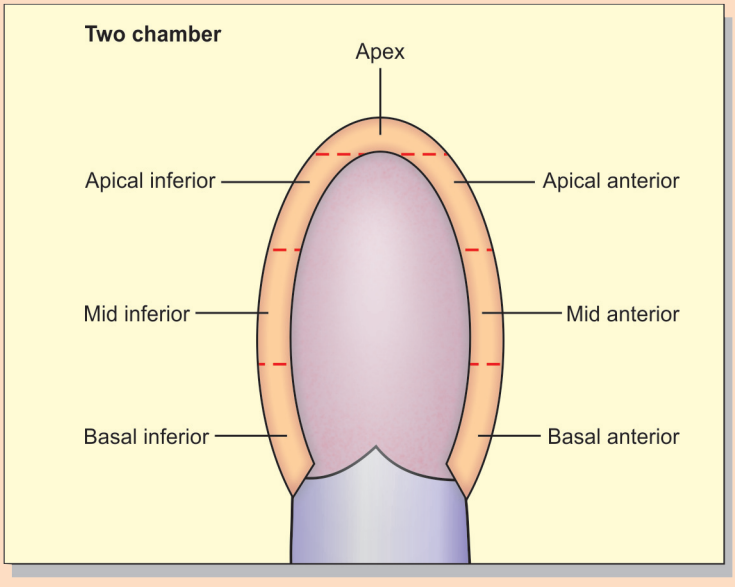


Fig. 20.13

13. c. For most stress modalities, a normal response includes a decrease in end-systolic volume. Failure of the end-systolic size to decrease is an abnormal response and can reflect severe, multivessel disease. Supine bicycle is an exception to this rule. Elevation of the legs throughout exercise will increase venous return. In addition, afterload may stay the same or increase with bicycle stress. As such, lack of reduction in end-systolic volume at peak stress may be a normal finding.
14. c. Pharmacologic stress using dobutamine with atropine supplementation is the most common form of pharmacologic stress used with echocardiography in this country. This method has comparable sensitivity to exercise echocardiography in most clinical settings. The utility of high-dose dipyridamole echocardiography (using a total of 0.84 mg/kg dipyridamole) has been well validated in numerous studies. Transesophageal atrial pacing stress echocardiography has high sensitivity for detection of coronary disease and is well tolerated. Pacing is performed to heart rates equivalent to 100% of the patient's age-predicted maximum. Adenosine is the least effective method for induction of ischemia, due to its short duration of action.
15. d. Performing a stress echocardiogram for the detection of coronary artery disease/risk assessment in asymptomatic, moderate to high coronary artery disease risk patient population with defined comorbidities (new-onset atrial fibrillation) is an appropriate indication. The three other statements are considered inappropriate indications.
16. c. The two- and four-chamber views in Figure 20.1 show an apical aneurysm. Aneurysms are characterized by myocardial thinning and dilatation both in systole and diastole.
17. a. The four-chamber still frame in Figure 20.2 shows a protruding apical thrombus. A thrombus may have a slightly different grayscale from the underlying myocardium based on its age. A protruding thrombus carries a greater chance of embolization than a mural thrombus lining a portion of the apex. Recommendations for anticoagulation vary, but treatment with warfarin is advocated for 3–6 months.
18. c. Tissue Doppler recordings from the inferior and anterior walls in the two-chamber view are shown in Figure 20.3. In a normal tissue Doppler spectral profile, there are four major velocities two systolic velocities (S1—isovolumic contraction, S2—ejection) and two diastolic velocities

E and A. In this example, the arrow points to an extra waveform in the isovolumic relaxation period and in early diastole, which represents postsystolic shortening. Postsystolic shortening is a marker of ischemia or infarction that may be a passive phenomenon. It is readily detected by tissue Doppler imaging and two-dimensional strain and strain rate imaging, methods that have fairly high temporal resolution.

19. c. With coronary occlusion, necrosis occurs first in the subendocardium and becomes transmural over time in the absence of reperfusion. Subendocardial infarction can be identified by echocardiography if scarring with dense fibrosis has occurred. This results in a highly echo reflective region, analogous to late gadolinium enhancement seen on cardiac magnetic resonance imaging. The location of the echo reflective region makes it unlikely to be mitral annular, subvalvular, or pericardial calcification.

20. b. The short-axis view at the base shows an echo reflective structure in the region of the proximal LAD artery. Color Doppler shows aliasing of coronary flow with a Nyquist limit (set at 53 cm/sec), which is above normal diastolic coronary flow velocities at rest indicating a partially obstructive atherosclerotic lesion. Direct visualization of the left main, proximal portions of the LCX and LAD arteries by transthoracic or transesophageal echocardiography has a reasonably high rate of success. Bright, globular echoes in the lumen or wall of the coronary arteries are highly specific for atherosclerosis.

21. d. During a treadmill stress echocardiogram, images are typically obtained at rest and immediately after cessation of exercise. It is recommended that more than one loop of stress images is obtained for each view since respiratory artifact and translational motion may decrease the quality of some loops. In this example, rest images (Figs 20.6A to D) of the parasternal long-axis view show normal LV systolic function with no wall motion abnormality. Poststress images reveal hypokinesis of the mid anterior septum. These findings are consistent with obstructive coronary disease in the LAD artery distribution. The normal basal anterior septal response to stress, which is a segment supplied by the first septal branch, indicates that the obstructive lesion is beyond the proximal LAD. Posterior wall motion is normal at rest and becomes hyperdynamic poststress suggesting no posterior circulation involvement.

22. c. The echocardiogram shows a dilated, hypokinetic right ventricle consistent with RV infarction. RV infarction frequently accompanies inferior LV infarction, although clinical evidence of RV infarction is relatively infrequent in the current era of urgent revascularization. Patients who suffer an RV infarct present with increased right-sided filling pressures (central venous, right atrial, RV end-diastolic pressures). The apical portion of the RV, an area supplied by the LAD artery, may be spared whereas the basal to mid RV free wall is affected. Use of preload reducing agents, such as nitroglycerin, can induce hypotension. The initial therapy in these cases should be volume expansion. An intravenous inotrope may often be needed.

23. a. A normal response to stress is an increase in wall thickening and excursion along with a decrease in LV dimensions. The rest images of the dobutamine stress test (Fig. 20.8A) show normal LV systolic function with no wall motion abnormality. With increasing doses of dobutamine, there are extensive stress-induced wall motion abnormalities, LV dilatation, and reduction of global systolic function—all indicators of severe and extensive coronary disease. The abnormalities that persist in the poststress period also indicate severe and extensive disease.

24. b. Myocardial stunning refers to a state of reversible regional wall motion abnormalities and LV dysfunction in the setting of acute ischemia and viable myocardium. The time course for recovery of function depends on the length and severity of the ischemic episode and the completeness of restoration of myocardial perfusion. Functional recovery may be rapid (minutes to days) when myocardial perfusion is quickly and completely restored. In myocardial hibernation, function and myocardial perfusion are chronically reduced. Degeneration of the contractile apparatus may occur; and as a consequence, functional recovery may be both late

and incomplete. Ischemic preconditioning refers to the lessening of effects of ischemia on myocardium that has been previously exposed to brief periods of ischemia.

25. d. In this example, rest images (Figs 20.10A and C) of the four-chamber view shows normal LV systolic function with no wall motion abnormality. Poststress images show a basal and midanterolateral wall motion abnormality. These findings are consistent with obstructive coronary disease in the LCX distribution. Septal wall motion is normal at rest and becomes hyperdynamic poststress suggesting no ischemia in the LAD circulation.

21

Dyssynchrony Evaluation/Atrioventricular Optimization

1. Which of the following statements about the echocardiographic assessment of cardiac dyssynchrony in patients with heart failure is correct?
   a. Atrioventricular (AV) dyssynchrony can be identified by a long left ventricular (LV) filling time (LVFT) (>40%)
   b. Interventricular dyssynchrony is defined by a prolonged delay between the right ventricular (RV) and LV ejections as assessed with pulsed-wave Doppler echocardiography (≥40 milliseconds)
   c. An early diastolic notching of the interventricular septum at M-mode LV parasternal long-axis recordings is observed in patients with left bundle branch block and indicates LV dyssynchrony
   d. Intra-LV dyssynchrony is observed only in patients with left bundle branch block, whereas interventricular dyssynchrony is observed only in patients with right bundle branch bock

2. AV dyssynchrony is characterized by prolonged AV conduction. Which of the following echocardiographic signs can be observed?
   a. LV diastolic filling is reduced because atrial contraction occurs against a closed mitral valve
   b. The diastolic LVFT lengthens as indicated by a relative early E wave on transmitral Doppler recordings
   c. A truncated A wave is observed on transmitral Doppler recordings
   d. The diastolic LVFT shortens with fusion of E and A waves

3. Which is the echocardiographic method used to measure interventricular dyssynchrony?
   a. M-mode echocardiography, measuring the time delay between peak systolic thickening of the interventricular septum and the RV free wall
   b. Pulsed-wave Doppler echocardiography, measuring the time delay between the onset of LV ejection and RV ejection
   c. Continuous-wave Doppler echocardiography, measuring the time difference between closure of tricuspid valve and mitral valve
   d. Tissue Doppler imaging (TDI), measuring the time delay between peak systolic velocity of the interventricular septum and the LV lateral wall

1. b 2. d 3. b

4. LV dyssynchrony can be measured with M-mode echocardiography obtaining the so-called septal-to-posterior wall motion delay (SPWMD) index. Which of the following statements about this method is correct?
   a. This index is derived by measuring the time delay between the peak inward motion of the interventricular septum and the LV posterior wall
   b. This index is measured by applying anatomic M-mode to the LV apical four-chamber view
   c. A cutoff value of ≥65 milliseconds predicts favorable response to cardiac resynchronization therapy (CRT)
   d. This method is highly feasible in patients with ischemic heart failure with prior myocardial infarction of the posterolateral wall
5. TDI techniques have been extensively used to quantify LV dyssynchrony. Which of the following statements about these methodologies is correct?
   a. Pulsed-wave TDI permits simultaneous interrogation of two opposing LV walls online
   b. TDI techniques permit the angle-independent assessment of LV myocardial velocities
   c. TDI data should be acquired at a frame rate of <90 frames/sec
   d. LV dyssynchrony can be measured by calculating the time delay between peak systolic velocities of two or four opposing walls
6. Which of the following recommendations to measure LV dyssynchrony with color-coded TDI is correct?
   a. Color-coded TDI data acquisition should be performed at a low frame rate (<90 frames/sec)
   b. The timing of LV ejection should be determined from the beginning to the end of the pulsed-wave Doppler recordings of the transmitral flow
   c. LV dyssynchrony is calculated as the difference in time to isovolumic contraction velocity from opposing walls
   d. The components of the velocity curve should be identified and include the isovolumic contraction velocity, the systolic wave (S), the early diastolic wave (E), and the late diastolic wave (A)
7. Which of the following sentences about the measurement of LV dyssynchrony based on color-coded TDI is correct?
   a. An opposing wall delay of ≥65 milliseconds predicts favorable response to CRT and long-term outcome
   b. The standard deviation of time to peak systolic velocities of 12 segments of the LV apical two- and four-chamber views (basal, mid, and apical segments) yields the most accurate measurement of LV dyssynchrony
   c. A standard deviation of time to peak systolic velocities of 12 LV segments of ≥65 milliseconds predicts clinical improvement after CRT
   d. A septal-to-lateral wall delay of ≥31 milliseconds predicts LV reverse remodeling after CRT
8. TDI-derived strain rate imaging has been demonstrated to identify LV dyssynchrony. Which of the following sentences is correct?
   a. TDI-derived strain rate imaging evaluates myocardial displacement
   b. TDI-derived strain rate imaging enables the measurement of time from QRS onset to peak strain in all LV segments (basal, mid, and apical) since this technique is not influenced by the insonation angle of the ultrasound beam
   c. In patients with ischemic heart failure, TDI-derived strain rate imaging permits detection of myocardial segments with active contraction and segments that are passively tethered (myocardial scar)
   d. Applied to LV short-axis images, a time delay of ≥33 milliseconds between peak systolic strain of the septal wall and the posterior wall predicts acute improvement in LV stroke volume after CRT

4. a 5. d 6. d 7. a 8. c

9. Which of the following sentences about LV dyssynchrony assessment with two-dimensional (2D) speckle tracking echocardiography is true?
   a. The measurement of time to peak strain with 2D speckle tracking echocardiography is highly dependent on the angle of insonation of the ultrasound beam
   b. Two-dimensional speckle tracking echocardiography permits the assessment of LV dyssynchrony in the radial, circumferential, and longitudinal directions
   c. A peak radial strain-time delay between the (antero)septal and the (postero)lateral region of ≥31 milliseconds predicts LV reverse remodeling
   d. Two-dimensional speckle tracking echocardiography does not distinguish between myocardial segments with active contraction and myocardial segments passively tethered

10. Three-dimensional (3D) echocardiography enables LV dyssynchrony assessment. Which of the following statements is correct?
   a. Currently, the evaluation of LV dyssynchrony with 3D echocardiography techniques relies only on qualitative assessment of LV wall motion of 3D full volume data
   b. With triplane tissue synchronization imaging (TSI), the standard deviation of time to minimum systolic volume of 16 segments (so-called systolic dyssynchrony index [SDI]) is calculated to quantify LV dyssynchrony
   c. With real-time 3D echocardiography, the time to peak systolic velocity of 16 segments is displayed in a polar map and time delays between two or four opposing walls as well as the standard deviation of 16 segments can be calculated
   d. The presence of substantial LV dyssynchrony defined by an SDI of ≥6.4% measured with real-time 3D echocardiography or ≥33 milliseconds measured with triplane TSI predicts response to CRT

11. Which of the following statements about AV delay optimization is correct?
   a. The optimal AV delay is the shortest AV interval without truncation of A wave
   b. An optimized AV synchrony is achieved by the shortest AV delay with fusion of the E and A waves
   c. In the optimal AV delay, the end of the left atrial contraction should coincide with the onset of the diastolic mitral regurgitation spectral signal
   d. The optimal AV delay is the longest AV delay that permits the longest LVFT regardless of whether A-wave truncation occurs

12. Which of the following echocardiographic signs can be observed when a short AV delay is programmed?
   a. Diastolic mitral regurgitation
   b. E and A wave fusion on transmitral pulsed-wave Doppler recordings
   c. Reduced LVFT
   d. Truncated A wave on transmitral pulsed-wave Doppler recordings

13. Which of the following echocardiographic methods can be used to optimize the AV delay?
   a. Pulsed-wave TDI, placing the sample volumes at the septal and lateral mitral annulus
   b. M-mode recordings of the mitral annulus
   c. Color-coded TDI, placing the sample volumes at the lateral wall of the left atrium and the LV lateral wall
   d. Pulsed-wave Doppler recordings of the transmitral blood flow

9. b 10. d 11. a 12. d 13. d

14. Which of the following statements about echocardiographic AV delay optimization is true?
    a. The Ritter's method can always be performed regardless of the duration of the intrinsic PR interval
    b. The iterative method involves programming a long AV delay and then shortening it by 20-millisecond increments until the A wave is truncated
    c. The peak rate of rise of LV pressure during isovolumic contraction, the so-called dP/dtmax, is the most feasible method to optimize the AV delay
    d. The shortest velocity-time integral of the flow across the LV outflow tract indicates the optimal AV delay

15. Which of the following sentences about interventricular (VV) delay optimization is true?
    a. The measurement of velocity-time integral of the LV outflow tract on pulsed-wave Doppler recordings can be used to optimize VV delay
    b. Color-coded TDI is the most used method to optimize VV delay, placing the sample volumes at the basal segments of the free right ventricular wall and the LV lateral wall
    c. The VV delay optimization can be performed only by electrocardiographic methods
    d. M-mode recording of the LV parasternal long-axis view, measuring the time delays between the peak inward motion of the septum and the posterior wall, is highly feasible in patients with ischemic heart failure

16. Based on Figure 21.1, which of the following sentences on AV dyssynchrony is true?

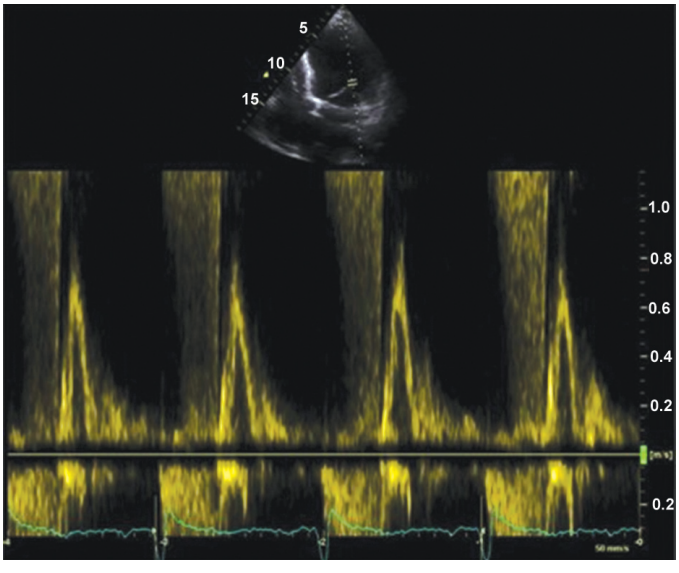


Fig. 21.1

    a. The AV delay is optimal and maximizes diastolic LVFT by starting the LV contraction at the end of the A wave
    b. The AV delay is too short and the A wave is truncated
    c. The AV delay is too long and, consequently, the E and A waves are fused reducing the diastolic LVFT
    d. The AV delay cannot be assessed because the patient is in atrial fibrillation

14. b 15. a 16. c

17. Figure 21.2 shows an example of LV dyssynchrony assessed with pulsed-wave TDI. Based on this example, which of the following statements is correct?

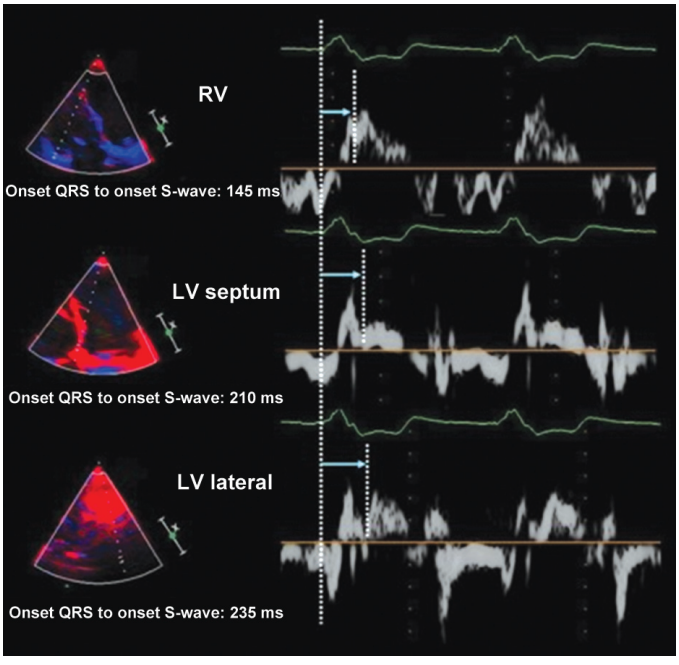
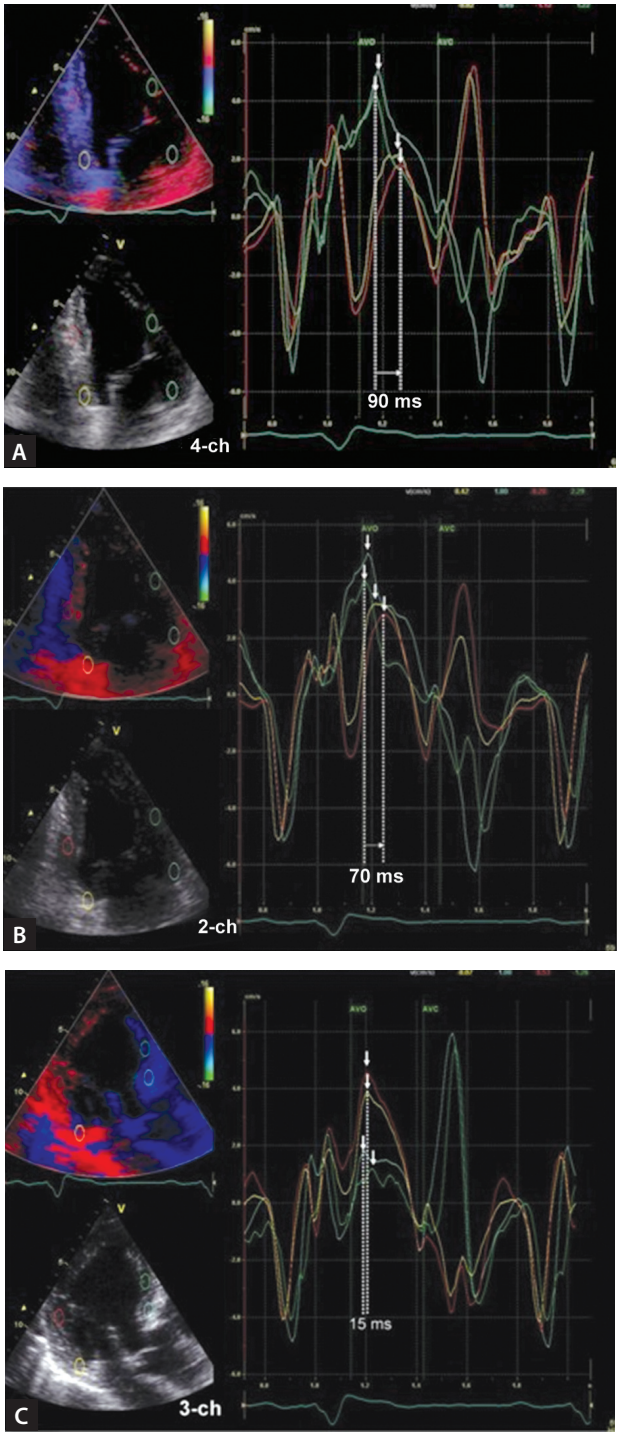


Fig. 21.2

a. Time from Q wave to onset of the first positive systolic velocity (isovolumic contraction) should be measured at the basal segments of the right ventricle, septum, and LV lateral wall
b. There is substantial LV dyssynchrony indicated by the difference in systolic velocities of LV septal and lateral walls
c. The measurement of the electromechanical delay in the septal wall is incorrect because the ultrasound beam is not aligned properly
d. There is substantial interventricular dyssynchrony (RV free wall to LV lateral wall delay of 90 milliseconds) but not LV dyssynchrony with a time delay of 25 milliseconds between LV septal and lateral walls

18. In Figures 21.3A to C, LV dyssynchrony is evaluated with color-coded TDI. What conclusion can be drawn from this example?
a. The likelihood of response to CRT is low
b. The timing of LV ejection does not include the first positive peak velocity and, therefore, LV dyssynchrony cannot be evaluated
c. There is substantial LV dyssynchrony with a maximum delay of 90 milliseconds between two opposing walls and, therefore, the likelihood of response to CRT is high
d. The LV segments where the sample volumes are placed show very high systolic velocities indicating active contraction and, therefore, the likelihood of response to CRT is high

17. d 18. c



Figs 21.3A to C

19. Doppler-derived strain imaging has been proposed to measure LV dyssynchrony. What is incorrect about Figure 21.4?

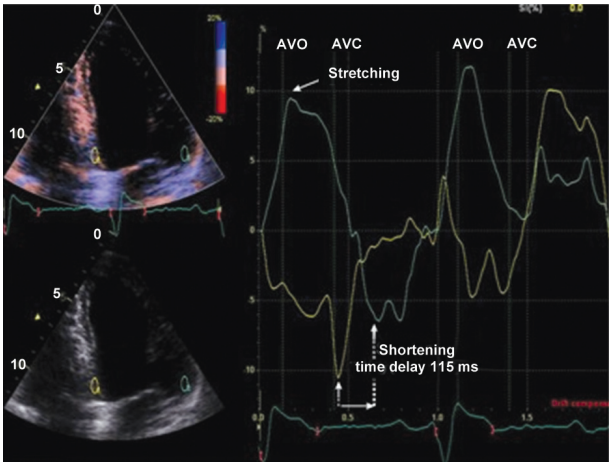


Fig. 21.4

a. There is substantial LV dyssynchrony with the lateral wall stretching while the septal wall shortens
b. In this example, strain imaging is not the best method to assess LV dyssynchrony since the lateral wall seems to be tethered by the adjacent segments
c. There is substantial LV dyssynchrony with a peak systolic strain-time delay of 115 milliseconds between the septal and the lateral walls
d. Strain (rate) imaging enables the assessment of active myocardial contraction and reflects, therefore, myocardial viability

20. LV dyssynchrony assessed with TDI-derived radial strain has been shown to be predictive of improvement in LV stroke volume after CRT. Which sentence about Figure 21.5 is correct?

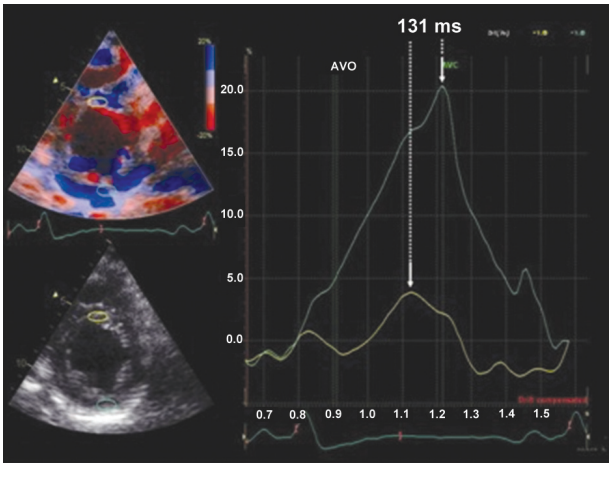


Fig. 21.5

19. b 20. b

a. The example shows circumferential strain-time curves and, therefore, LV dyssynchrony cannot be assessed
b. Septal peak radial strain is earlier than the posterior peak radial strain indicating significant LV dyssynchrony
c. The sample volumes are not correct and should be placed in the inferior and lateral walls
d. Radial strain-time curves in this example are too noisy and, therefore, LV dyssynchrony assessment results are inaccurate

21. Based on Figure 21.6, which of the following sentences about 2D speckle tracking is correct?

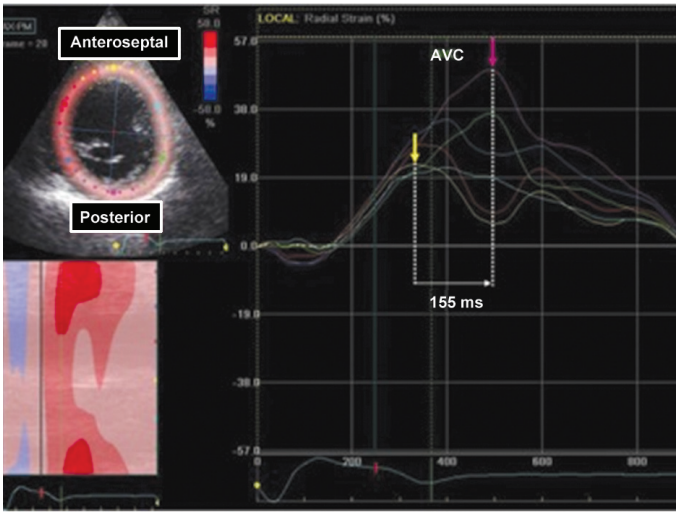


Fig. 21.6

a. LV dyssynchrony can only be assessed by measuring the time delay between peak radial strain of the anteroseptal segment and the posterior segment since those are the segments aligned along the ultrasound beam
b. With this method, the latest activated segment can be identified and may be useful to indicate where the LV pacing lead should be placed
c. There is no significant LV dyssynchrony since the time delay between peak radial strain of the anteroseptal and posterior segments is <130 milliseconds
d. The low values of radial strain of the septal, anteroseptal, and anterior segments indicate that these segments are tethered by the adjacent segments and they do not show active contraction

22. Triplane TSI permits to characterize LV mechanical activation. Based on Figure 21.7, which of the following statements is correct?

a. In patients with ischemic heart failure, triplane TSI is the best tool to distinguish those segments with active contraction from those that are passively tethered
b. Activation time intervals from 16 LV segments (six basal, six mid, and four apical segments) are obtained simultaneously during the same heartbeat
c. The site of maximal mechanical delay cannot be identified
d. The TSI algorithm calculates time to peak myocardial systolic velocities in 12 LV segments and converts these time intervals into color codes

21. b 22. d

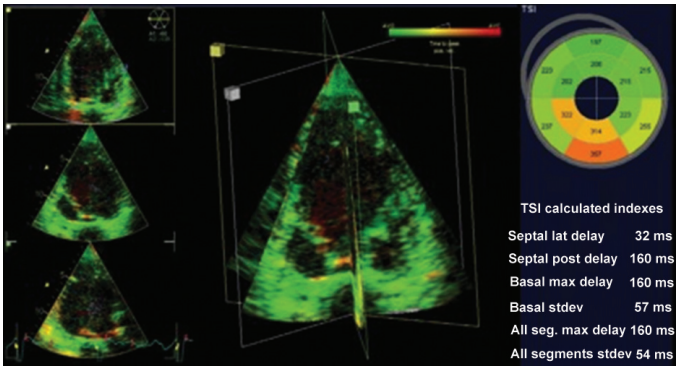


Fig. 21.7

23. Figures 21.8A and B illustrate the analysis of LV dyssynchrony with real-time 3D echocardiography. Which of the following sentences about this technique is correct?
    a. LV dyssynchrony is quantified by calculating the standard deviation of time to minimum systolic volume of 16 LV subvolumes, the so-called SDI.
    b. The polar maps show the time to minimum systolic volume of the 16–17 LV subvolumes, but the latest activated region cannot be identified.
    c. The time-volume curves indicate which segments show active contraction and which segments are tethered by the adjacent segments.
    d. After 6-month follow-up (panel B), there is still substantial LV dyssynchrony.

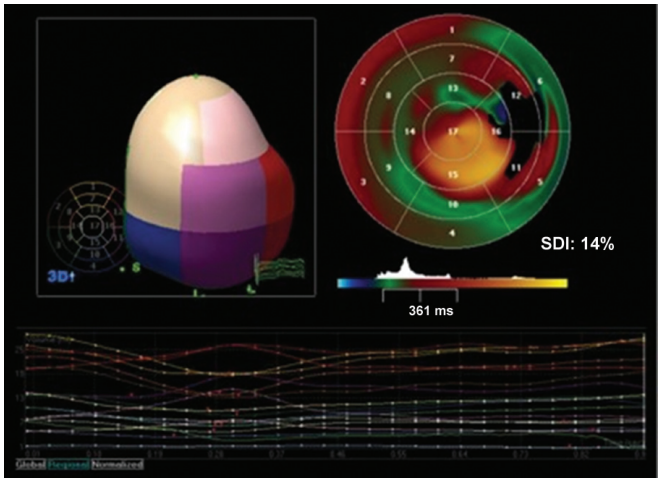


Fig. 21.8A

23. a

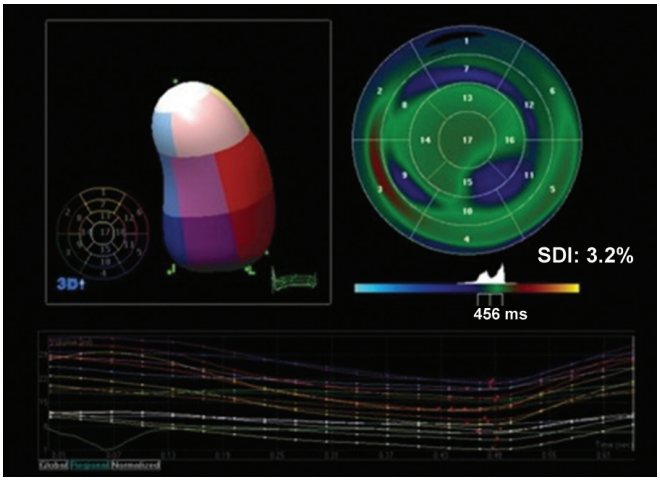


Fig. 21.8B

24. The iterative method to optimize AV delay has been used in several single-center and randomized multicenter CRT studies. Based on the sequence shown in Figure 21.9, which of the following sentences is correct?

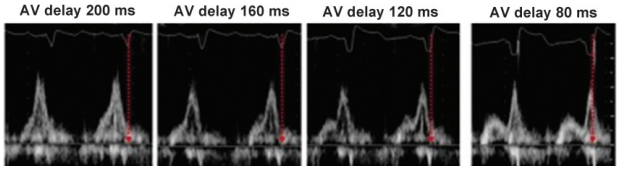


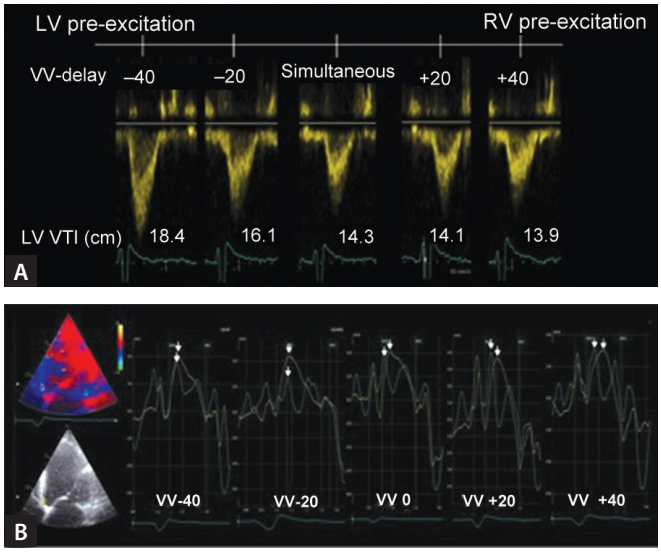
Fig. 21.9

a. The sequence is incorrect since this method starts with the shortest AV delay and lengthens in 10-millisecond steps until the E and A waves are fused
b. The optimal AV delay is 120 milliseconds
c. The optimal AV delay is defined by the longest AV delay with truncation of the A wave
d. This method cannot be applied if there is no mitral regurgitation signal

25. Optimization of VV delay can be performed with pulsed-wave Doppler recordings of the LV outflow tract, by measuring the cardiac output, and with TDI, by evaluating LV dyssynchrony. Based on Figures 21.10A and B, which of the following statements is correct?

a. The VV delay that provides the highest cardiac output does not provide the smallest amount of LV dyssynchrony
b. Prestimulation of the right ventricle usually provides the highest cardiac output
c. In this example, the best VV delay should be set at −40 milliseconds (prestimulation of the LV) since it yields the highest cardiac output and the more LV synchronous contraction
d. Once the optimal VV delay is programmed, it remains stable and no further adjustments are needed

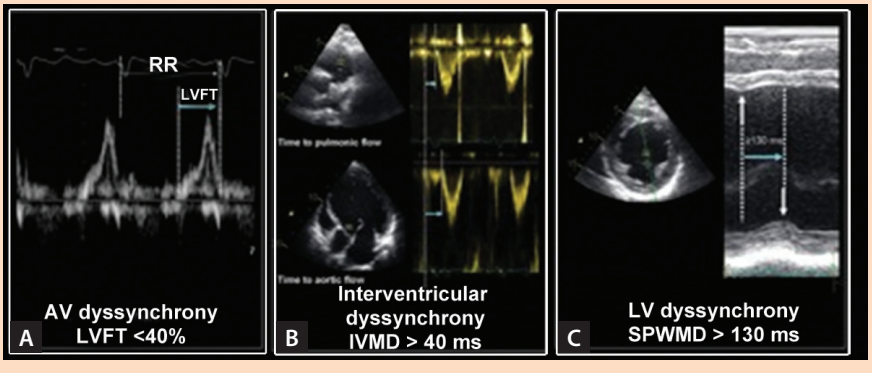
24. b 25. c



Figs 21.10A and B

Answers

1. b. Cardiac dyssynchrony can occur at three different levels: atrioventricular (AV), interventricular, and left ventricular (LV) dyssynchrony. Prolonged AV conduction (first-degree AV block) is commonly observed in patients with heart failure. On echocardiography, pulsed-wave Doppler recordings of the transmitral flow permit the evaluation of AV dyssynchrony and is defined by an LV filling time (LVFT) (indexed to R-R interval) of ≤40% (Fig. 21.11A). Prolonged ventricular conduction, most commonly left bundle branch block, causes either interventricular dyssynchrony or LV dyssynchrony. Interventricular dyssynchrony is commonly assessed by measuring the time delay between the onset of the RV and LV ejections, the so-called interventricular mechanical dyssynchrony (IVMD) index (Fig. 21.11B). An interventricular mechanical index of ≥40 milliseconds indicates substantial interventricular dyssynchrony and has been proposed as a predictive index of favorable response to cardiac resynchronization therapy (CRT). Finally, LV dyssynchrony can be assessed with multiple and sophisticated echocardiographic techniques, and this parameter is the most associated with response to CRT. On M-mode echocardiography, LV dyssynchrony is defined by a time delay between the systolic inward motion of the septum and the posterior wall ≥130 milliseconds, the so-called septal-to-posterior wall motion delay (SPWMD) index (Fig. 21.11C).



Figs 21.11A to C

(A) Example of AV dyssynchrony with an LV filling time (LVFT) of <40% of the R-R interval. (B) Assessment of interventricular dyssynchrony by measuring the time delay between the onset of the right and left ventricular ejections on pulsed-wave Doppler recordings of the pulmonic and aortic flows. (C) Assessment of LV dyssynchrony by one of the echocardiographic methods proposed, M mode. The systolic septal inward motion occurs >130 milliseconds earlier than the posterior inward motion.

2. d. Prolonged AV conduction is not uncommon in patients with heart failure and, in that situation, atrial contraction occurs too early in diastole shortening the effective LVFT. On pulsed-wave Doppler recordings of the transmitral flow, a fusion of the E and A waves is observed (Fig. 21.12). In addition, following atrial contraction, the mitral valve remains open and, as a consequence, late diastolic mitral regurgitation may occur.

   An optimal AV delay provides the best atrial contribution to the LV filling and the mitral valve closes (MVC) at the end of the A wave. However, a long AV delay results in an early atrial contraction with a subsequent fusion of the E and A waves and a shortening of the LV diastolic filling. In addition, after atrial contraction, mitral valve remains open and diastolic mitral regurgitation can occur.

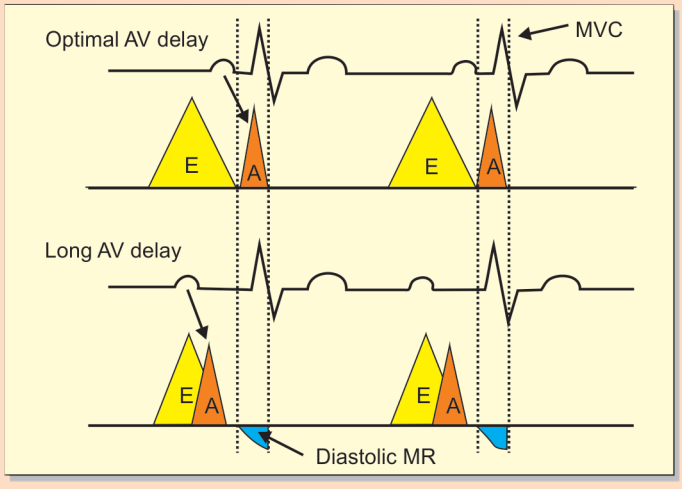


Fig. 21.12

3. b. Interventricular dyssynchrony is usually quantified by using the IVMD index. This index is derived by calculating the time delay between the onset of the right ventricular and LV ejections on pulsed-wave Doppler recordings of the pulmonic and aortic flows, respectively (Fig. 21.11B). A cutoff value of ≥40 milliseconds indicates substantial interventricular dyssynchrony and has been related to favorable response to CRT.
4. a. M-mode echocardiography was one of the first techniques to assess LV dyssynchrony and to predict response to CRT. Applied to midventricular short-axis view of the left ventricle, M-mode recordings display the motion of the septum and posterior wall along the cardiac cycle. The time delay between the inward motion of the septum and posterior wall yields the SPWMD index. A cutoff value of ≥130 milliseconds indicates the presence of LV dyssynchrony and predicts response to CRT. However, further studies have demonstrated that the feasibility of M-mode to assess LV dyssynchrony is limited in ischemic heart disease. In addition, several echocardiographic techniques have been developed to quantify LV dyssynchrony and predict response to CRT.
5. d. LV dyssynchrony has been extensively studied with tissue Doppler imaging (TDI). Among several TDI modalities, assessment of LV longitudinal velocities is the principal method used in clinical practice. Pulsed-wave TDI or color-coded TDI are the main approaches to evaluate LV longitudinal velocities. Pulsed-wave TDI permits interrogation of only one region at a time and precludes simultaneous comparison of two opposite regions. This technical issue may reduce the accuracy of LV dyssynchrony assessment. In contrast, color-coded TDI permits the assessment of LV longitudinal velocities in multiple regions simultaneously. Myocardial velocities are obtained by postprocessing color-coded TDI data, and, subsequently, LV dyssynchrony is evaluated by means of time delay to peak systolic velocity between two to four opposing regions or calculating the standard deviation of time to peak systolic velocity of 6–12 LV segments. As all Doppler-based techniques, TDI data analysis is highly dependent on the angle of insonation of the ultrasound beam, and, therefore, accurate LV dyssynchrony assessment requires proper alignment of ultrasound beam with the direction of the motion.
6. d. To assure proper analysis of LV dyssynchrony with TDI techniques, tissue Doppler data acquisition, and postprocessing require the following actions:

    High frame rate color tissue Doppler (>90 frames/sec)

    Optimized gain and time gain control settings for clear myocardial definition. Position of the LV cavity in the center of the sector and aligned with the Doppler ultrasound beam for optimal LV longitudinal motion assessment. Have Patients hold breathing for 5 seconds

while a three-to-five-beat digital acquisition is performed. Record standard apical two-, four, and three-chamber views. Determine the LV ejection interval; from pulsed-wave Doppler recordings of the LV outflow tract, the aortic valve opening and closure timings can be defined. Place the regions of interest (5 × 10 mm to 7 × 15 mm size) at the basal and midventricular segments of opposing LV walls to obtain time-velocity tracings. Check physiologic signal quality identifying the components of the velocity curve: isovolumic contraction positive curve (<60 milliseconds from the Q wave), the systolic wave (S), and the early (E) and late (A) diastolic waves (Fig. 21.13). Adjust the regions of interest to obtain the most reproducible peak systolic velocity. Time from the onset of QRS to peak S wave should be measured for basal and midventricular segments of the three apical views (12 segments). Alternatively, the difference in time to peak S wave from opposing walls can define LV dyssynchrony.

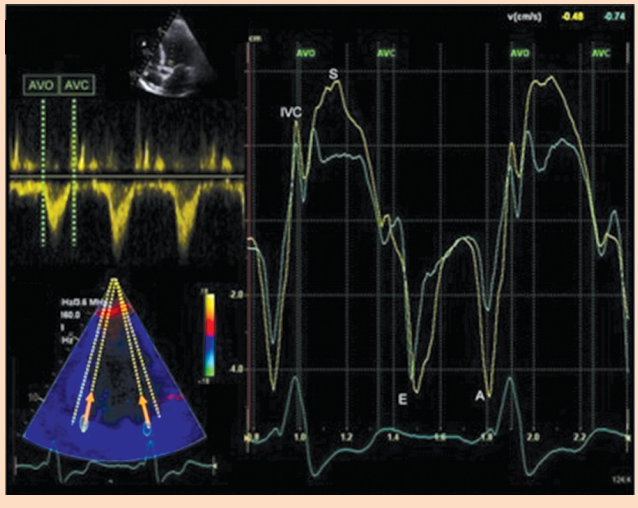


Fig. 21.13

LV dyssynchrony assessment with color-coded TDI. First, LV ejection interval should be defined (panel A). TDI data acquisition requires proper alignment of the ultrasound beam along the LV motion direction (panel B). Postprocessing of TDI data provides velocity-time curves of two opposing LV walls. The components of the velocity-time curves should be identified (panel C): the isovolumic contraction (IVC) curve, systolic velocity (S), and early (E) and late (A) diastolic velocities. Finally, time delay between peak systolic velocities (S wave) can be measured to assess LV dyssynchrony.

7. a. Color-coded TDI is the technique most frequently used to evaluate LV dyssynchrony and to predict mid- and long-term prognosis after CRT. Several LV dyssynchrony parameters have been developed in the last decade. The measurement of time delay in peak systolic velocity between the basal septal and basal lateral segments of the apical four-chamber view is the simplest parameter to identify LV dyssynchrony. A cutoff value of ≥60 milliseconds predicts favorable echocardiographic response to CRT with a sensitivity and specificity of 76% and 78%, respectively. In addition, LV dyssynchrony can be defined by the time delay between four opposing walls (basal segments of the anterior, inferior, septal, and lateral walls). A cutoff value of ≥65 milliseconds predicts favorable clinical and echocardiographic response to CRT at midterm follow-up and improved long-term prognosis. Finally, Yu et al. developed an LV dyssynchrony index that integrates information from the 3 apical views (two, four-chamber and long-axis views). This index is derived by calculating the standard deviation of time to peak systolic velocity of 12 segments (basal and midventricular segments). A cutoff value of

≥31.4 milliseconds predicts favorable response to CRT with a sensitivity and specificity of 96% and 78%.

8. c. Strain and strain rate imaging evaluate myocardial deformation and permit distinction of myocardial segments with active contraction from segments that are passively tethered (scar segments). From TDI data, strain and strain rate-time curves can be obtained. As all Doppler techniques, TDI-derived strain and strain rate measurements are highly dependent on the angle insonation of the ultrasound beam. At the apical views of the left ventricle, only longitudinal strain or strain rate can be measured; whereas from the short-axis views, radial strain and strain rate can be measured at the (antero)septal and posterior walls and circumferential strain and strain rate can be measured at the inferior and lateral walls. Several studies have evaluated the role of strain and strain rate imaging to define LV dyssynchrony and to predict response to CRT. LV dyssynchrony can be evaluated either with longitudinal or radial strain and strain rate by measuring the time delay between peak strain of two opposing walls. A time delay of ≥130 milliseconds between the (antero)septal and the posterior walls measured on radial strain-time curves has been predictive of acute improvement in stroke volume after CRT while longitudinal strain failed to predict LV reverse remodeling after CRT.

9. b. Two-dimensional (2D) speckle tracking echocardiography permits angle-independent myocardial strain and strain rate assessment in three orthogonal directions (radial, circumferential, and longitudinal) and in all LV segments. Strain analysis, based on this novel modality, also enables the differentiation of myocardial segments with active contraction from segments that are passively tethered by the adjacent segments. From radial strain-time curves, a time delay between peak strain of the anteroseptal and posterior walls of ≥130 milliseconds predicts LV reverse remodeling after CRT (Fig. 21.14). In addition, strain analysis based on 2D speckle tracking echocardiography permits the detection of the latest activated segment. This has important clinical implications since positioning the LV pacing lead at the latest activated site provides a high likelihood of favorable response to CRT and superior clinical outcome.

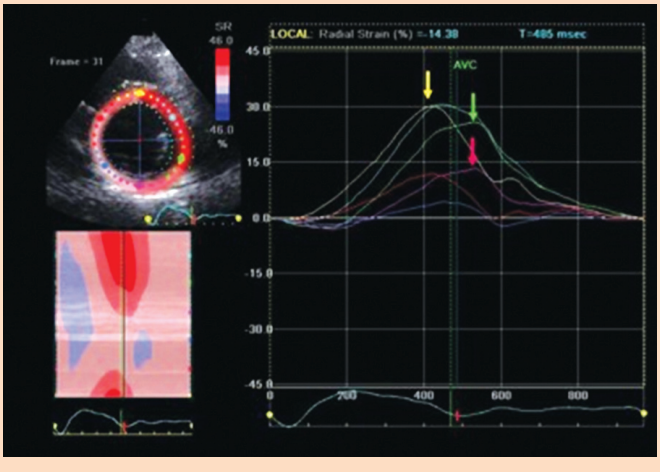


Fig. 21.14

LV dyssynchrony assessed with 2D speckle tracking analysis. From the midventricular LV parasternal short-axis view, time-radial strain tracings of the 6 LV segments are obtained. A time delay of ≥130 milliseconds between peak radial strain of the anteroseptal (yellow arrow) and the posterior (red arrow) segments define the presence of substantial LV dyssynchrony. In addition, the latest activated segments can be identified (purple and green arrows) indicating where the LV pacing lead should be preferably placed.

10. d. Three-dimensional (3D) echocardiography allows for the assessment of LV dyssynchrony in the entire left ventricle and in the same cardiac cycle. 3D echocardiography analysis of LV

dyssynchrony can be performed by direct volumetric analysis (real-time 3D echocardiography) or by triplane TSI analysis. With real-time 3D echocardiography, an LV full volume is obtained and, subsequently, divided in 17 subvolumes. LV dyssynchrony is calculated as the standard deviation of time to minimum regional systolic volume for 16 segments, the so-called systolic dyssynchrony index (SDI). A cutoff value of ≥6.4% predicts LV reverse remodeling after CRT. Triplane TSI calculates automatically time to peak systolic velocity in basal and midventricular segments of the septal, lateral, inferior, anterior, posterior, and anteroseptal walls. This method selects a specific interval of the cardiac cycle to calculate time delays (only in the LV ejection interval) and excludes the early isovolumic contraction and the late postsystolic shortening. A color-coded overlay is added onto 2D images to visually identify the regional mechanical delay. The earliest activated areas are coded in shades of green, whereas the latest activated areas are coded in shades of red. Time to peak systolic velocities are displayed in a 12-segment polar map and LV dyssynchrony is defined by the septum and lateral walls and the standard deviation of 12 segments. A standard deviation of time to peak systolic velocity of 12 segments of ≥33 milliseconds has been shown to predict favorable clinical and echocardiographic response to CRT at midterm follow-up.

11. a. The optimal AV delay is defined by the shortest AV interval achievable without compromising the left atrial contribution to LV filling. On pulsed-wave Doppler recordings of the transmitral flow, the end of the A wave should coincide with the onset of rise in LV pressure. The optimal AV delay settings provide a complete late-diastolic filling by atrial contraction and the maximum diastolic LVFT resulting in maximal LV stroke volume.

12. d. When the AV delay is programmed too short, LV contraction occurs earlier and MVC prematurely compromising the left atrial contribution to LV filling. On pulsed-wave Doppler recordings of transmitral flow, a truncation of the A wave is observed together with a relatively early E wave. As a consequence, LVFT lengthens with widely separated E and A waves (Fig. 21.15).

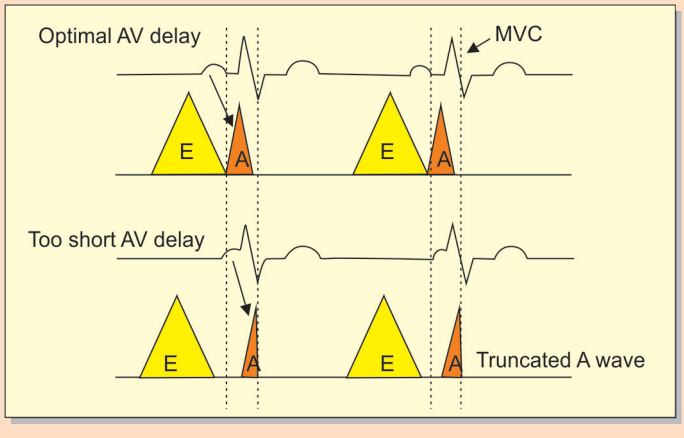


Fig. 21.15

Too short AV delay compromises left atrial contribution to LV filling. Left atrial contraction is interrupted by an early LV contraction. On transmitral pulsed-wave Doppler recordings, A wave is truncated and LV filling time lengthens with widely separated E and A waves.

13. d. The echocardiographic methods used to optimize the AV delay aim to improve either diastolic LVFT or hemodynamic markers of LV systolic function. Diastolic LVFT is usually evaluated using pulsed-wave Doppler recordings of the transmitral flow. LV hemodynamics are usually evaluated using the following: (1) continuous-wave or pulsed-wave Doppler recordings of the LV outflow tract, measuring the velocity-time integral of the flow and calculating the cardiac

output or (2) continuous-wave Doppler recordings of the mitral regurgitation, measuring the peak rate of rise of LV pressure during isovolumic contraction (dP/dtmax).

14. b. Echocardiographic AV optimization techniques aiming to improve LV diastolic filling include the iterative method, the Ritter's method, the mitral inflow velocity-time integral method, and the simplified (Meluzin) mitral inflow method. Echocardiographic AV optimization methods aiming to improve LV hemodynamics include the assessment of aortic valve or LV outflow tract velocity-time integral, dP/dtmax, and myocardial performance index. Figure 21.16 summarizes and illustrates these methods.

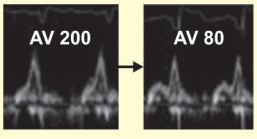
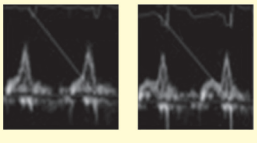
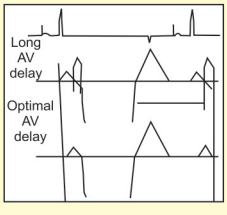
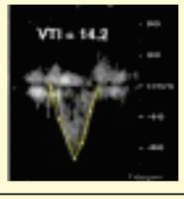
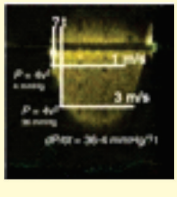
Echocardiographic optimization method	Technique
Optimization of LV diastolic filling	
 Iterative method	– Pulsed wave Doppler recordings of the transmitral flow. – A long AV delay is programmed and then it is shortened by 20 ms increments until truncation of the A wave. Then, the optimal AV delay is identified by lengthening the AV delay until A wave is not longer truncated
Long AV delays 300 ms Short AV delays 20 ms  Ritter's method	– Pulsed wave Doppler recordings of the transmitral flow – Two extreme AV delays are programmed – Long AV delay without A wave attenuation (AV_{long}) – Short AV delay with truncation of A wave (AV_{short}) – For each AV delay, the time between QRS onset and completion of the A wave is measured (QA_{long} and QA_{short}) – Optimal AV delay is calculated using the formula: $AV_{opt} - AV_{short} + \{(AV_{long} + QA_{long}) - (AV_{short} + QA_{short})$ – Limitation : high heart rates, intrinsic AV conduction <150 ms
 Simplified mitral inflow method	– Pulsed wave Doppler recordings of the transmitral flow for 5-10 s. – A long AV delay is defined as the maximum AV delay allowing full ventricular capture (lowered by 5-10 ms). – The time between the end of the A wave and onset of mitral regurgitation spectral signal is measured (t1). – The optimal AV delay is calculated by subtracting t1 from the long AV delay and t1. – Limitation : detectable mitral regurgitation is needed.
Optimization of LV hemodynamics	
 Aortic valve/LV outflow tract velocity time integral	– Continuous or pulsed wave Doppler recordings of the aortic valve or LV outlow tract flow respectively – The product of LV outflow tract area and its velocity time integral yields stroke volume – The optimal AV delay provides the optimal LV filling and the optimal stroke volume.
 dP/dt_{MAX}	– The peak rate of rise of LV pressure during is isovolumic contraction or dP/dt_{MAX} can be non-invasively assessed on mitral regurgitation continuous wave Doppler recording – The time difference between two points on the continuous wave mitral regurgitation spectral signal (corresponding to 1 and 3 m/s) is measured – The pressure gradient is calculated according to Bernoulli equation – Limitation : detectable regurgitation is needed.

Fig. 21.16

15. a. The most common echocardiographic methods to optimize the VV delay include the measurement of velocity-time integral on pulsed-wave Doppler recordings of the LV outflow tract and the evaluation of LV dyssynchrony on color-coded TDI data by measuring septal-to-lateral peak systolic velocity time delay.
16. c. Prolonged AV conduction induces late ventricular contraction. Left atrial contraction occurs relatively early in diastole and, on pulsed-wave Doppler recordings of the transmitral flow, the E and A waves appear fused (superimposition of atrial contraction on the early diastolic LV filling phase). Subsequently, diastolic LVFT is reduced. In addition, after left atrial contraction, mitral valve remains open and diastolic mitral regurgitation can be observed.
17. d. Interventricular and LV dyssynchrony can be assessed with pulsed-wave TDI. Interventricular dyssynchrony is measured as the peak systolic velocity time delay between the basal segment of RV free wall and the most delayed basal LV segment. LV dyssynchrony is calculated as the peak systolic velocity time delay between 2, 4, or 6 basal LV segments. The combination of both, interventricular and LV dyssynchrony, predicts favorable response to CRT with high sensitivity and specificity. In this case, the sum of both delays results in 115 milliseconds and, therefore, the likelihood of favorable response to CRT is high.
18. c. Color-coded TDI is one of the most used echocardiographic techniques to evaluate LV dyssynchrony. The time delay between two (septal-to-lateral) or four opposing walls (anterior, inferior, septal, and lateral) as well as the standard deviation of time to peak systolic velocity of 12 segments define LV dyssynchrony and predict favorable response to CRT. In this case, a septal-to-lateral wall delay of 120 milliseconds (≥65 milliseconds) is highly predictive of LV reverse remodeling.
19. b. In this example, there is substantial LV dyssynchrony as assessed with TDI-derived longitudinal strain: the lateral wall stretches, whereas the septal wall shortens. Peak shortening of the lateral wall occurs after aortic valve closure. TDI-derived strain imaging is a valuable technique to evaluate patients with heart failure who are candidates for CRT since it provides information not only on LV dyssynchrony but also on myocardial active contraction. TDI-derived strain imaging permits differentiation of myocardial segments with active deformation or contraction (viable segments) from those segments with a substantial amount of scar tissue that are usually tethered by the adjacent segments. Previous studies have demonstrated the importance of assessing the extent and location of scar tissue before CRT implantation. Thus, when the LV pacing lead is placed at a region with transmural scar or when the LV content of scar tissue is excessive, the likelihood of favorable response to CRT reduces dramatically. In this example, the LV lateral wall shows active contraction, although more delayed as compared to the septal wall.
20. b. From midventricular short-axis images of the left ventricle, radial or circumferential strain can be assessed. Although TDI-derived strain is highly dependent on the ultrasound angle of incidence, radial strain can be assessed at the (antero)septal and posterior walls. With radial strain, myocardial thickening is evaluated and scored as positive values. Circumferential strain can be assessed only at the lateral and inferior(septum) walls and evaluates myocardial shortening along the curvature of the left ventricle. Circumferential shortening is scored as negative values. In this example, LV dyssynchrony is evaluated with TDI-derived radial strain and demonstrates the presence of substantial LV dyssynchrony with a peak radial strain-time delay between the septum and the posterior wall of ≥130 milliseconds.
21. b. Strain imaging based on speckle tracking echocardiography has emerged as a powerful technique to evaluate patients with heart failure who are candidates for CRT. This imaging technique enables angle-independent multidirectional LV strain and strain rate assessment. LV dyssynchrony can be assessed with radial strain speckle tracking analysis. In addition, the latest activated segment can be identified having important implications on CRT response. In patients with an LV pacing lead placed at the latest activated areas, a higher response

rate to CRT and superior long-term outcome have been demonstrated. Finally, as all strain imaging techniques, viable LV segments, showing active contraction, may be identified and differentiated from those scar segments passively tethered.

22. d. The assessment of LV dyssynchrony can be performed with triplane TSI. First, the apical two-, four-, and three-chamber views of the left ventricle are simultaneously acquired rendering an LV 3D volume. Color-coded TSI is applied to the triplane view to assess myocardial longitudinal velocities. The time from onset of QRS complex to peak systolic velocity in every segment of the left ventricle is calculated automatically, and LV dyssynchrony is expressed as time delays between the septum and the lateral wall and the standard deviation of 12 segments. In addition, the TSI algorithm color codes the time delays ranging from the green (earliest activated) over yellow-orange to red (latest activated) within the systolic period. The electromechanical activation times are presented in a polar map allowing for the identification of the earliest and latest activated segments (Figure 21.7) illustrates an example of a patient with substantial LV dyssynchrony, as indicated by a standard deviation of 12 segments of 54 milliseconds, being the posterobasal and most delayed activated segment. However, triplane TSI relies on myocardial velocity Doppler imaging and, therefore, data analysis is highly dependent on ultrasound beam angle. In addition, LV segments with active contraction are not distinguished from segments that are tethered by the adjacent segments.

23. a. LV dyssynchrony analysis based on real-time 3D echocardiography is performed by calculating the SDI: standard deviation of time to minimum regional volume of 16 subvolumes in which the left ventricle is divided. This time dispersion can be also displayed graphically in a color-coded polar map illustrating the most delayed areas. After CRT, the LV synchrony improves and the SDI decreases. Consequently, the polar map shows a homogeneous mechanical activation. Real-time 3D echocardiography evaluates the excursion or displacement of the 16 LV subvolumes but does not provide information on segmental active contraction and, therefore, its accuracy may be limited in patients with ischemic heart failure.

24. b. The iterative method is one of the most commonly used echocardiographic methods to optimize the AV delay. With pulsed-wave Doppler recordings of the transmitral flow, the LVFT is evaluated at different AV delays. From a long AV delay, the AV delay is shortened by 20-millisecond steps until the A wave is truncated. Afterward, the AV delay is lengthened in 10-millisecond increments until truncation of the A wave is no longer observed. Therefore, the shortest AV delay without truncation of the A wave is set as the optimal AV delay that provides the optimal LV filling.

25. c. Echocardiographic optimization of the VV delay is usually performed by measuring the velocity-time integral on pulsed-wave Doppler recordings at the LV outflow tract or by TDI techniques evaluating the amount of LV dyssynchrony. Optimal VV delay aims to decrease LV dyssynchrony and, subsequently, to improve LV hemodynamics. The role of VV delay optimization remains controversial. Two multicenter randomized trials (DECREASE-HF and RHYTHM II ICD) did not demonstrate any benefit, whereas the recent INSYNC III trial and other multiple single-center studies demonstrated slight but significant improvement in clinical status and stroke volume after VV optimization. The range of optimal VV delay is narrow but usually involves LV preexcitation by 20–40 milliseconds. RV pre-excitation may induce impairment in LV function and should be reserved for patients with LV dyssynchrony in the septal and inferior walls. At follow-up, optimization of AV and VV delays may be necessary secondary to the effects of CRT on LV reverse remodeling and systolic function.

22

Transthoracic Echocardiography

1. Which leaflets of the tricuspid valve are visualized on the apical four-chamber view?
   a. Septal and anterior
   b. Septal and posterior
   c. Anterior and posterior
   d. None of above

2. Calculation of left ventricular (LV) mass on the basis of M-mode echocardiography assumes that the geometry of the LV is:
   a. Spherical
   b. Ellipsoid
   c. Cylindrical
   d. None of the above

3. Which parameter of systolic function is independent of ventricular preload?
   a. Ejection fraction (EF)
   b. Peak rate of change in pressure (dP/dT)
   c. End systolic volume
   d. Fractional shortening
   e. Velocity of circumferential fiber (Vcf) shortening

4. In which of the following conditions would auscultation reveal a soft first heart sound?
   a. Mitral stenosis
   b. Calcific aortic stenosis
   c. Right bundle branch block
   d. First degree atrioventricular (AV) block

5. According to the American Society of Echocardiography's most recent guidelines, chamber dimensions on 2D (two-dimensional) echocardiography should be measured:
   a. Leading edge to leading edge
   b. Trailing edge to leading edge
   c. Trailing edge to trailing edge
   d. None of the above

6. Which statement concerning quantitation of LV volumes is true?
   a. Echo. LV volumes are usually similar to contrast angiographic volumes
   b. Echo. LV volumes are usually smaller than contrast angiographic volumes
   c. Echo. LV volumes are usually greater than contrast angiographic volumes
   d. Echo. LV volumes are usually much greater than contrast angiographic volumes

1. a 2. b 3. c 4. d 5. d 6. b

7. In which condition would you expect to see normal motion of the interventricular septum on M-mode?
   a. Right ventricular pacing
   b. Severe tricuspid regurgitation
   c. Atrial septal defect
   d. Aortic valve replacement
   e. Aortic insufficiency

8. The biplane method of disks shows an EF of 60% in a 40-year-old woman with palpitations. Systolic strains are also measured using speckle-tracking software. What would be expected values for systolic strains in the longitudinal and radial directions?
   a. 10% and 20%
   b. 20% and 40%
   c. 40% and 60%
   d. None of the above

9. The American Society of Echocardiography's recommended method to calculate LV EF on the basis of 2D echocardiography is:
   a. Area length
   b. The truncated ellipse
   c. Automated boundary detection
   d. Teichholz method
   e. Biplane method of disks

10. The principal determinant of the first component of the pulmonary vein systolic velocity (S1) is:
   a. RV systolic pressure
   b. Left atrial pressure
   c. LV systolic function
   d. Atrial relaxation

11. Of the following conditions, which is most likely to be characterized by an improvement in LVEF following valve replacement:
   a. Acute severe mitral regurgitation due to flail leaflet
   b. Chronic severe aortic stenosis
   c. Severe mitral stenosis
   d. Acute aortic regurgitation due to bacterial endocarditis

12. In which condition is LV mass index expected to be lowest?
   a. Mitral stenosis
   b. Ventriculoseptal defect with a significant left-to-right shunt
   c. Chronic severe aortic regurgitation
   d. Chronic severe mitral regurgitation due to mitral valve prolapse

13. Which of the following is most helpful in preventing foreshortening of the apex in standard 2D imaging:
   a. Placing the transducer at the site of the most forceful apical impulse
   b. Use of perflutren contrast
   c. Use of a cut out mattress
   d. Shifting to a shallow left lateral decubitus position

14. When comparing 2D with M-mode echocardiography, which of the following statements is true?
   a. The axial resolution of M-mode echocardiography is superior to that of 2D echocardiography
   b. The temporal resolution of M-mode echocardiography is superior to that of 2D echocardiography
   c. The axial resolution of M-mode echocardiography is inferior to that of 2D echocardiography
   d. The lateral resolution of M-mode echocardiography is superior to that of 2D echocardiography

7. e 8. b 9. e 10. d 11. b 12. a 13. c 14. b

15. Of the following M-mode signs, which is most specific to suggest the presence of cardiac tamponade?
    a. Right atrial inversion for less than one-third of the cardiac cycle
    b. Plethora of the inferior vena cava (IVC)
    c. Rapid mitral EF slope
    d. Right ventricular diastolic collapse

16. This M-mode echocardiogram was taken from the study of a 48-year-old man with dyspnea (Fig. 22.1). His blood pressure is 120/90 mm Hg. What may be said about this patient's hemodynamic state?

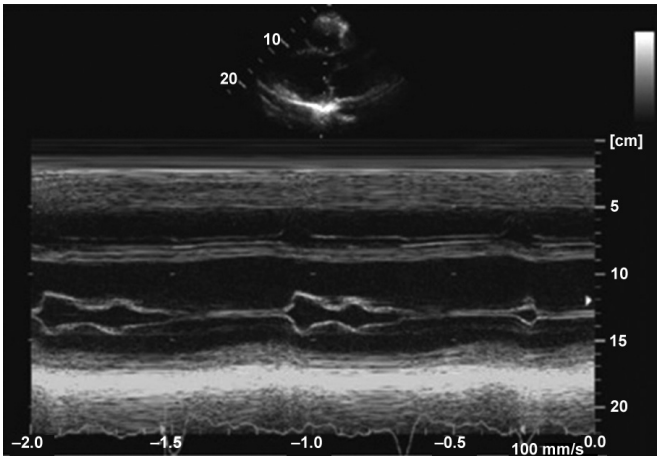


Fig. 22.1

    a. There is severe aortic regurgitation
    b. The LV end-diastolic pressure is high
    c. The stroke volume is normal
    d. The stroke volume is low
    e. The cardiac output is normal

17. A 54-year-old man undergoes echocardiography. He has severe hypertension, refractory to three drugs. He has no history of coronary or valvular heart disease. His septal and posterior wall thickness is 12 mm and his end-diastolic dimension is 44 mm. His LV mass index is 92 g/m^2. Which statement regarding this patient is most accurate (Fig. 22.2)?
    a. He has concentric remodeling
    b. He likely has normal diastolic function
    c. Left ventricular function is likely abnormal
    d. He has LV hypertrophy

15. d 16. d 17. a

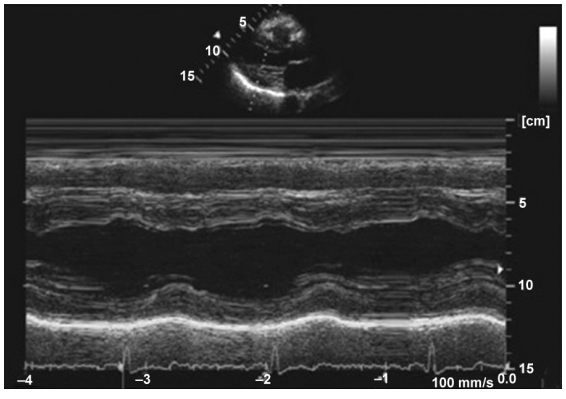
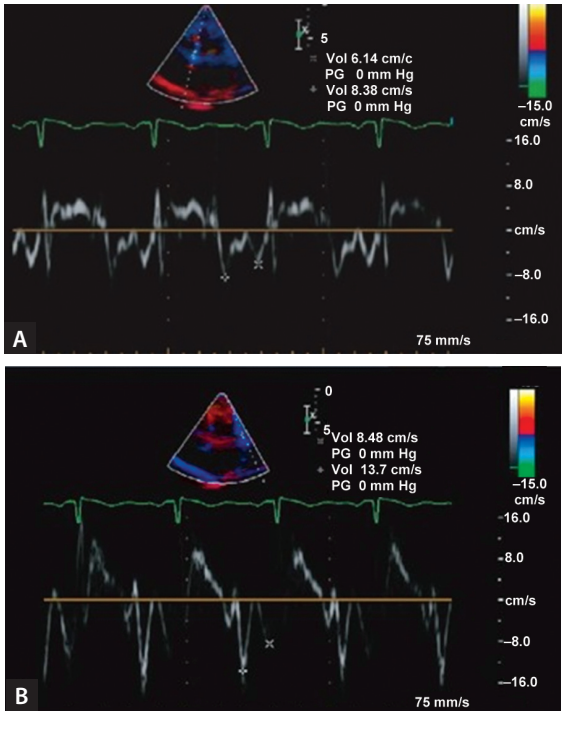


Fig. 22.2

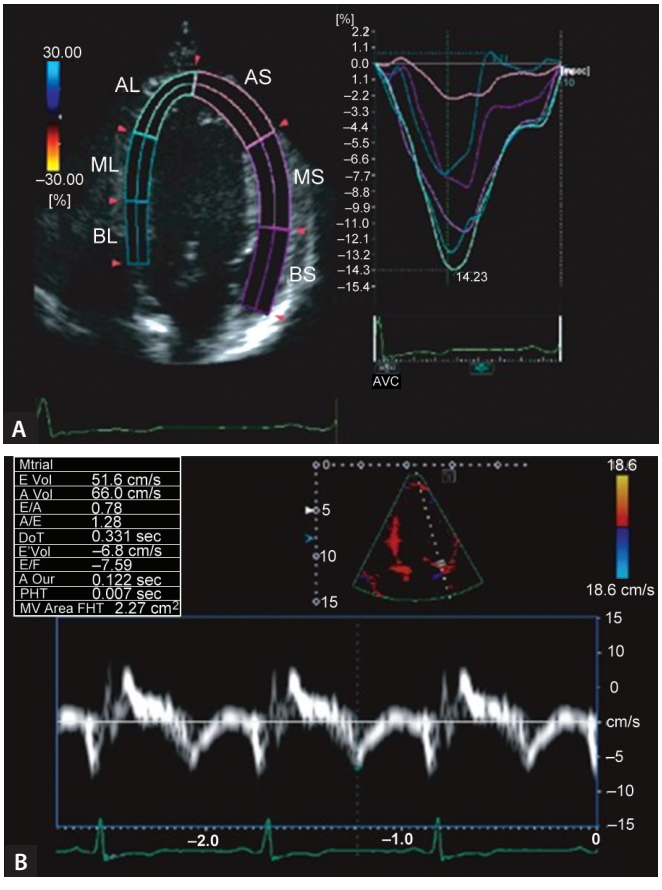
18. The tracings in Figures 22.3A and B are tissue Doppler tracings taken from the study of an asymptomatic 62-year-old woman undergoing echocardiography for the evaluation of a systolic murmur. Which of the following is correct?
    a. Figure 22.3A is taken from the septal annulus
    b. The patient likely has an infiltrative cardiomyopathy
    c. The patient likely has constrictive pericarditis



Figs 22.3A and B

18. a

19. A 43-year-old man is seen in your office for exercise-induced dyspnea. He has no history of heart failure symptoms or prior coronary heart disease. On a standard Bruce protocol exercise treadmill test (ETT), he is only able to complete 5 minutes before stopping due to dyspnea. His resting blood pressure is 150/90 mm Hg. His study showed normal LV size, mildly increased wall thickness, and an EF of 50%. As part of his echocardiographic evaluation, longitudinal strain imaging (A) and tissue Doppler imaging (B) are completed. An image from this study is shown in Figures 22.4A and B. What is the least likely conclusion, given the data presented?



Figs 22.4A and B

a. He has normal heart
b. He has hypertrophic cardiomyopathy
c. He has an infiltrative cardiomyopathy
d. He has hypertensive heart disease

19. a

20. This M-mode is taken from the study of a 59-year-old man who presents with severe heart failure symptoms (Fig. 22.5). You would expect his exam to show:

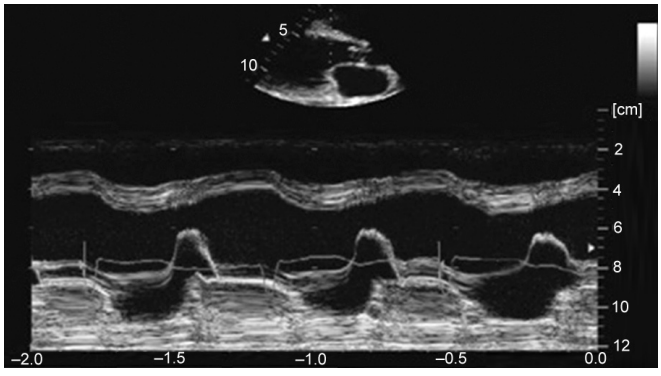


Fig. 22.5

a. An opening snap
b. Rales
c. An apical systolic murmur
d. A holodiastolic murmur

21. A 56-year-old man presents to the hospital with progressive shortness of breath. Based on the results of the recorded M-mode echocardiogram (Fig. 22.6), the following conclusions can be drawn:

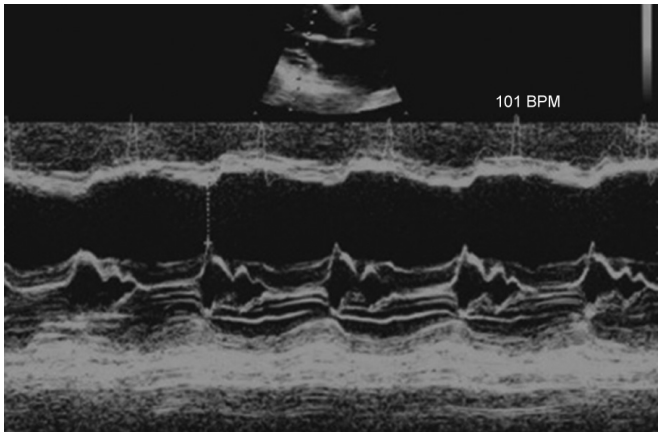


Fig. 22.6

a. The LV cavity size is normal, stroke volume is increased, and LV end-diastolic pressure is normal
b. The LV cavity is dilated, stroke volume is reduced, and the LV end-diastolic pressure is increased
c. The LV cavity is dilated, stroke volume is reduced, and LV end-diastolic pressure is normal
d. The LV cavity size is normal, stroke volume is increased, and mean left atrial pressure is increased

20. d 21. b

22. The structures depicted on the RV inflow view in Figure 22.7 include:

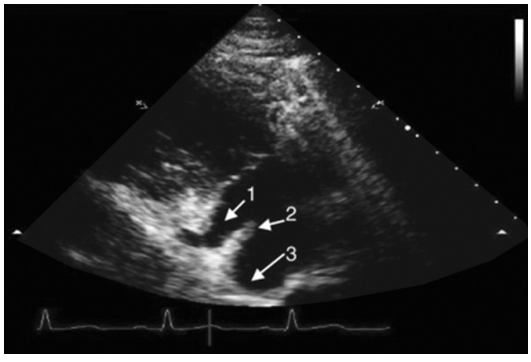


Fig. 22.7

a.
   i. The orifice of the IVC
   ii. The Eustachian valve
   iii. The superior vena cava

b.
   i. The coronary sinus
   ii. The crista terminalis
   iii. The orifice of the superior vena cava

c.
   i. The coronary sinus
   ii. The Eustachian valve
   iii. The orifice of the IVC

d.
   i. The coronary sinus
   ii. A prominent Chiari network
   iii. The orifice of the IVC

23. The condition most commonly associated with the M-mode finding in Figure 22.8 is:

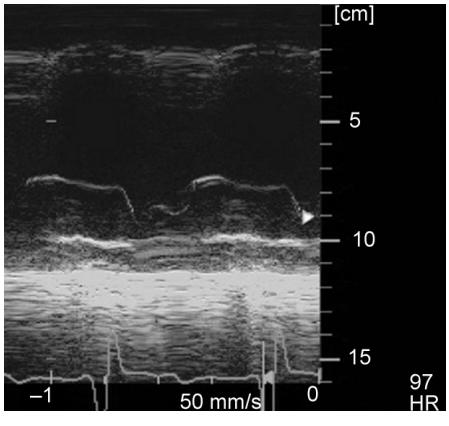


Fig. 22.8

a. Chronic severe pulmonary arterial hypertension
b. Severe pulmonary valve stenosis
c. Primary tricuspid valve regurgitation
d. Acute pulmonary emboli

22. c 23. a

24. A 55-year-old woman is admitted to the hospital with syncope. Based on the M-mode shown in Figure 22.9, what is your diagnosis?

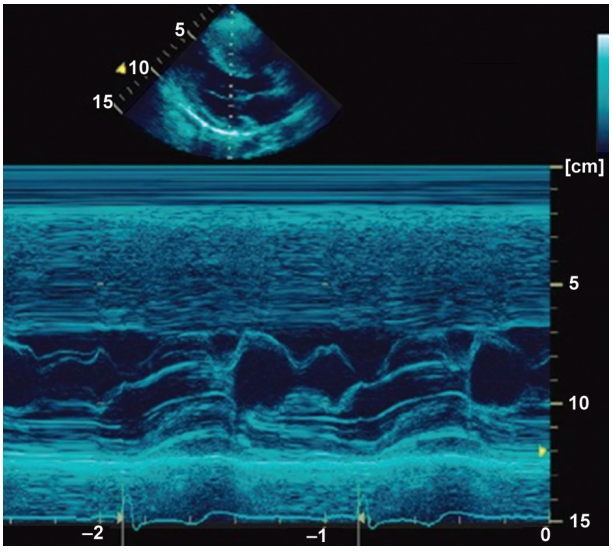


Fig. 22.9

a. Hypertrophic obstructive cardiomyopathy
b. Acute severe mitral regurgitation due to flail mitral leaflet
c. Constrictive pericarditis
d. Aortic regurgitation, unknown severity

25. The M-mode in Figure 22.10 is most consistent with what abnormality?

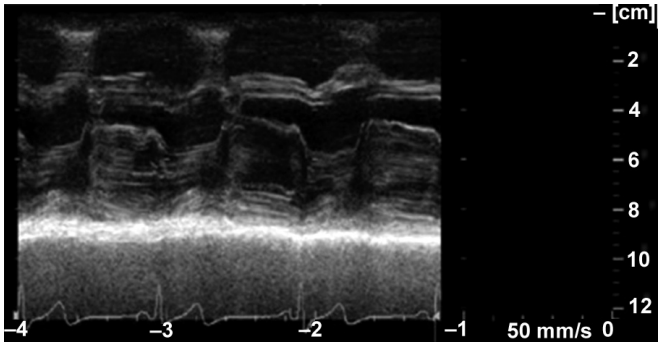


Fig. 22.10

a. Acute severe aortic regurgitation
b. Rheumatic mitral stenosis
c. Left atrial myxoma
d. Hypertrophic cardiomyopathy

24. a 25. c

Answers

1. a. On transthoracic imaging, the posterior leaflet of the tricuspid valve is only visualized on the RV inflow view. The septal and anterior leaflets are visualized on the apical four-chamber view.
2. b. LV mass and LV volume measurements from M-mode and 2D echo are based on the geometric assumptions that the ventricle is an ellipsoid with a 2:1 long-axis to short-axis ratio. The mass formula, LV mass (g) = 0.8 (1.04[(LVIDd + PWTd + SWTd)^3 – LVIDd^3]) + 0.6 (where LVIDd, PWTd, and SWTd are diastolic LV internal dimension, posterior wall thickness, and septal thickness, respectively) calculates the volumes of an inner and outer ellipsoid and subtracts the inner volume from the outer volume. The resulting volume is that of a "shell" of myocardium. The volume of this shell of myocardium is then multiplied by the specific gravity of myocardium, 1.04 g/m^2, to yield LV mass. This geometric assumption limits the applicability of the formula to normally shaped hearts.
3. c. Virtually all parameters of systolic function (EF, dP/dT, fractional shortening, and Vcf shortening) depend on loading conditions. Preload is the force that acts to stretch the myocardial fibers at end diastole, and is related to end-diastolic volume. By Starling's law of the heart, increased preload will be associated with increased fiber stretch and increased force of contraction. Afterload is the force that opposes LV ejection. End-systolic volume is also a parameter of systolic function. A related concept is that at any given contractile state, the LV will contract to the same end-systolic volume even as the LV diastolic volume increases.
4. d. The degree to which the mitral valve leaflets are separated when ventricular activation closes the mitral valve is an important determinant of the loudness of the mitral component of the S1. Accordingly, in a patient with a long PR interval (choice D), the mitral and tricuspid leaflets float into a semi-closed position because of the long period between atrial contraction and ventricular activation. Mitral stenosis is characterized by a loud first sound, if the leaflets are pliable, because the transmitral gradient at end diastole prevents the leaflets from drifting close together. Calcific aortic stenosis (by itself) or right bundle branch block do not have much of an impact on the loudness of the S1.
5. d. According to the most recent echocardiographic quantification guidelines, "Use of 2D echocardiographically derived linear dimensions overcomes the common problem of oblique parasternal images resulting in overestimation of cavity and wall dimensions from M-mode. Consequently, it is now possible to measure the actual visualized thickness of the ventricular septum and other chamber dimensions as defined by the actual tissue–blood interface, rather than the distance between the leading edge echoes, which had previously been recommended."
6. b. Numerous comparison studies have shown that LV volumes derived from echocardiography are systematically smaller than those derived from contrast angiography. The two reasons for this discrepancy are that echocardiographic algorithms that utilize apical views (e.g. biplane method of disks) underestimate the true length of the LV, when compared with angiography; and second, angiographic contrast fills the recesses between trabeculations, yielding a larger area.
7. e. The interventricular septum normally moves posterior (leftward) in early ventricular systole. Paradoxical septal motion is an early systolic anterior (rightward) motion of the septum. Thickening of the septum still occurs. Paradoxical septal motion is associated with conditions in which there is RV volume overload, with the septum, or left bundle branch block, either developed or due to RV pacing. After aortic valve replacement, or indeed any cardiac surgery, and there is prominent translation of the heart that can give the appearance of paradoxical septal motion. Aortic insufficiency, a situation in which there is LV volume overload, would not be expected to be associated with paradoxical septal motion and is, therefore, the correct answer.

8. b. Left ventricular systolic function involves the coordinated contraction of longitudinal and circumferential fibers. In the normal LV, subendocardial and subepicardial fibers are oriented longitudinally. In the midwall, fibers are oriented circumferentially. Descriptors of systolic function include the percentage shortening of the LV along the long-axis (apex-to-base) orientation. This percentage shortening of the long axis in normal patients ranges from 15%–25%. This percent longitudinal shortening is also known as longitudinal strain. This means that if the LV is 10 cm in length at end diastole, its end-systolic length would be about 8 cm. The "compression" or "shortening" of the length is 2 cm and as a percentage of initial length, it would be 20%. This in essence is longitudinal systolic strain. Circumferential fiber shortening leads to wall thickening and reduction of the radius of the LV. This wall thickening, in the normal ventricle, averages approximately 30% to 40%, and is known as radial strain, the percent change in the thickness of the ventricular wall going from end diastole to end systole. As an example, a normal LV wall might have a wall thickness of 1.0 cm in diastole and, if the wall thickens 40%, a wall thickness of 1.4 cm at end systole.
9. e. Numerous 2D echocardiographic methods have been utilized to assess EF. Limitations for each method should be expected because all of these methods are based on geometric assumptions. Using apical longitudinal views, the modified Simpson's method, also known as the biplane method of disks, has been endorsed by the American Society of Echocardiography to calculate EF on the basis of 2D echocardiography in most instances.
10. d. Many variables affect pulmonary vein flow. These include age, preload, LV systolic function, AV conduction, and heart rate. In patients with normal systolic function, S2 velocity is related to LA pressure. By contrast, S1 is more closely related to atrial relaxation.
11. b. This question requires some understanding of LV function in valvular heart disease. LV EF is inversely related to afterload and directly related to preload and inotropic state. Afterload, or wall stress, is directly related to systolic pressure and heart size, and inversely related to wall thickness. In acute severe regurgitation of either mitral or aortic valve, catecholamine tone is high, which supports the pump function despite severe regurgitation. Thus, of the following choices, chronic severe aortic stenosis (AS) is the most likely condition to have high afterload; in mitral stenosis, afterload is low, as is the case in acute mitral regurgitation (MR), where the LV ejects into the "low impedance" left atrium. In both acute severe MR and AR, catecholamine tone is likely to be high and EF is often normal if not above normal. Thus, LV EF in the latter two conditions would not be expected to rise significantly. Furthermore, LV EF would not be expected to decrease significantly after mitral valve replacement (MVR) for mitral stenosis (MS), as the afterload in that condition is usually normal. By contrast, in severe AS, systolic loads are often quite high, due to very high intracavitary pressures and, in later stages, cavity dilation. Hypertrophy may be inadequate to normalize afterload. However, following aortic valve replacement (AVR), systolic pressure comes down, heart size usually decreases (if there is dilation), and these factors lead to lower afterload and improved EF.
12. a. Choices B–D will feature LV dilation, but choice A does not. Since the LV mass formula (see question 2) depends on chamber size, a large LV will usually be associated with a large LV mass index.
13. c. In general, foreshortening of the apex will be minimized by use of a steep left lateral decubitus position, a cut out mattress, and avoiding the most forceful apical impulse.
14. b. The high temporal resolution of M-mode echocardiography is due to the fact that this technique has a much higher sampling rate compared with 2D echocardiography. For both techniques, the axial resolution is similar because the same transducer frequency is used. Lateral resolution is superior with 2D echocardiography because sampling occurs only along a single scan line with the M-mode technique.

15. d. Right atrial inversion and plethora of the IVC are sensitive signs suggesting increased intrapericardial pressures but they are not the most specific signs suggesting cardiac tamponade. When right atrial inversion extends for more than one-third of the cardiac cycle, however, the reported specificity is high. Plethora of the IVC is a nonspecific marker associated with increased right atrial pressures; plethora can be observed even when the right atrial pressure is not increased as is seen with certain highly trained athletes. With inspiration, the mitral EF slope has been observed to diminish and, thus, is not rapid in the presence of cardiac tamponade. Of the choices available, right ventricular diastolic collapse is the most specific sign of cardiac tamponade.
16. d. This study was obtained in a patient with an idiopathic dilated cardiomyopathy. The M-mode echocardiogram shows marked dilation, with an end-diastolic dimension approaching 6 cm, and an end-systolic dimension of 5.5 cm. The fractional shortening is therefore quite low. There is a large separation between the anterior leaflet of the mitral valve and the septum (the "e-point septal separation," because the peak anterior position of the anterior leaflet is known as the e-point in M-mode parlance). This sign is associated with a low forward stroke volume. It is important to realize that LV dilation by itself does not lead to an abnormal e-point septal separation. An individual with severe aortic regurgitation might have a dilated LV but normal fractional shortening. In that case, the e-point septal separation would be normal. As for the incorrect choices, while this patient might have high left ventricular end-diastolic pressure (LVEDP), there is no definite evidence thereof. The pathognomonic M-mode sign of this physiology, the so-called a-c shoulder or b-bump is not present. (Figure 22.11 shows a prominent b-bump.)

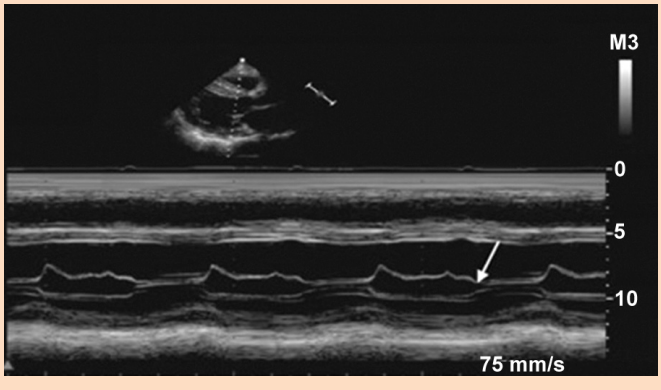


Fig. 22.11

As far as cardiac output is concerned, recall that it can be normal despite a low stroke volume, if there is compensatory tachycardia. Finally, the etiology of the LV dysfunction shown in this case could have been chronic aortic regurgitation, with the development of contractile failure, but this M-mode tracing is not specific for such a cardiomyopathy. The lack of fluttering of the mitral leaflets provides some evidence against significant aortic regurgitation.
17. a. This patient's LV mass index is normal, by the partition values in the ASE quantitation guidelines, so he does not have LV hypertrophy, by definition. According to the pioneering work of Ganau et al. and as recommended by the ASE quantitation guidelines, the combination of a high relative wall thickness with a normal LV mass index is termed concentric remodeling. This individual clearly has an elevated relative wall thickness, defined as (2 × PWTd)/LVIDd with the upper limit of normal 0.42. The term concentric hypertrophy refers to an elevated LV mass index (i.e. 95 g/m^2 in women, greater than 115 g/m^2 in men) and a high relative wall thickness.

According to work by Wachtell and coworkers, most individuals with hypertension and evidence of remodeling, as the case with this individual, have abnormalities in diastolic filling. The M-mode clearly shows normal fractional shortening; although this is not necessarily the same as a normal EFm. The absence of a coronary heart disease by history argues that global EF is normal.

18. a. Tissue Doppler tracings give insight into systolic and diastolic function and can be used to estimate LV filling pressures in many instances. Some basic facts about tissue Doppler imaging tracings are that the septal annulus diastolic velocity is less than the lateral annulus velocity in the absence of coronary heart disease/myocardial infarction. A notable exception to this generalization is constrictive pericarditis (annulus paradoxus). There are data concerning normal values for tissue Doppler diastolic velocities, which vary inversely with age; according to data from Tighe et al. the mean tissue Doppler E, obtained from the lateral annulus, in normal individuals aged 60–70 years is 12 ± 3 cm/sec. At the age of 62 years, the velocity shown (13.7 cm/sec) is within the expected range.

19. a. These data show significant systolic and diastolic dysfunction in this patient with symptoms of exertional dyspnea. The strain image demonstrates longitudinal strain. Longitudinal strain can be thought of as the degree of compression of 6 segments of myocardium along the long axis. Normal data from our laboratory indicate that longitudinal strain averages 22% ± 3%. There is regional variation in strain values, with higher values seen in the apical segments. In this example, however, the highest strain values are approximately 14%, which are low and indicative of systolic dysfunction. The values demonstrate the usual apex-to-base gradient, though the values are consistently lower than normal. In addition, what secures the diagnosis of abnormal LV function is the tissue Doppler diastolic findings. The average diastolic velocities for a 43-year-old normal individual should be in the range of 16 ± 4 cm/sec, more than twice as high as what is shown. Thus, the systolic and diastolic data shown indicate abnormalities of systolic and diastolic function. Given that there are no focal wall motion abnormalities, one must suspect a global process, such as infiltrative cardiomyopathy (e.g. amyloidosis), hypertrophic cardiomyopathy, or severe hypertensive heart disease, where some of the dysfunction may be related to high afterload.

20. d. The M-mode shows a classic example of early mitral valve closure which is pathognomonic of acute severe AR. There is also LV dilation and a generous e-point septal separation. The early closure of the mitral valve is caused by the rapid equilibration of LV diastolic pressure and aortic diastolic pressure. Patients with acute severe aortic regurgitation are likely to have evidence of elevated filling pressure and rales. An opening snap is heard in patients with rheumatic mitral stenosis with pliable leaflets. This is not the echocardiogram of such a patient. An apical systolic murmur implies mitral regurgitation and there is no suggestion that this patient has coexisting MR.

21. b. This 56-year-old man presented with symptoms and signs of heart failure. This M-mode echocardiogram is recorded through the mitral leaflet tips (Fig. 22.12). This recording shows significantly increased LV cavitary dimensions in systole and diastole (stippled arrows), a significantly increased e-point septal separation distance (stippled lines), and interrupted AC closure of the mitral valve echo. The findings of this M-mode echocardiogram suggest that very poor systolic performance is present. The LV cavity is dilated and the LV EF is severely reduced. Stroke volume is severely reduced as indicated by the increased e-point septal separation distance (normal <7 mm). The LV end-diastolic pressure is elevated as indicated by the presence of the interrupted AC closure or "b-bump." The mean left atrial pressure, although likely elevated, cannot be derived from the information presented.

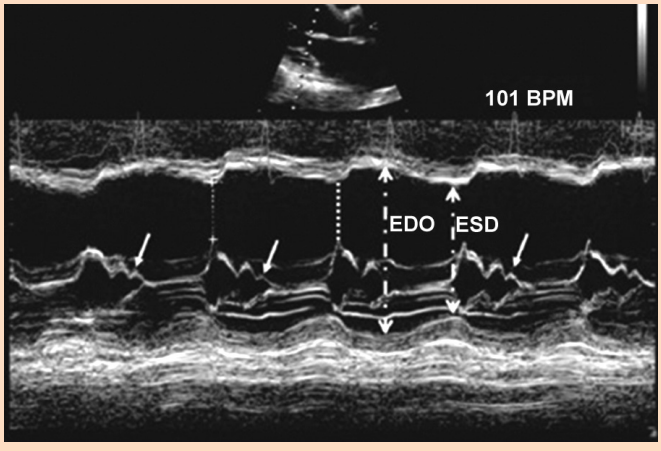


Fig. 22.12

22. c. The right ventricular inflow view in Figure 22.13 illustrates the origin of the coronary sinus in the posterior septal space adjacent to the tricuspid valve leaflet. The Eustachian valve, also known as the right sinus valve or the valve of the IVC, is somewhat prominent in this example. Adjacent to the Eustachian valve is the orifice of the IVC. Also well illustrated in this view are the posterior and anterior leaflets of the tricuspid valve (small stippled arrows). A Chiari complex is derived embryologically from the same structures as the Eustachian valve; however, it would appear as a highly mobile thin filamentous structure. The orifice of the superior vena cava cannot normally be seen in this tomographic imaging plane.

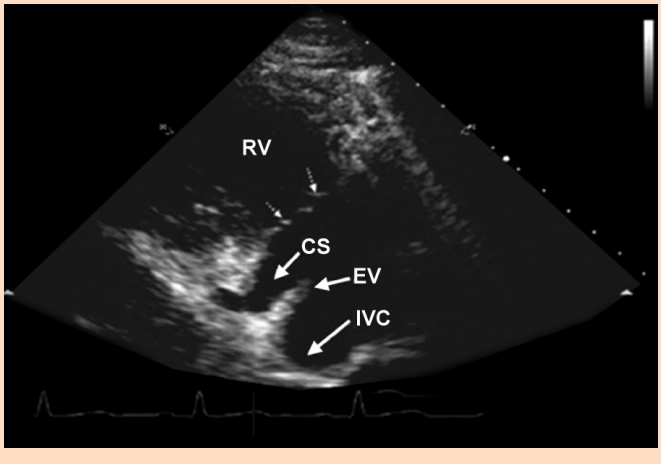


Fig. 22.13

23. a. This M-mode recording of the pulmonary valve illustrates the "flying-W sign". The normal pulmonary valve M-mode is characterized by presystolic a-wave with motion away from the transducer followed by further posterior motion of the valve leaflet during systole. With chronic severe pulmonary hypertension, a characteristic appearance to the M-mode tracing, termed "the flying-W sign," may be generated. This tracing is characterized by the loss of the a-wave (solid arrow) and mid-systolic notching (stippled arrow). With pulmonary valve stenosis, the a-wave is characteristically preserved, or even accentuated, and mid-systolic notching is not observed. In a pure right heart volume load state, such as occurs with primary

tricuspid regurgitation, one would not expect pulmonary hypertension to be present and thus the pulmonary valve M-mode tracing should not be altered significantly. Among patients with acute pulmonary embolism, the level of elevation of the pulmonary artery pressure does not usually exceed 50 mm Hg and thus the M-mode findings of chronic severe pulmonary arterial hypertension would not be expected to be observed.

24. a. This M-mode shows evidence of systolic anterior motion of the mitral valve, a sign that is pathognomonic for hypertrophic obstructive cardiomyopathy (Fig. 22.14). Recent work has shown that 70% of patients with hypertrophic cardiomyopathy have obstruction either at rest or provoked by exercise. In hypertrophic obstructive cardiomyopathy, there is hyperdynamic systolic function, with low levels of wall stress; the LV outflow tract is narrowed in by septal hypertrophy and, in some patients, by anterior displacement of the mitral valve. The posterior systolic motion of the interventricular septum further narrows the LV outflow tract; this results in high LV outflow tract blood velocities, which pull the mitral valve leaflet toward the interventricular septum (Venturi effect). The arrow points to systolic anterior motion of the mitral valve with septal–mitral contact (see Video 3-9).

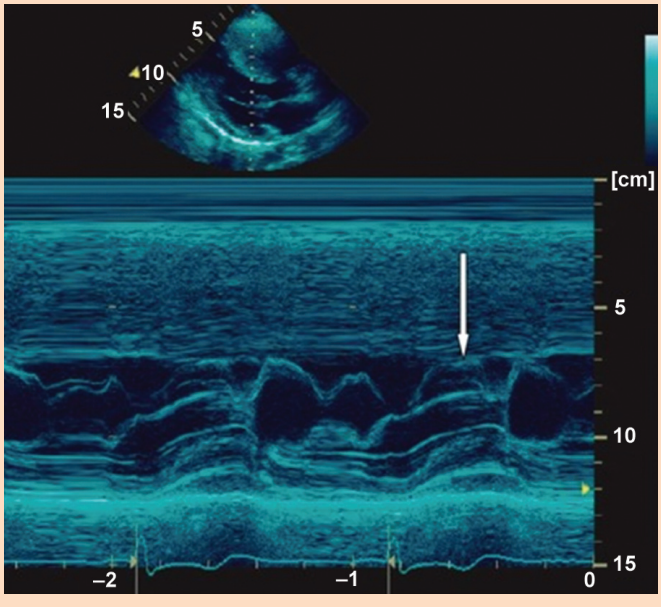


Fig. 22.14

25. c. This M-mode recording illustrates a classic case of a left atrial myxoma prolapsing into the mitral orifice with valve opening (Fig. 22.10, shown in real time on the accompanying Video 3-10). The tumor (Myx) appears as a mass of echoes behind the mitral valve during diastole. Note the echo free space behind the anterior leaflet at the onset of diastole (thin arrows). This occurs because a time lag exists between the early diastolic opening of the valve and when the tumor mass subsequently moves into the mitral orifice. Although the mitral EF slope is diminished significantly (thick white arrow), this recording is not consistent with rheumatic mitral stenosis. The mitral leaflets are not thickened and the posterior leaflet moves normally (black arrow). Findings consistent with the presence of acute severe aortic insufficiency, such as high-frequency diastolic fluttering of the mitral valve or, possibly, the interventricular septum (depending upon jet direction) and premature mitral valve closure,

are not demonstrated. With hypertrophic obstructive cardiomyopathy, increased thickness of the interventricular septum and systolic anterior motion of the mitral apparatus would be expected; these findings are not demonstrated on this M-mode recording (Fig. 22.15).

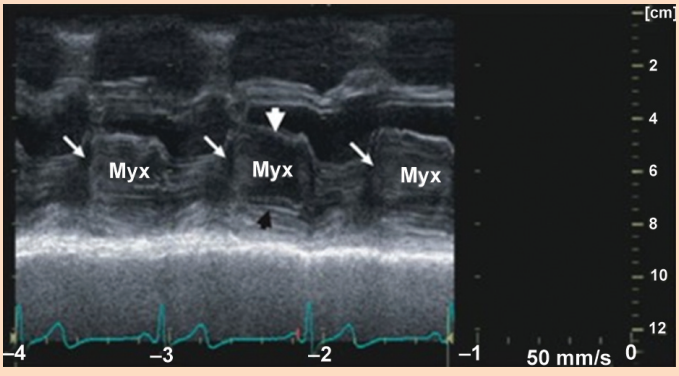


Fig. 22.15

23

3D Echocardiography

1. Early efforts in three-dimensional (3D) imaging required a series of two-dimensional (2D) images. Which method(s) use this approach?
   a. Sparse matrix array
   b. Fully sampled matrix array
   c. Freehand and mechanically driven scanning
   d. Phased array
   e. Pyramidal array

2. Which factors affect the quality of 3D reconstructions derived from 2D images?
   a. 2D image quality, motion artifact, and electrocardiogram (ECG) and respiratory gating
   b. 2D image quality
   c. Image density
   d. ECG and respiratory gating
   e. Image density, gain, persistence, and frame rate

3. Which of the following is currently utilized in 3D imaging?
   a. Sparse matrix array transducer and ECG and respiratory gating
   b. Sparse matrix array transducer and ECG gating
   c. Fully sampled matrix array transducer and ECG and respiratory gating
   d. Fully sampled matrix array transducer, ECG gating, and a breath hold
   e. B and C

4. Assessment of left ventricular (LV) function is pivotal in clinical decision making. Which of the following imaging modes should be used to obtain a 3D volume data set for assessment of LV volume and function?
   a. Live 3D mode (narrow-angled acquisition)
   b. 3D zoom mode
   c. Full-volume mode (wide-angled acquisition)
   d. Biplane imaging mode
   e. Triplane imaging mode

1. c 2. a 3. d 4. c

5. Which of the following statements is true regarding the accuracy and reproducibility of 2D echocardiography (2DE) versus 3D echocardiography (3DE) in regard to assessment of LV volumes?
   a. 3DE has superior accuracy and reproducibility compared with 2DE
   b. 2DE has better accuracy and reproducibility compared with 3DE
   c. Both 2DE and 3DE have similar accuracy and reproducibility
   d. Both 2DE and 3DE have similar accuracy and but differ in reproducibility
   e. All of the above are incorrect
6. What is the primary reason influencing the difference in accuracy observed between 2DE and 3DE?
   a. Image quality is better with 3DE
   b. Frame rate is higher with 3DE
   c. Quantitative methods used result in improved accuracy with 3DE
   d. Less artifacts with 3DE
   e. Ability to obtain a true long-axis in a 3D volume data set
7. Left atrial volume reflects the long-term effects of high left atrial pressure, severity of diastolic dysfunction, and is a predictor of mortality and outcome. Which quantitative method has the best test-retest variability?
   a. M-mode echocardiography
   b. Prolate ellipsoid
   c. Biplane Simpson's
   d. Area-length method
   e. 3DE
8. Which statement pertaining to 3D assessment of the right ventricle (RV) is correct?
   a. Quantitation of RV function by 3DE is an online program using method of discs
   b. Quantitation of RV volumes is accurate and reproducible using method of discs
   c. Quantitation of RV volumes is a widespread application since it is most accurate and reproducible
   d. Quantitation of RV volumes involves geometric modeling and mathematical equations easily performed off-line
   e. Quantitation of RV volumes is similar to LV assessment using a bullet-shaped geometric model
9. What factor is primarily responsible for making quantitative assessment of the RV so challenging?
   a. The shape of the tricuspid valve annulus
   b. The presence of the moderator band
   c. The shape of the right ventricular cavity
   d. The interdependence of the LV and RV
   e. Heavy trabeculation of the RV
10. Why is the diagnosis of mitral valve prolapse established only in the long-axis view?
   a. Based on 2DE studies, the long-axis view is most sensitive in visualizing prolapse
   b. Based on 2DE studies, the four-chamber and two-chamber views are less sensitive but more specific in visualizing prolapse
   c. Based on 3DE studies, since the mitral valve annulus is planar, the mitral leaflets ascend above the annulus the most in a long-axis view
   d. Based on 3DE studies, since the mitral valve annulus is nonplanar, the mitral leaflets can ascend above the annulus in a four-chamber view
   e. The mitral valve annulus, leaflets, and papillary muscles are best seen from a long-axis view

5. a 6. e 7. e 8. b 9. c 10. d

11. What is the mechanism of mitral regurgitation in patients with chronic ischemia?
    a. Typically, there is anterior mitral leaflet displacement
    b. There is elongation of chordae tendineae
    c. There is tethering of the posterior leaflet due to displacement of the posteromedial papillary muscle and an increase in the anterior-posterior annular perimeter
    d. There is equal mitral annular dilatation due to increased interventricular pressure
    e. There is bilateral displacement of the papillary muscle

12. 3DE has been recommended as the new standard for measurement of mitral valve area in patients with mitral stenosis. Which statement pertaining to measurements (quantification) of mitral valve area is correct?
    a. 3DE has more accurate and reproducible measurements because the 2D cut plane can be obtained and placed en-face to the mitral valve orifice
    b. 3DE is accurate but not as reproducible as 2D planimetry because of plane angulations
    c. 3DE is not as accurate but reproducible compared with 2D planimetry because of the effect of thresholding and opacification used
    d. 3DE is as accurate as 2D planimetry but not as reproducible compared to the flow convergence method
    e. 3DE is as accurate as 2D planimetry but not as reproducible as the pressure half-time method

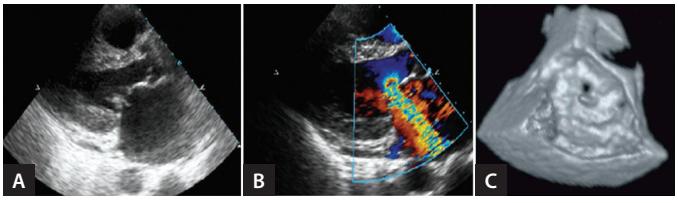
13. Which modality is most accurate and reliable to use for measuring the mitral valve orifice area after balloon mitral valvuloplasty for mitral stenosis?
    a. Pressure half-time
    b. Flow convergence method
    c. 2D planimetry
    d. 3D planimetry
    e. Continuity equation

14. Advantages of 3D echocardiographic assessment of an atrial septal defect (ASD) include:
    a. En-face view of the ASD and accurate assessment of the size, shape, and location of the defect and surrounding rim
    b. En-face view of the ASD and assessment of only the size and shape of the defect
    c. En-face view of the ASD and the relationship to other structures
    d. Ability to observe the ASD from different orientations
    e. Ability to measure the defect from both right and left atrial perspectives

15. Which statement is correct pertaining to contrast 3DE?
    a. Contrast 3DE has been extensively used to evaluate myocardial perfusion
    b. Contrast 3DE is easily performed with or without triggered imaging
    c. Contrast 3DE can be used to evaluate the volume of left atrial masses
    d. Contrast 3DE is performed using only agitated saline
    e. Contrast 3DE has been used to improve LV volume and ejection fraction quantitation

16. A 52-year-old man presents with a history of tricuspid valve endocarditis due to intravenous drug use. He is status post-treatment 3 months ago and now presents with fevers and congestive heart failure. On presentation, he was noted to have a 3/6 holosystolic murmur at the left sternal border radiating to the axilla (Figs 23.1A to C)
    Based on this finding you conclude:
    a. There is a posterior leaflet vegetation with mitral regurgitation.
    b. There is an anterior leaflet perforation with significant mitral regurgitation.

11. c 12. a 13. d 14. a 15. e 16. b

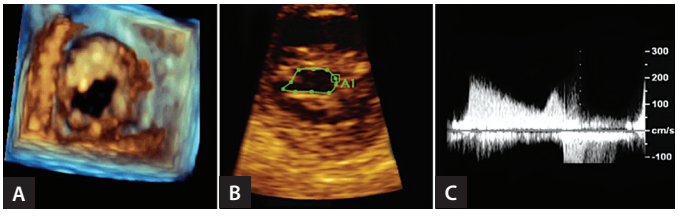


Figs 23.1A to C

c. There is a posterior leaflet perforation with significant mitral regurgitation
d. There is a ruptured chordae with mitral regurgitation
e. There is a flail mitral leaflet with significant regurgitation

17. What would you do next?
    a. Continue with medical management and follow-up with serial echocardiograms
    b. Continue antibiotic therapy and follow-up with serial transesophageal echocardiograms
    c. Ask your interventionalist to close this percutaneously
    d. Ask for a surgical consultation for mitral valve repair
    e. Discharge to drug rehabilitation, continue medical therapy, and arrange for follow-up in clinic

18. A 35-year-old woman from Guatemala has a history of rheumatic fever as a child, had balloon valvuloplasty when she was a teenager, and has not had follow-up since her arrival to the United States. She does not complain of shortness of breath with housework (Figs 23.2A to C)



Figs 23.2A to C

Her echocardiogram shows the following (Fig. 23.2):
    a. Mitral valve prolapse and significant mitral regurgitation
    b. Normal opening of the mitral valve consistent with successful balloon valvuloplasty
    c. Decreased opening of the mitral valve leaflets due to low flow
    d. Decreased mitral valve opening due to restenosis
    e. Severe mitral stenosis with atrial fibrillation

19. The mitral valve orifice area measured by 3D planimetry demonstrated a mitral valve area of 1.4 cm^2 with a mean mitral valve gradient of 5 mm Hg. The right ventricular systolic pressure was 40 mm Hg. Since she does not complain of dyspnea with housework but typically tries not to exert herself, what is your next choice of management?
    a. Start amiodarone since she probably has atrial fibrillation as a cause of shortness of breath
    b. Place her on warfarin (Coumadin) since she probably has atrial fibrillation
    c. Inform her that she needs another balloon mitral valvuloplasty
    d. Inform her that she will need a mitral valve repair
    e. Schedule a stress echo to demonstrate an increase in mitral valve gradient and right ventricular systolic pressure during exercise

17. d 18. d 19. e

20. A 60-year-old man with a history of hypertension and hypercholesterolemia has a routine follow-up with a new primary care physician who hears a holosystolic murmur at the apex radiating to the axilla on examination. The patient did not have a history of fever, weight loss, recent trauma to the chest, or rheumatologic illness. He noted difficulty working in his garden because of fatigue. At the end of the visit, he remembered that on a previous health physical for the Army he was told that he had a murmur. A transthoracic echocardiogram revealed severe mitral regurgitation but was unable to elucidate the mechanism of mitral regurgitation. After being referred to a cardiologist, a 2D and 3D TEE (transesophageal echocardiogram) was performed.

    Figure 23.3 is a view from a left atrial perspective demonstrating the mitral valve from a surgeon's view. (Ao = Aorta; LAA = Left atrial appendage.)

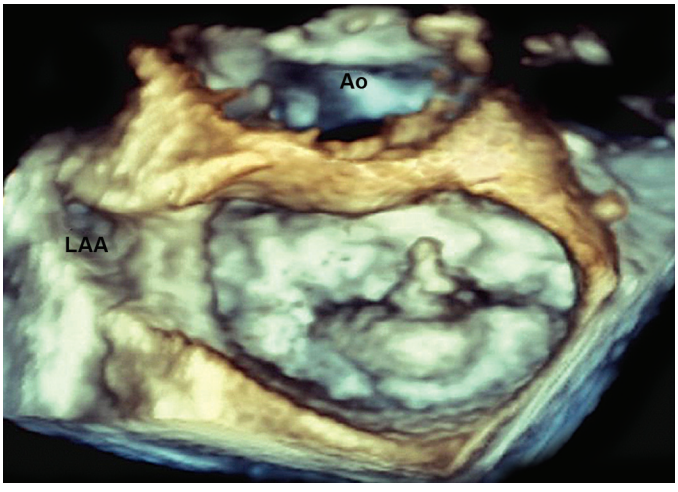


Fig. 23.3

    Which segment of the mitral valve is the cause of the mitral regurgitation?
    a. A1
    b. A2
    c. P1
    d. P2
    e. P3

21. What is the mechanism of mitral regurgitation in this patient?
    a. Bacterial endocarditis with a vegetation on the P2 scallop
    b. Barlow disease
    c. Rheumatic heart disease
    d. SLE (systemic lupus erythematosis) with P2 Libman-Sacks lesion
    e. Flail P2 scallop

22. A 75-year-old woman with a history of a mitral valve replacement, hypertension, and hypercholesterolemia presents with progressive shortness of breath, lower extremity edema, and palpitations. She has been faithfully taking all her medications including Coumadin. Her blood pressure is 180/100 mm Hg, heart rate is 100 bpm, and on auscultation, she has loud mechanical heart sounds and a 2/6 murmur that is nonradiating at the apex.

20. d 21. e

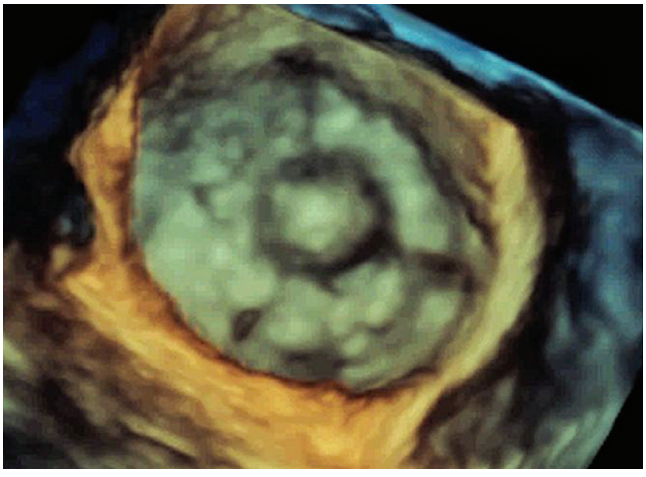


Fig. 23.4

From the TEE demonstrated in Figure 23.4, what type of mechanical valve does she have?

a. Bioprosthetic valve
b. Homograft
c. Ball-Cage valve
d. Single tilting disc valve
e. Bileaflet tilting disc valve

23. After giving her furosemide, a beta-blocker, and angiotensin-converting enzyme inhibitor, her blood pressure is 120/80 mm Hg and heart rate is 65 bpm. She still has lower extremity edema and feels breathless vacuuming. Reviewing her echocardiogram again, she has a mean mitral valve gradient of 4 mm Hg and mitral regurgitation (Fig. 23.5).

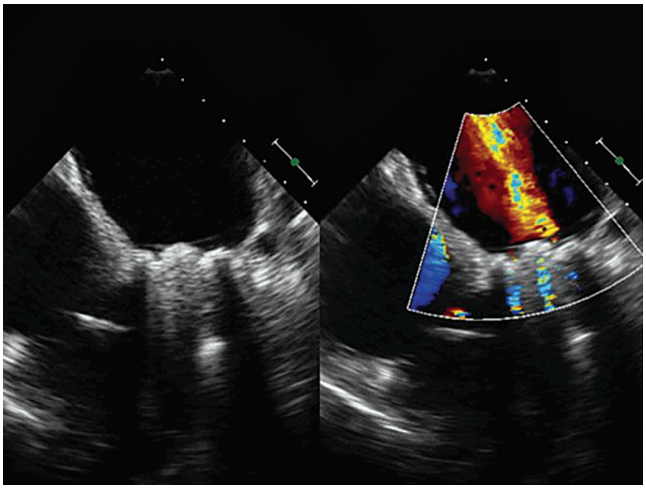


Fig. 23.5

22. c

What do you decide to do next?

a. Increase her doses of diuretics and beta-blocker
b. Increase anticoagulation and consider heparin therapy
c. Add high-dose statin therapy
d. Thrombolytics
e. Mitral valve replacement

24. A 60-year-old man has a history of mitral valve prolapse and severe mitral regurgitation. He does not admit to having symptoms and tells you that his wife told him to go to the physician's office. She notices that he is more sedentary and does not walk as fast as he used to. On auscultation, he has a 3/6 murmur at the apex radiating to his axilla and back with an absent S1 and loud P2 component. He has severe mitral regurgitation by transthoracic echocardiogram. Because of poor acoustic windows on TTE study, he agrees to a TEE. A 3D image of the mitral valve as visualized from a left atrial perspective is shown in Figure 23.6. (AV = Aortic valve.)

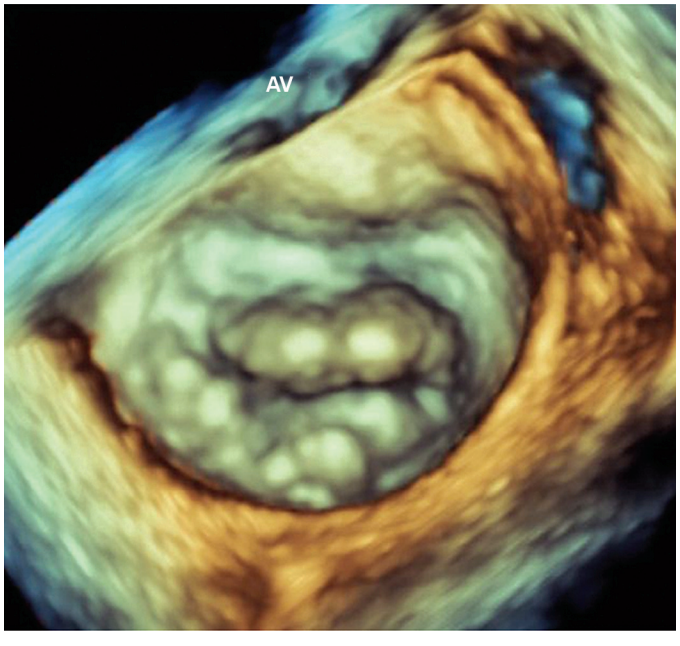


Fig. 23.6

What are your findings?

a. There is mitral stenosis
b. There is a P2 scallop flail
c. There is A2 and P2 prolapse
d. There is multiscallop prolapse including A2, A3, P2, P3 and the medial commissure
e. There is multiscallop prolapse including A1, A2, P2, P1 and the lateral commissure

23. e 24. d

25. A 40-year-old man with a dilated cardiomyopathy had improvement in his symptoms after undergoing mitral valve surgery 6 months ago. He had improved exercise tolerance after the surgery but now presents with breathlessness going up a flight of stairs, lower extremity edema, and coughing that wakes him during the night. On echocardiogram, you find that he has severe mitral regurgitation and a vague echodensity that appears like calcification. A 3D TEE is shown from a left atrial perspective in Figure 23.7. (Ao = Aorta.)

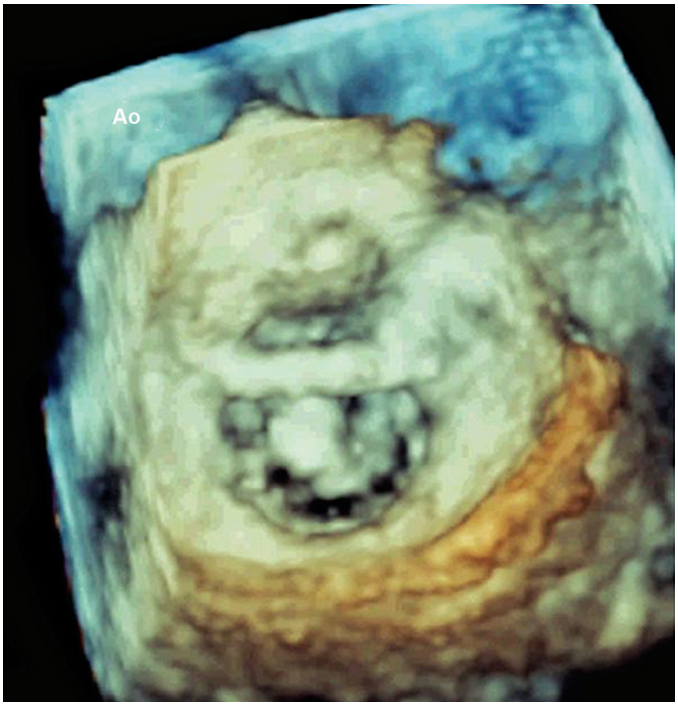


Fig. 23.7

What are your findings?

a. There is a complete dehiscence of the mitral valve annuloplasty ring from the posterior mitral annulus
b. There is endocarditis of the mitral valve ring
c. There is a single tilting disc valve
d. There is a bileaflet tilting disc valve
e. There is a bileaflet tilting disc valve with significant mitral valve dehiscence

25. a

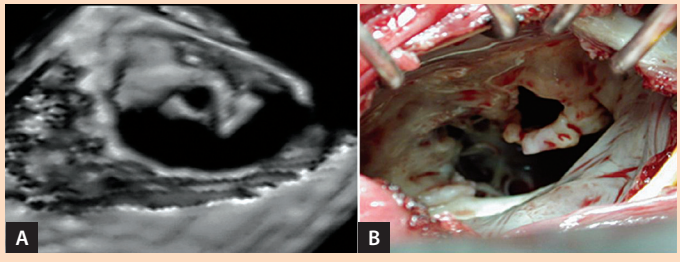
Answers

1. c. Three-dimensional echocardiography (3DE) has evolved over several decades since the 1970s. Initial 3D echocardiographic methods of acquiring a 3D volume required multiple two-dimensional (2D) images obtained with either freehand scanning or a mechanically driven transducer and typically gated to the ECG. Freehand scanning is achieved by collecting a series of 2D images along a fixed plane. A spatial locator coupled with a commercially available transducer determines the 3D location onto a Cartesian coordinate system. These locators can be either a spark gap system or an electromagnetic field. A mechanically driven transducer obtains multiple images at a fixed window and set intervals in a parallel, rotational, or fanlike manner. These images are then converted into a Cartesian coordinate system for further analysis.
2. a. The quality of a 3D reconstruction using multiple 2D images depends on the quality of the 2D images and the ability to avoid motion during acquisition by either the operator or the patient. ECG and respiratory gating were also essential in ensuring the location in time and space. Hence, patients with atrial fibrillation or irregular heartbeats were usually excluded in studies. The data integrity in such patients could not be ensured.
3. d. The first volumetric scanner was introduced by von Ramm. This scanner was a sparse array transducer consisting of 256 elements firing non-simultaneously. The resolution was poor, frame rates were low, and the sector angle was narrow (60 degrees) and resulted in 2D cut-planes in a 3D volume. The current volumetric transducer called the fully sampled matrix array transducer has a smaller footprint, improved image quality, higher frame rates, better penetration, and harmonic capabilities. It is able to display 2D images, perform bi- or triplane imaging, acquire true real-time 3D images; and in some probes, pulse and continuous wave Doppler.
4. c. The real-time three-dimensional (RT3D) imaging modes are (1) live 3D or narrow-angle acquisition, (2) zoom mode, and (3) full-volume mode or wide-angle mode. If the region of interest is small, such as valves, small cardiac masses or the interatrial septum, a zoom mode of acquisition should be used. For cardiac chambers, a full-volume or wide-angle acquisition mode is the preferred method since it will allow inclusion of the entire chamber.
5. a. Three-dimensional echocardiography has repeatedly been shown to be superior to two-dimensional echocardiography (2DE) when compared with cardiac magnetic resonance imaging as a gold standard. Specifically, real-time three-dimensional echocardiographic studies have demonstrated less variability in repeated measurements (intra- and interobserver variability), which is explained by the ease of obtaining a common long-axis in 3D volume data. Image alignment is pivotal in the accuracy of 2D quantitation of LV volumes. Although both 2DE and 3DE underestimate LV volumes, underestimation occurs mostly when using 2DE methods for quantitation (Biplane Simpson's Method or method of discs).
6. e. The primary difference in accuracy between 2DE and 3DE is the ability to obtain a true long-axis in two orthogonal planes from a 3D volume data set. Foreshortening is a ubiquitous problem in traditional 2DE, frequently occurring in a two-chamber view. This difference in long-axis length leads to underestimation seen in both LV mass and LV volume measurements. Certainly, quantitative methods may also influence the accuracy; however, this is not well established. When the 3DE biplane use of method of discs was compared to online automated border detection software, there was higher accuracy and less underestimation with automated border detection. However, in another study comparing online and off-line 3D software, there was higher accuracy with off-line 3D software due to greater user interaction in drawing endocardial borders and less interpolation.
7. e. Three-dimensional echocardiography has the lowest test-retest variability compared with other methods, making it the best modality to use for serial follow-up of patients long term.
8. b. The right ventricle (RV) has been described as a crescent-shaped ventricle not easily conforming to any geometric shape. Therefore, its quantitative assessment is very difficult.

Right ventricle imaging has previously required a reconstructive 3D method using either rotation or a freehand approach, but currently real-time 3DE is the method of choice. Most efforts in quantitation of the RV have utilized the method of discs. This method results in accurate and reproducible assessment. Off-line assessment using a rotational approach and automated border detection has also been proven to be accurate but does not have widespread use.

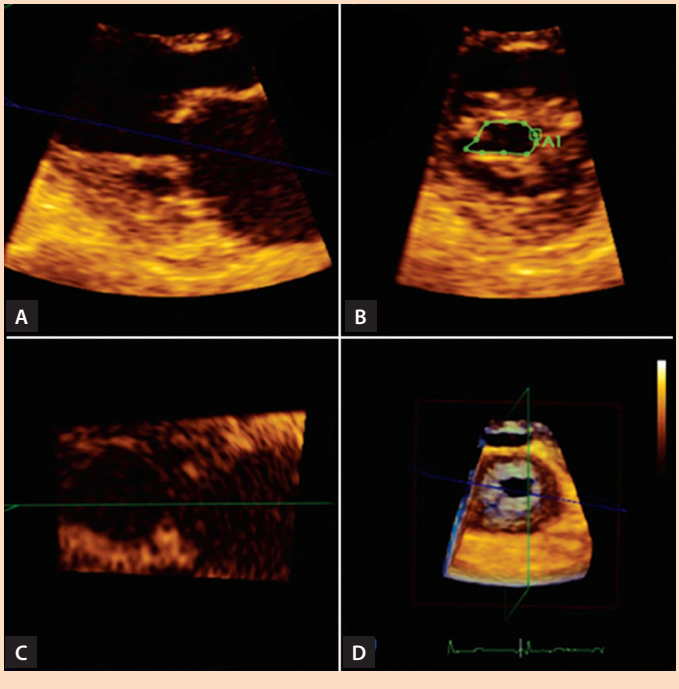
9. c. The shape of the RV does not conform to any known geometric shape. The tricuspid annulus is not on the same level with the pulmonary valve which also makes it challenging when determining the last basal slice.
10. d. The true structure of the mitral valve annulus was revealed in large part on the basis of 3D studies. With this in-depth analysis of the mitral valve, we now understand that the anterior and posterior mitral valve annular points are higher than the medial and lateral mitral annulus. Hence, leaflets in the four-chamber view appear to rise above the mitral annulus even in absence of prolapse. This seminal study changed the diagnosis of mitral valve prolapse.
11. c. Chronic ischemia leads to distortion of the left ventricle, particularly, displacement of the posteromedial papillary muscle that leads to tethering of the posterior mitral leaflet. There is also evidence of an increase in the anterior-posterior annular perimeter. Three-dimensional reconstructions performed in animal studies have led to a better understanding of the mechanism of ischemic mitral regurgitation.
12. a. Measurement of mitral valve area in patients with rheumatic mitral stenosis is more accurate and has less variability with 3DE compared with conventional 2D methods using the invasive Gorlin equation as the reference standard. Generally, 3DE underestimates the valve area whereas 2DE overestimates the valve area. The advantage of 3DE is that the cut-plane can be angulated, adjusted, and placed at the tips of the mitral leaflets en-face to the mitral orifice. Two-dimensional valve area planimetry is highly dependent on the imaging plane obtained by the operator.
13. d. In patients post–balloon mitral valvuloplasty, 3DE measurements of the mitral valve orifice are more accurate and reliable compared with the pressure half-time method and 2D planimetry. A continuity equation should not be used in the setting of coexisting aortic or mitral regurgitation, as the latter is usually a complication of valvuloplasty.
14. a. Three-dimensional echocardiography has clear advantages over 2DE since it provides unique en-face views of the atrial septal defect (ASD), accurate measurements of size and surrounding rim, and location of defect. Studies have shown, ASD shape varied from being round, to oval, and racquet-shaped with a variation of 68% in size during the cardiac cycle. Three-dimensional echocardiography has also played a role in sizing of ASDs for closure. It has been demonstrated that 3D measurements are more accurate than 2D measurements and there is less underestimation of size when compared to balloon stretched diameters.
15. e. A triggered acquisition seems to increase the signal-to-noise ratio and a continuous infusion of contrast is probably better than an injection. Its use is not widespread probably due to the cost and difficulty with administration of continuous infusion of contrast during 3D acquisition. The detection of perfusion abnormalities using 3DE and contrast has been limited to animal studies and has been used only in a limited number of cases.
16. b. This patient has an anterior leaflet perforation with severe mitral regurgitation through the perforated leaflet. In the parasternal long-axis view, there is a discontinuity of the anterior leaflet with a mobile echodensity in proximity to the perforation, which could be part of the leaflet or vegetation. On the reconstructed 3D image, there is a large area of perforation of the anterior leaflet seen from a left atrial perspective.
17. d. The class I indications for mitral valve surgery in the setting of endocarditis include severe mitral regurgitation resulting in heart failure, mitral regurgitation with evidence of elevated LV end-diastolic or left atrial pressure, or moderate/severe pulmonary hypertension, fungal or

highly resistant organisms causing endocarditis, or those complicated by heart block, abscess, or destructive lesions (e.g. sinus of Valsalva to right atrium, RV or left atrium fistula; mitral leaflet perforation; or infection in the annulus fibrosa). Severe mitral regurgitation with heart failure and a perforated leaflet were indications for surgery in this patient. Three-dimensional echocardiographic findings were confirmed with intraoperative surgical pathology (Figs 23.8A and B).



Figs 23.8A and B

18. d. This patient has moderate mitral stenosis with a moderate transmitral gradient. Figures 23.9A to D is a view of the mitral valve from a LV perspective. There is doming of the anterior mitral leaflet with medial and lateral commissural fusion. Using multiplanar reconstruction, a 2D cut-plane can be placed at the tips of the mitral leaflet en-face to the valve opening to derive a mitral valve area. In this case, the mitral valve orifice area was 1.4 cm^2.



Figs 23.9A to D

19. e. This patient with mitral stenosis has a valve area of ≤1.5 cm^2 with a gradient of 5 mm Hg and mild pulmonary hypertension. In asymptomatic moderate mitral stenosis, there is an indication to perform stress echo testing to evaluate a rise in mean mitral valve gradients or an increase in pulmonary pressures of >15 mm Hg or >60 mm Hg. If patients have valve morphology amenable to valvuloplasty and meet these criteria then there is an indication for percutaneous balloon mitral valvuloplasty.
20. d. The abnormal scallop in this case is the P2 scallop. The P2 scallop is most frequently affected and is typically across from the aorta (Fig. 23.10). (Ao = Aorta; LAA = Left atrial appendage.)

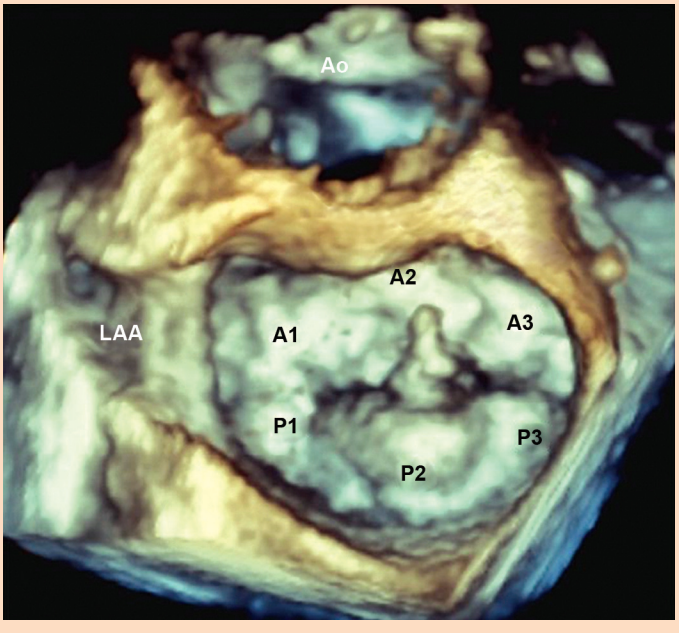
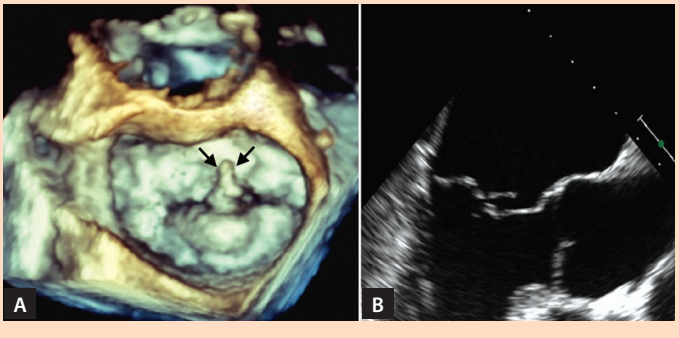


Fig. 23.10

21. e. This is a P2 scallop that is flail (Figs 23.11A and B). The tip of the ruptured chordae can be seen from this left atrial perspective, noted by the arrows.



Figs 23.11A and B

22. c. This is a Ball-Cage valve. Figure 23.12 demonstrates the ball moving up above the annulus in systole.

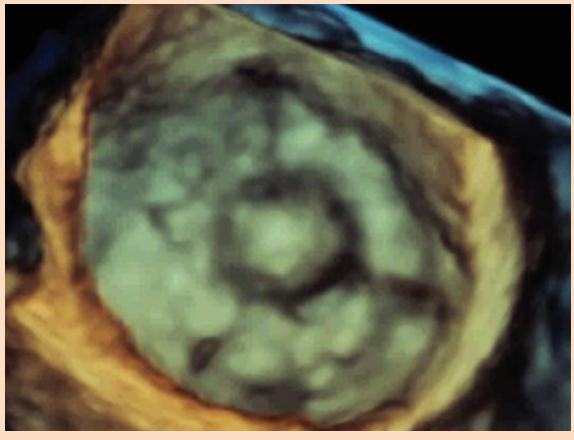


Fig. 23.12

23. e. Since the patient's symptoms persist even with maximum medical therapy, mitral valve replacement is advised. The patient takes Coumadin regularly with a therapeutic INR and her symptoms are progressive which indicates that this is probably not an acute event such as valve thrombosis. The most likely problem since she has had this valve for many years is pannus. On echocardiogram, she has mitral regurgitation that is significant. Typically, there is only a small amount of physiologic mitral regurgitation with a Ball-Cage valve due to the movement of the ball upward toward the left atrium.

24. d. Besides the multisegmental prolapse and the medial commissural involvement, there is calcification over the P2 scallop noted by the arrow (Fig. 23.13). (AV = Aortic valve; C = Commissure.)

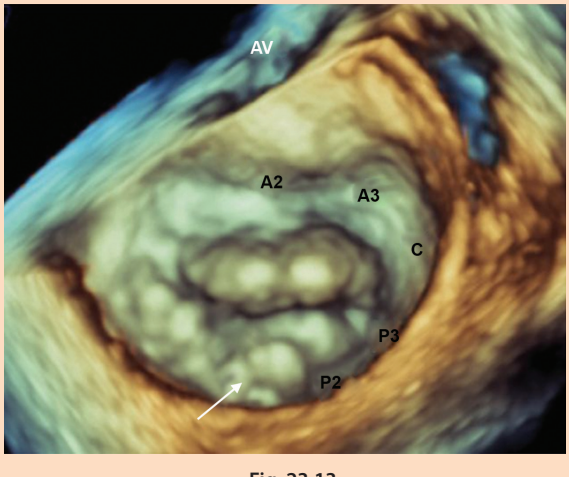


Fig. 23.13

25. a. There is complete dehiscence of the mitral valve ring from the posterior mitral annulus, but the ring is still attached at the fibrous trigone from this left atrial view.

24

Echocardiography Using TEE Probe

1. Which of the following left atrial appendage (LAA) emptying velocities are associated with stroke in patients with atrial fibrillation?
   a. >50 cm/sec
   b. <2 m/sec
   c. 20 mm/sec
   d. <20 cm/sec
   e. None of the above
2. The sensitivity of transesophageal echocardiography (TEE) for acute ascending aortic dissection is:
   a. 100%
   b. 80–89%
   c. >95%
   d. 75–80%
   e. Better compared to descending thoracic dissections
3. The specificity of TEE for all aortic dissections is:
   a. 100%
   b. 50%
   c. ≥75%
   d. >90%
   e. As good as transthoracic echocardiography (TTE)
4. The most consistent method to visualize the right pulmonary veins by TEE is:
   a. Transducer array set at 0–30 degrees and rotate probe to the right
   b. Transducer array set at 90–130 degrees and rotate probe to the right
   c. Transducer array set at 0–30 degrees and rotate probe to the extreme left
   d. Transducer array set at 45–60 degrees with clockwise probe rotation
5. The most consistent method to visualize the left pulmonary veins by TEE is:
   a. Transducer array set at 90–100 degrees and rotate probe to the right
   b. Transducer array set at 110–140 degrees and counterclockwise rotation
   c. Transducer array set at 0–30 degrees and rotate probe to the extreme left
   d. Transducer array set at 45–60 degrees and rotate probe to the extreme right

1. d. 2. c 3. c 4. d 5. b

6. The transverse sinus is:
   a. A pericardial reflection between the posterolateral left ventricular wall, the left atrium, and the right pulmonary vein
   b. A pericardial reflection between the left atrium and great vessels
   c. A pericardial reflection between the right atrium and right ventricle
   d. The posterior sinus in bicuspid aortic valves
   e. The proximal portion of the coronary sinus

7. Aortic valvular gradients are best obtained using TEE in which is view?
   a. Midesophageal window with anterior flexion
   b. Midesophageal window with retroflexion
   c. Deep transgastric window at 30 degrees with retroflexion
   d. Deep transgastric window at 0 degree with anteflexion

8. Which of the following is considered an inappropriate use of TEE?
   a. Evaluation of a patient with atrial fibrillation/flutter for left atrial thrombus or spontaneous contrast when a decision has been made to anticoagulate and not to perform cardioversion
   b. Evaluation of a patient with atrial fibrillation/flutter to facilitate clinical decision making with regards to anticoagulation and/or cardioversion and/or radiofrequency ablation
   c. Guidance during percutaneous noncoronary cardiac interventions including septal ablation in patients with hypertrophic cardiomyopathy, mitral valvuloplasty, patent foramen ovale/atrial septal defect (PFO/ASD) closure, and radiofrequency ablation
   d. Persistent fever in a patient with an intracardiac device

9. Which of the following statements is correct about TEE findings in patients with atrial fibrillation?
   a. Cardioversion can be safely performed off anticoagulation if TEE is negative for thrombus
   b. Spontaneous echo contrast is common and does not offer independent prognostic value
   c. Spontaneous echo contrast is highly associated with previous stroke or peripheral embolism in patients with atrial fibrillation
   d. Surgical ligation excludes flow into the left atrial appendage in >90% of the cases

10. The differential diagnosis in patients with suspected aortic valve endocarditis includes:
    a. Lambl's excrescences, Arantius nodules, fibroelastoma, and Tebessian nodules
    b. Chiari strands, unicuspid raphe, fibroelastomas, and fibromas
    c. Lambl's excrescences, Arantius nodules, and fibroelastomas
    d. Ruptured chordi, Arantius nodules, and eustachian valve

11. The relative risk of stroke in patients with aortic arch atheroma >4 mm is:
    a. >2.0 times even after correction for other risk factors
    b. Not significant after adjusting for atrial fibrillation and carotid disease
    c. <2 times if you correct for atrial fibrillation, carotid disease, and peripheral artery disease
    d. Only significant in patients with coronary artery disease

12. The distal ascending aorta is difficult to be visualized by TEE for what reason?
    a. The esophagus is to the right of the distal ascending aorta
    b. Interference from the trachea
    c. The esophagus is too close to the ascending aorta
    d. None of the above

6. b 7. d 8. a 9. c 10. c 11. a 12. b

13. Which of the following statements is correct regarding methemoglobinemia occurring after benzocaine topical anesthetic for TEE?
    a. Oxygen saturation is low, and arterial PO_2 is normal and there is no cyanosis
    b. There is no cyanosis, low oxygen saturation, and low arterial PO_2
    c. There is cyanosis, low oxygen saturation, and normal arterial PO_2
    d. The treatment of choice is 100% oxygen

14. When encountering resistance to insertion of the TEE probe in the midesophagus, which of the following maneuvers is recommended?
    a. Withdraw the probe to the mouth and reinsert
    b. Withdraw the probe slightly, anteflex, and try again to advance the probe forward
    c. Withdraw the probe slightly, retroflex, and try again to advance the probe forward
    d. Withdraw the probe and recommend an endoscopy

15. Which of the following is an absolute contraindication for TEE?
    a. Prothrombin time/International normalized ratio PT INR level of 4.9
    b. Cervical arthritis
    c. Hiatal hernia
    d. Esophageal varices
    e. Uncooperative patient

16. What is the main pathologic finding in this midesophageal view is (Fig. 24.1)?

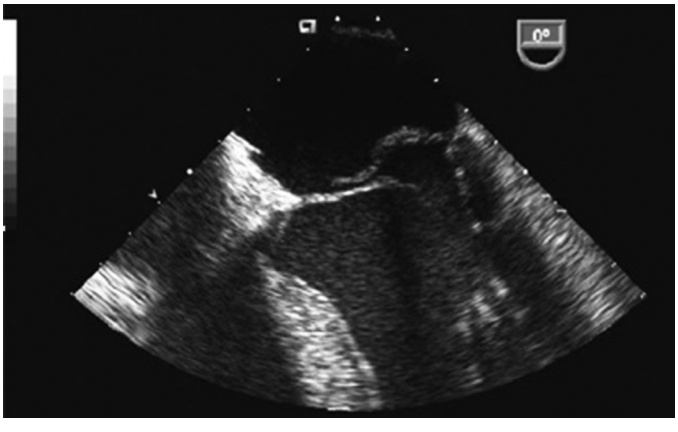


Fig. 24.1

    a. Bileaflet mitral valve (MV) prolapsed
    b. Large vegetation
    c. Systolic anterior motion of the mitral valve
    d. Flail posterior mitral valve leaflet

17. The pulmonary vein flow from the prior patient is consistent with (Fig. 24.2):
    a. Large atrial reversal secondary to increased left ventricular end diastolic pressure (LVEDP)
    b. Mild mitral regurgitation
    c. Severe mitral regurgitation
    d. Mitral stenosis

13. c 14. c 15. e 16. d 17. c

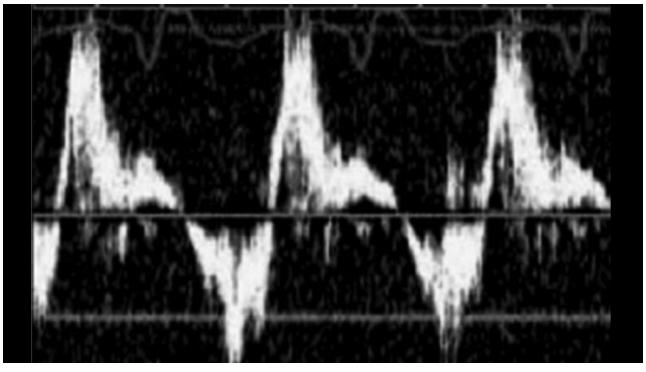


Fig. 24.2

18. This short axis of the aortic valve shows (Fig. 24.3):

Fig. 24.3

a. Bicuspid aortic valve
b. Lambl's excrescence
c. Fibroelastoma of the left coronary cusp
d. Fibroelastoma of the noncoronary cusp

19. What is the finding in this patient with back pain (Fig. 24.4)?
a. Ascending aorta with intramural hematoma
b. Descending aorta with intramural hematoma
c. Descending aorta dissection with pericardial effusion
d. Descending aorta dissection with left pleural effusion

18. d 19. d

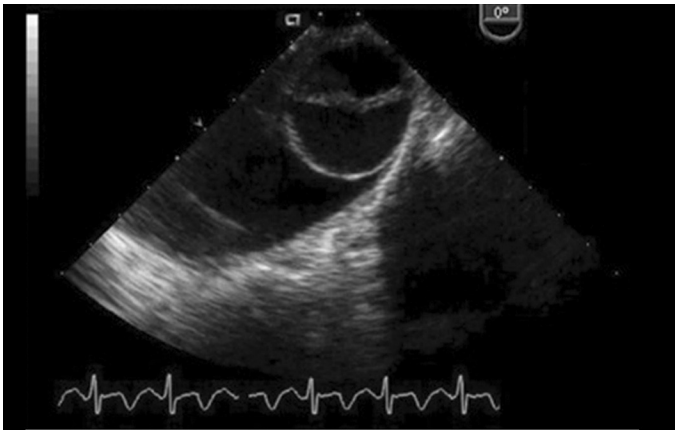


Fig. 24.4

20. What is the main finding in this biplane view of the LAA in Figure 24.5?

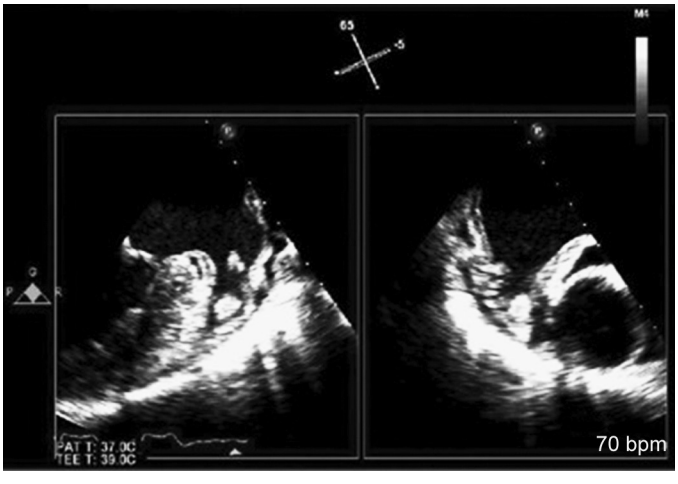


Fig. 24.5

a. Spontaneous echo contrast
b. Spontaneous echo contrast with prominent pectinate muscles
c. Normal left atrial appendage
d. Multiple left atrial thrombi

21. Which of the following statements is correct regarding the findings seen in Figures 24.6A and B?
a. It is the most common benign tumor of the heart
b. It is usually attached to the interatrial septum
c. Surgery is the treatment of choice
d. All of the above

20. d 21. d

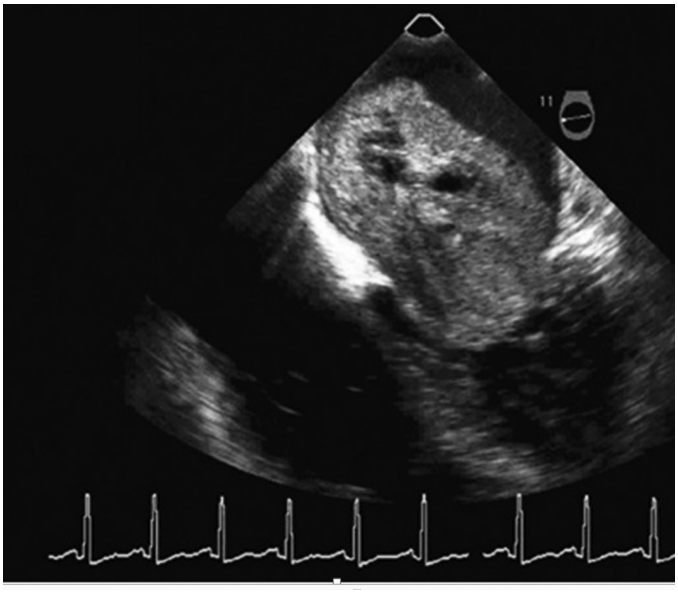


Fig. 24.6A

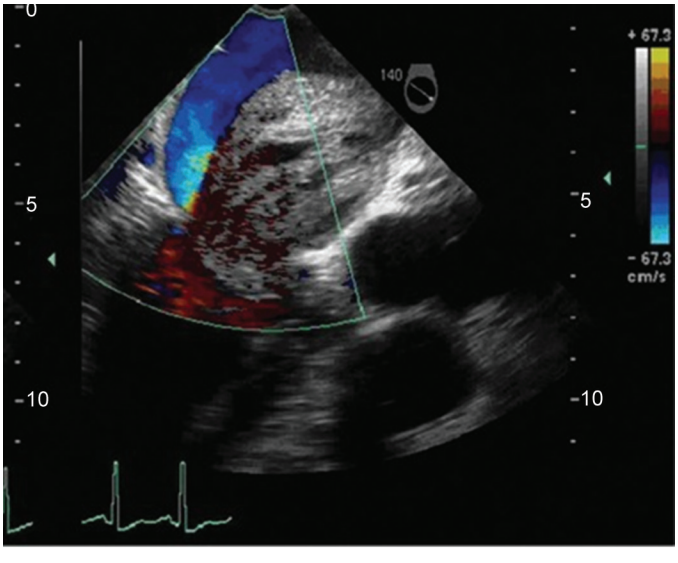


Fig. 24.6B

22. Which of the following structures is visualized in Figure 24.7?

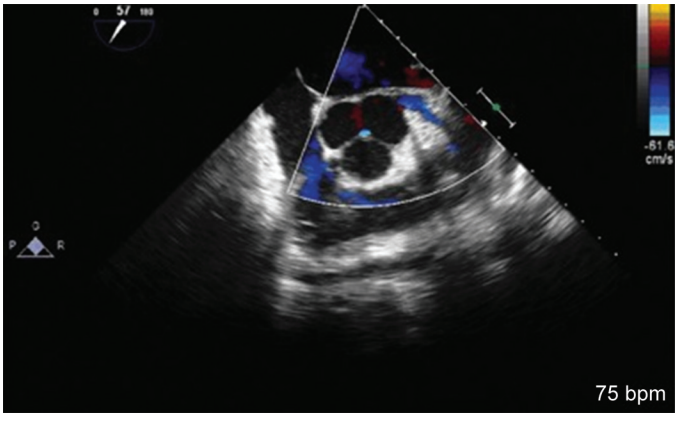


Fig. 24.7

a. Right coronary artery
b. Periaortic abscess
c. Anomalous origin of the left main coronary artery
d. Normal left main trunk

23. The abnormality of the aortic valve seen in Figure 24.8 is consistent with:
a. Rheumatic aortic valve disease
b. Normal bioprosthetic valve
c. Bicuspid aortic valve
d. Unicuspid aortic valve

Fig. 24.8

22. d 23. d

24. This color Doppler image of the pulmonary vein bifurcation (angle—110 degrees) most likely represents (Fig. 24.9):

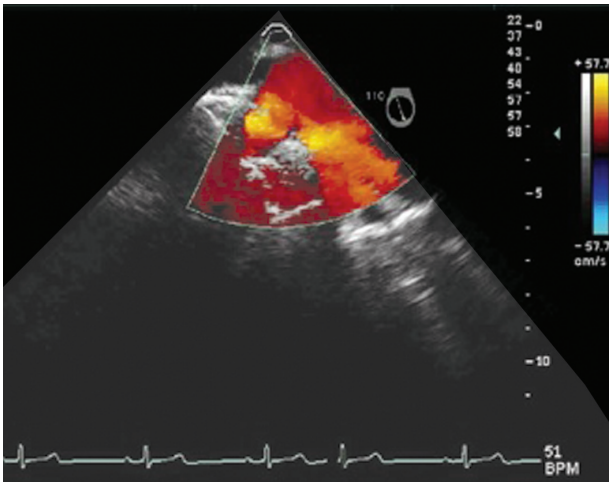


Fig. 24.9

a. The left pulmonary veins
b. The right pulmonary veins
c. The right upper and left upper pulmonary veins
d. The right lower and left lower pulmonary veins

25. Figures 24.10A and B were acquired minutes apart. What is the most likely explanation for the difference?

a. Phenylephrine infusion
b. Change in equipment settings
c. Failed mitral valve repair
d. Systolic anterior motion of the mitral valve

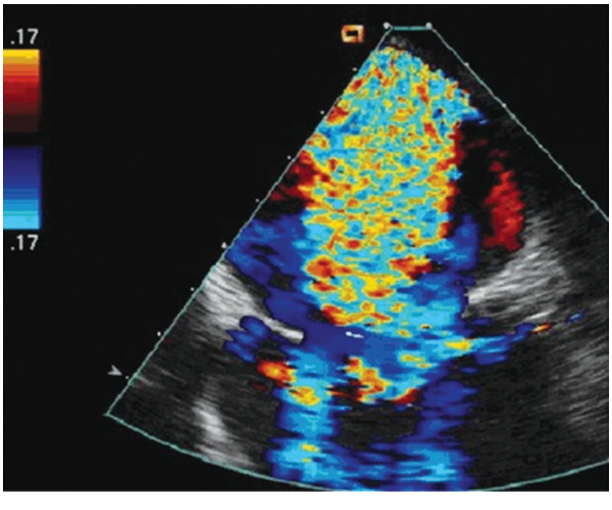


Fig. 24.10A

24. a 25. b

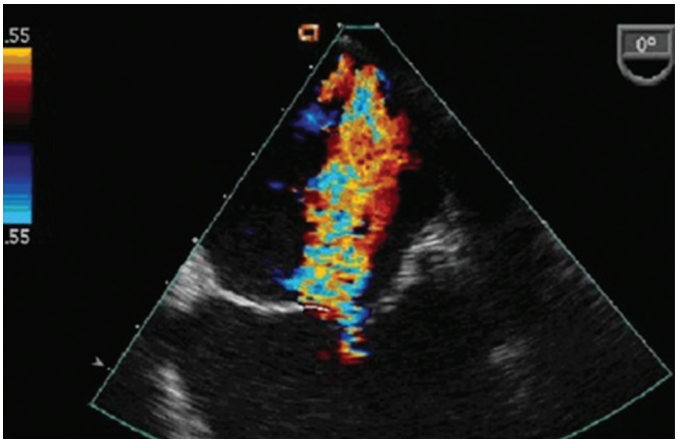


Fig. 24.10B

Answers

1. d. In patients with nonvalvular atrial fibrillation, the low left atrial emptying velocities (<20 cm/sec) have been associated with severe spontaneous echocardiographic contrast, appendage thrombus, and subsequent cardioembolic events. Data also suggest that patients with severe echo contrast have a poor prognosis with increased mortality.
2. c. Transesophageal Echocardiography (TEE) is a sensitive and highly specific technique for the diagnosis of aortic dissection. Intimal flaps are easily visualized when present in the proximal ascending aorta, distal arch, and descending thoracic aorta. Studies comparing TEE with computer tomography (CT) and magnetic resonance imaging (MRI) have shown that its sensitivity is >95%.
3. c. The specificity of TEE for aortic dissection detection is approximately 75%. The reduced specificity is the result of false positive findings in the ascending aorta due to reverberation artifacts.
4. d. Pulmonary veins evaluation is part of a comprehensive TEE evaluation. Pulmonary vein flow may add important information in patients with mitral regurgitation, anomalous pulmonary vein drainage, and in patients after pulmonary vein isolation procedures. Visualization of the right pulmonary vein is most challenging but can usually be seen from a 45–60 degrees transducer position with clockwise rotation.
5. b. The left upper pulmonary vein is the easiest to visualize because of its close proximity to the left atrial appendage. Left pulmonary veins are usually seen at 110–140 degrees with counterclockwise rotation.
6. b. The transverse pericardial sinus is important for the cardiac surgeon because it is through this sinus where they usually place the aortic clamp. During routine TEE, it is important to remember that the pericardial reflection may contain small amounts of fluid. Operators without experience may misinterpret this finding as aortic dissection or periaortic abscess.
7. d. The evaluation of patients with aortic stenosis using TEE includes visualization of the aortic valve anatomy and planimetry of the aortic valve area. When possible, transvalvular gradients are obtained. However, obtaining accurate transaortic gradients can be technically challenging. It requires a deep transgastric view at 0 degree with anteflexion of the probe's tip. The objective is alignment of the aortic valve and proximal ascending aorta as parallel as possible with the CW Doppler cursor. Alternatively, the transducer position can be set at 90–100 degrees and the probe slowly pulled back keeping the anteflexion and the tip adjusted with the lateral knob. These maneuvers are important not only in patients with valvular aortic stenosis but also in patients with hypertrophic obstructive cardiomyopathy.
8. a. In 2007, the criteria for appropriateness for echocardiography were published. A group of experts were asked to assess whether the use of the test for each indication was appropriate, uncertain, or inappropriate. Of the options offered in question 8, answer (a) was considered an inappropriate indication for TEE. In patients with atrial fibrillation that are already anticoagulated and are not going to undergo electrical or pharmacological cardioversion, it is not necessary to evaluate for the presence of left atrial thrombus. TEE remains a useful tool in patients undergoing cardioversion or pulmonary vein isolation to rule out left atrial thrombus. TEE is also widely used in the guidance of noncoronary interventions and is important in assessing for the presence of vegetations in patients with suspected infection of an intracardiac device.
9. c. In patients with permanent atrial fibrillation, the presence of severe spontaneous contrast or smoke is a marker of increased risk of thromboembolic events. Electrical cardioversion causes left atrial appendage stunning with increased severity of echocontrast immediately after the procedure. There have been published series of cases of embolic stroke after cardioversion in patients with a negative TEE for left atrial thrombus who are not anticoagulated. For that reason, patients should have therapeutic levels of anticoagulation before proceeding with

cardioversion. A recent series of patients with surgical LAA ligation showed a high incidence of residual flow between the left atrium (LA) and LAA.

10. c. Transesophageal echocardiography is highly sensitive for vegetations; however, other valvular structures should be considered in the differential diagnosis. In the aortic valve, these structures include Lambl's excrescences, thickened Arantius nodules, and fibroelastomas. Lambl's excrescences are filamentous structures attached to the ventricular side of the valve. Arantius nodules are present at the center of the free margin of each of the three cusps of the aortic valve. Fibroelastomas are benign tumors often attached to the aortic side of the valve.
11. a. Evaluation for source of embolism is one of the most common indications for TEE. Atrial fibrillation, PFO, valvular heart disease, and diseases of the aorta are frequent sources of stroke. Severe atheroma of the ascending aorta and/or arch carries a high risk of subsequent stroke. This finding is also important in patients undergoing open heart surgery because clamping of the aorta may dislodge the atheroma and cause a stroke or embolism to other organs. Identification of ascending atheroma may be difficult using TEE and in the operating room TEE is usually complemented with epicardial echocardiography. Large, protruding atheromas in the aortic arch are associated with an increase risk of stroke, >2 times even after correcting for carotid stenosis, atrial fibrillation, and other risk factors.
12. b. Transesophageal echocardiography is an excellent technique to visualize the ascending aorta, distal arch, and the descending thoracic aorta. However, the distal aorta and proximal arch constitute a blind spot for TEE visualization. The blind spot is caused by the interposition of air, located in the trachea and main bronchi, between the echo-transducer and the aorta.
13. c. Methemoglobinemia related to benzocaine topical anesthetic given during TEE is a rare reaction occurring in ~ 0.1% of patients. Methemoglobin levels are elevated due to conversion of iron from a reduced to oxidized form of hemoglobin which results in poor oxygen carrying capacity. This results in cyanosis, low oxygen saturation levels, and normal arterial PO_2 levels. The treatment of choice is intravenous methylene blue.
14. c. Sometimes, the TEE probe will become coiled in the esophagus with the tip pointed toward the mouth. Often this can be remedied by withdrawing the probe to a slight extent, retroflexion of the probe, and then attempting to advance the probe forward. However, it is always true that if simple maneuvers such as this do not work then the TEE should not be continued and an endoscopy should be performed to rule out stricture or obstructing lesions.
15. e. Absolute contraindications to TEE include esophageal or pharyngeal obstruction, instability of the cervical vertebrae, active gastrointestinal bleeding from an unknown source or severe bleeding diathesis or overanticoagulation, or an uncooperative patient. Relative contraindications include esophageal varices, PT INR >3.5 < 5.0, or platelet count <50,000.
16. d. Degenerative mitral valve disease is the most common cause of severe mitral regurgitation requiring surgery. Echocardiography is the main diagnostic modality to assess mitral valve disease. Although TTE often offers enough diagnostic information, TEE is the gold standard for anatomical definition. Posterior mitral prolapse and/or flail are more common than anterior mitral pathology. A flail leaflet is diagnosed when ruptured chordae are visualized and the tip of the leaflet points superiorly into the left atrium in systole. In cases of posterior leaflet flail, the regurgitant jet is anteriorly directed.
17. c. Pulmonary vein flow assessment is part of a comprehensive evaluation in patients with mitral regurgitation. Figure 24.2 shows holosystolic flow reversal consistent with severe mitral regurgitation. In patients with mild mitral regurgitation, usually the pulmonary vein flow is normal with predominant or mildly blunted systolic flow. A large atrial reversal is seen in patients with increased end diastolic pressure. In patients with mitral stenosis, the typical finding is a slow deceleration slope in the diastolic wave of the pulmonary vein flow.
18. d. Papillary fibroelastomas are benign tumors that can be seen on the aortic valve. These tumors are described as small, well-delineated, pedunculated masses with a predilection for valvular

endocardium. These tumors can be highly mobile and carry an embolic risk. The diagnoses are usually incidental or during investigation for an embolic source. Sun et al. have summarized the echocardiographic characteristics of fibroelastomas:

- The tumor is round or oval, irregular in appearance, with well-demarcated borders and a homogeneous texture.
- Most are relatively small <20 mm.
- Nearly half have small stalks, and those with stalks are mobile.
- They may be single or multiple and are often associated with valvular disease.
- They more commonly appear on the aortic valve followed by the mitral valve.

19. d. This is an example of an aortic dissection flap of the descending thoracic aorta with associated pleural effusion. Note the characteristic intimal flap that separates the true from the false lumen. The presence of a pleural effusion may represent a contained rupture but more often this represents an inflammatory pleural reaction. In patients with associated ascending aortic dissection with involvement of the aortic valve, pleural effusion may also indicate congestive heart failure.
20. d. This example shows two left atrial appendage thrombi. They are usually related to stagnant flow that can be seen in patients with atrial fibrillation or mitral valve disease, in particular stenotic lesions. These thrombi are more often seen at the tip of the appendage. Although usually they are single, they can be multilobulated. Differential diagnoses include prominent pectinate muscles and severe spontaneous echo contrast. Pectinate muscles are usually easy to identify using a multiplane TEE probe and can be seen as finger-like structures at 100–110 degrees rotation. Severe spontaneous echo contrast (sludge) can be challenging to differentiate from a true clot. In some cases, the use of commercially available echo contrast agents may be helpful.
21. d. Myxomas are the most common benign tumors of the heart. They can be found in any of the heart cavities but most often in the left atrium. Typically, these tumors are attached by a stalk to the interatrial septum. Surgery is usually indicated due to the potential for embolism or obstruction of the mitral valve orifice. In most cases, these are single tumors; although in their familial form, they can be multiple and recurrent. Carney's syndrome is an autosomal dominantly transmitted multisystem tumorous disorder characterized by myxomas (heart, skin, and breast), spotty skin pigmentation (lentigines and blue nevi), endocrine tumors (adrenal, testicular, thyroid, and pituitary), and peripheral nerve tumors (schwannomas). In Carney's syndrome, the cardiac myxomas are also multiple and contribute to the mortality of this disease.
22. d. The proximal coronary arteries can be visualized using TEE. In patients with normal origin of the coronaries, the left main can be visualized as shown in the example. The right coronary artery can be more challenging due to its anterior origin and can be masked by aortic calcification.
23. d. This is an example of a unicuspid aortic valve. This is a relative rare entity accounting for less than 5% of the adult population with aortic stenosis requiring surgery. Unicuspid valves can be unicommissural (most common) or acommissural.
24. a. Visualization of the pulmonary veins is important in a variety of situations: postpulmonary vein ablation, in patients with sinus venosus ASD, and in the assessment of mitral regurgitation. The easiest vein to visualize is the left upper pulmonary vein that runs next to the left atrial appendage. It is possible to visualize the bifurcation of the left and right pulmonary veins. The left pulmonary veins are typically seen from 110 to 140 degrees with counterclockwise rotation. In the example, the bifurcation can be easily seen with a transducer position at 110 degrees, and Figures 24.11A and B corresponds to the left upper (A) and left lower (B) pulmonary veins. The right pulmonary veins are usually visualized from 45 to 60 degrees transducer position with clockwise rotation (RLPV: Right lower pulmonary vein; RUPV: Right upper pulmonary vein).

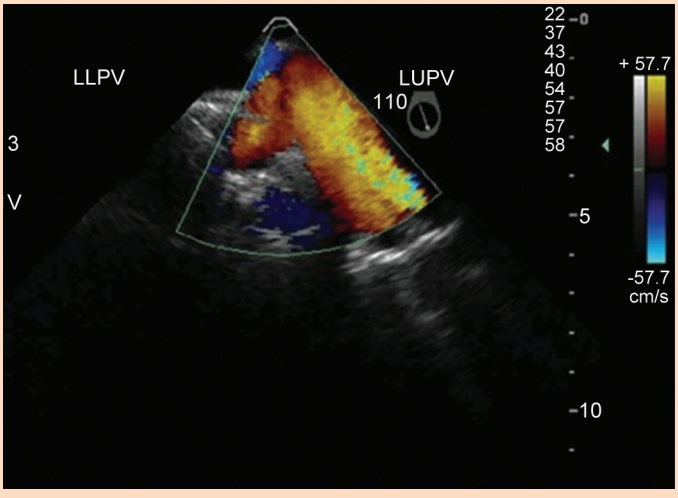


Fig. 24.11A

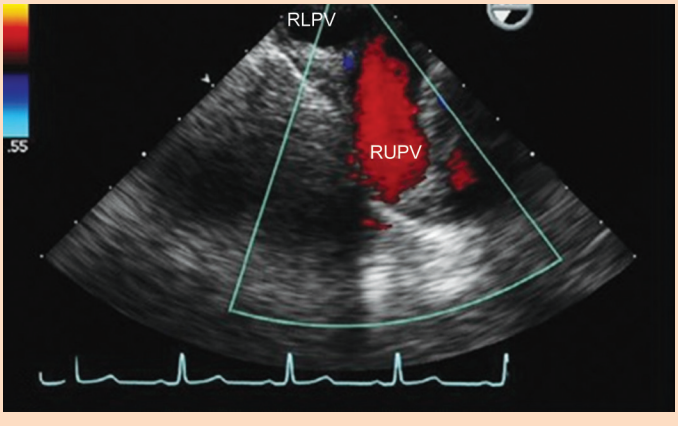


Fig. 24.11B

25. b. The answer is a change in the echo settings, in particular the Nyquist limit. This is a frequent mistake in evaluating regurgitant lesions. The appearance of a jet by color Doppler depends on jet momentum (flow × velocity). In addition, changes in gain, pulse repetition frequency, and Nyquist limit may markedly change the size of the jet. The standard Nyquist limit to evaluate a regurgitant lesion is around 45–60 cm/sec. In this particular example, the Nyquist limit was lowered to interrogate the interatrial septum (low-velocity PFO flow) and then was not changed back to assess the degree of mitral regurgitation.

25

Echocardiography for Torsion, Tissue Doppler Stress and Strain

1. Compared with standard Doppler, tissue Doppler settings make use of:
   a. The lesser reflectivity of tissue
   b. The faster motion of tissue
   c. Filters to exclude highly reflective tissue
   d. Filters to exclude higher velocities

2. Strain rate for tissue Doppler is defined as:
   a. Measured tissue velocity × time
   b. Absolute difference in velocities
   c. The change in velocity between two points divided by the end distance
   d. The change in distance between two points divided by the initial distance

3. Which is correct regarding Doppler strain?
   a. Doppler-derived strain may be obtained in any direction from a single view
   b. Doppler-derived strain is more dependent on translational motion than tissue velocity imaging
   c. Doppler-derived systolic strain rate correlates with indices of contractility
   d. Doppler-derived strain has lower spatial and temporal resolution than magnetic resonance imaging strain

4. Which is the best acoustic window to obtain the Doppler-derived radial strain of the anterior wall?
   a. Parasternal long axis
   b. Parasternal short axis
   c. Apical four chamber
   d. Apical two chamber
   e. Subcostal

5. Which of the following hemodynamic parameters best correlates with a combination of mitral E-wave velocity and early diastolic longitudinal velocities of the myocardium (e')?
   a. Superior vena cava pressure
   b. Right atrial pressure
   c. Right ventricular systolic pressure
   d. Mean left atrial pressure

1. d 2. c 3. c 4. b 5. d

6. Compared with Doppler-derived strain, speckle-tracking strain:
   a. Provides no discernible advantage
   b. Can be performed independent of grayscale distribution
   c. Is based on the Doppler shift of reflected sound waves
   d. Does not rely on a particular angle of imaging with respect to tissue motion

7. Which of the following radial strain rates obtained at the mid-inferior wall during systole of a patient with ischemic cardiomyopathy is consistent with dyskinesis?
   a. 0
   b. 1
   c. −1
   d. 10

8. In left ventricular (LV) torsion:
   a. During systole, the basal segments of the LV myocardium rotate counterclockwise
   b. During systole, the apical segments rotate counterclockwise
   c. During diastole, the basal segments of the LV myocardium rotate counterclockwise
   d. Basal twisting is the main component of LV systolic torsion

9. Which of the following is a true statement about Doppler tissue imaging (DTI)?
   a. It is more preload dependent than traditional Doppler imaging
   b. A normal velocity and pattern of mitral annular velocities does not always indicate normal diastolic function
   c. It is unable to discriminate passive motion from active motion
   d. M-mode color DTI has lower spatial resolution than pulsed DTI

10. Which of the following instrumental setting changes will not result in improved temporal resolution for strain imaging?
   a. Altering the sector width of interrogation
   b. Selecting a point of interest at a closer image depth
   c. Selecting a point of interest that typically suffers from echo dropout
   d. Altering the harmonics setting

11. In asymmetric septal hypertrophic cardiomyopathy, tissue Doppler e′:
   a. Is abnormal in the lateral wall
   b. Is normal in the septum
   c. Has an inverse relationship with septal thickness
   d. Has a direct relationship with septal thickness

12. In diabetic patients, which of the following statements is correct?
   a. HgbA1C correlates with E/e′
   b. Diabetic patients have a higher Doppler E′
   c. Asymptomatic diabetic patients do not demonstrate an abnormal E/e′
   d. The mechanism for any diastolic dysfunction is thought to be related to concomitant renal dysfunction

13. In which of the following conditions has e′ been shown to improve after treatment?
   a. Cardiac amyloidosis
   b. Hypertrophic cardiomyopathy
   c. Dyskinesis in ischemic heart disease
   d. Aortic stenosis

14. Which of the following tissue Doppler indices has been shown to carry the most prognostic value after myocardial infarction (MI)?
   a. E
   b. e′
   c. E/e′
   d. S

6. d 7. c 8. a 9. c 10. c 11. c 12. a
13. d 14. c

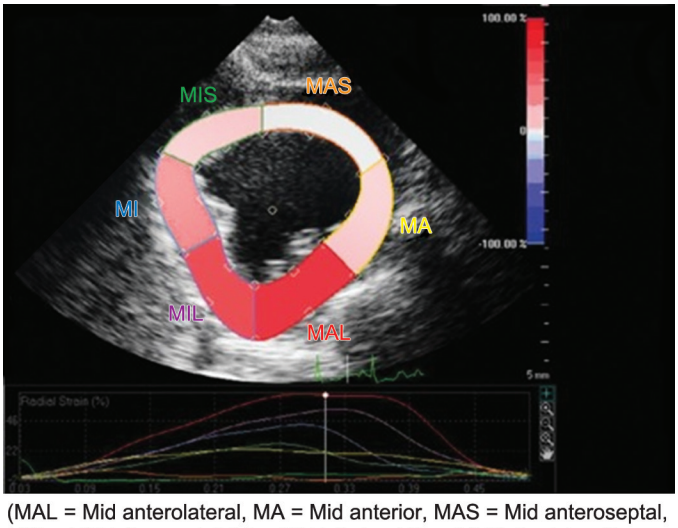
15. Which of the following parameters is not directly related to active LV relaxation?
    a. Isovolumic relaxation time
    b. e′ velocity
    c. A velocity
    d. LV torsion

16. Strain measurements obtained from color tissue Doppler:
    a. Are not affected by the angle of interrogation
    b. May vary from one heart beat to another
    c. Achieve higher temporal resolution when using a wider color sector angle
    d. Achieve higher temporal resolution when extending the depth of the sampling region
    e. Cannot be obtained in patients with atrial fibrillation

17. Which of the following cardiac conditions is associated with a normal or high e′?
    a. Friedreich's ataxia
    b. Fabry's disease
    c. Hypertrophic cardiomyopathy
    d. Cardiac amyloidosis
    e. Myocardial hypertrophy in athletic hearts

18. In a patient with a localized basal lateral infarct with evidence of akinesis by two-dimensional Doppler imaging, the expected longitudinal tissue Doppler velocities (m/sec) and strain rate (1/sec) would be:
    a. Tissue Doppler velocity = 0.2, strain rate = 0
    b. Tissue Doppler velocity = 0, strain rate = 0.2
    c. Tissue Doppler velocity = 0.2, strain rate = −0.5
    d. Tissue Doppler velocity = 0, strain rate = 0

19. The radial strain map in Figure 25.1, obtained from a patient with chest pain demonstrates:



(MAL = Mid anterolateral, MA = Mid anterior, MAS = Mid anteroseptal, MIS = Mid inferoseptal, MI = Mid inferior, MIL = Mid inferolateral)

Fig. 25.1

    a. Normal LV function
    b. Segmental dyskinesis
    c. Anterolateral hypokinesis
    d. Anteroseptal akinesis

15. c 16. b 17. e 18. a 19. d

20. The strain rate pattern in Figure 25.2 is consistent with:

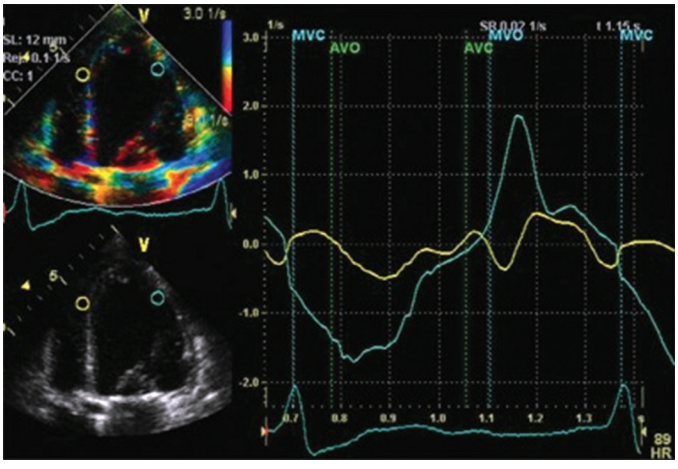


Fig. 25.2

a. Anteroseptal infarct
b. Anterolateral infarct
c. Extensive apical infarct
d. Normal LV function

21. A 70-year-old woman with ischemic heart disease and chronic obstructive pulmonary disease (COPD) presents for evaluation of dyspnea. What would you recommend on the basis of the echo Doppler findings in Figures 25.3A and B?
a. Evaluation for pulmonary embolism
b. Intravenous diuresis and evaluation for ischemia
c. Initiation of therapy for COPD exacerbation
d. Right heart catheterization

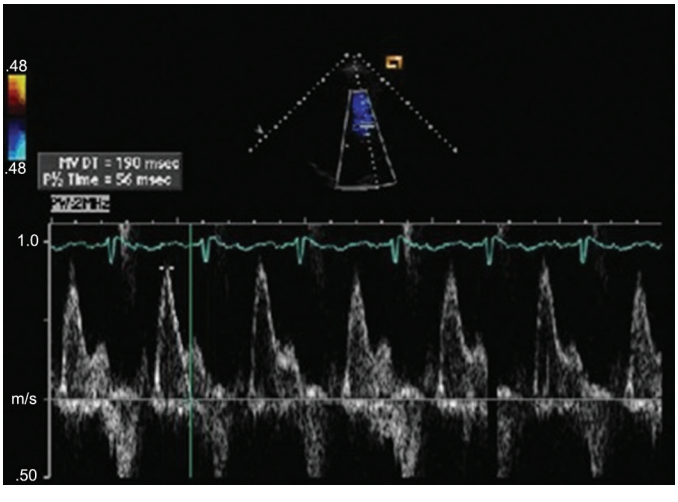


Fig. 25.3A

20. a 21. b

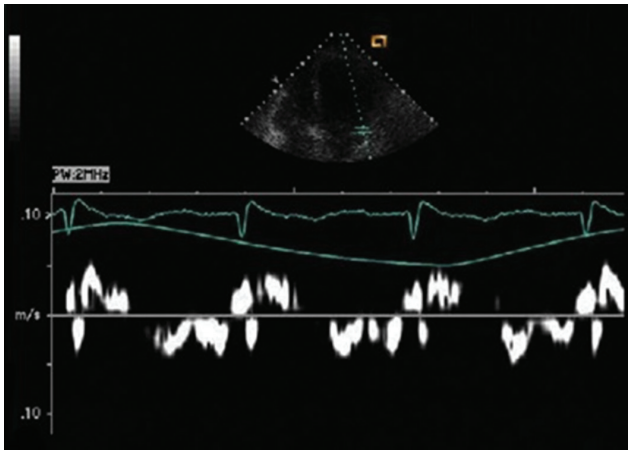
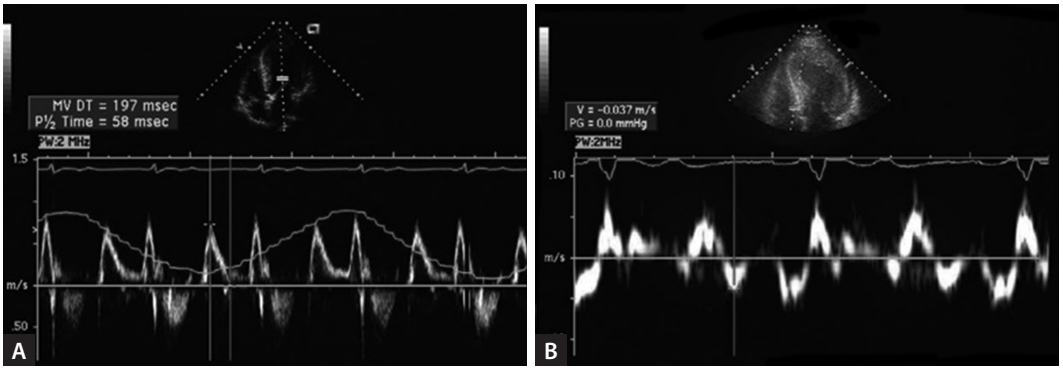


Fig. 25.3B

22. Two days after successful medical treatment in the previous case, symptoms of dyspnea have resolved. An echocardiogram is repeated, and the Doppler images are shown in Figures 25.4A and B.

What can you conclude?

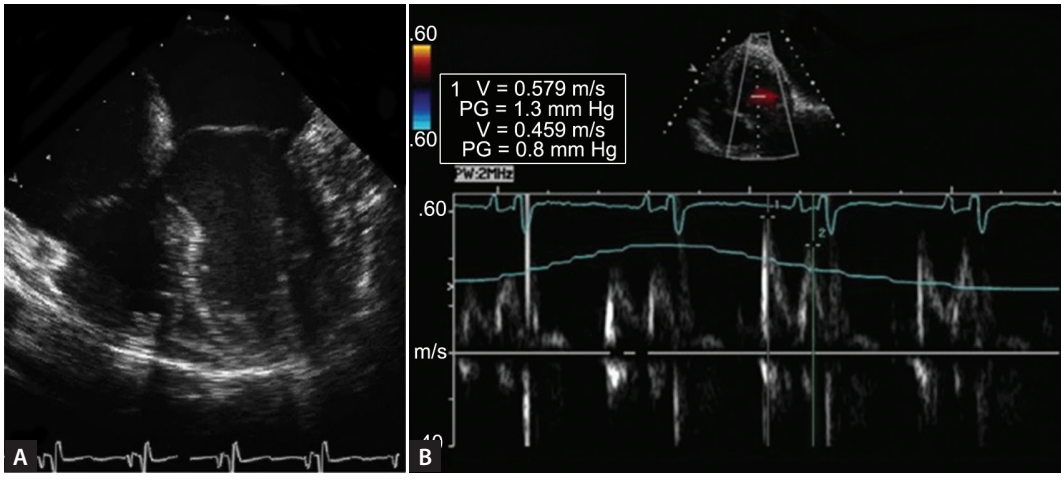
a. Patient requires more aggressive diuresis
b. Patient has abnormal diastolic function
c. Patient has a restrictive filling pattern
d. Patient requires Doppler pulsed wave interrogation of her pulmonary veins to assess diastolic function



Figs 25.4A and B

22. b

23. A 46-year-old woman with previous history of breast cancer treated with mastectomy, chemotherapy, and radiation therapy presents for evaluation of symptoms of fatigue. On examination she has a heart rate (HR) of 100 bpm, BP of 85/60 mm Hg, elevated jugular venous pressure (JVP), and decreased breath sounds at the lung bases, ascites, and 3+ edema. Transesophageal and transthoracic echo Doppler images are shown in Figures 25.5A and B. The most likely diagnosis is:
    a. Hypertrophic cardiomyopathy
    b. Constrictive pericarditis
    c. Cardiac amyloidosis
    d. Restrictive cardiomyopathy postradiation



Figs 25.5A and B

24. A 68-year-old woman presents for evaluation of dyspnea on exertion. Tissue Doppler images are shown in Figures 25.6A and B.

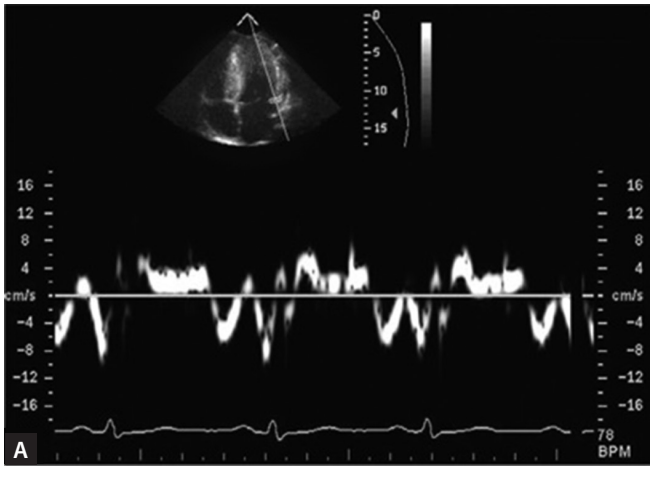


Fig. 25.6A

23. b

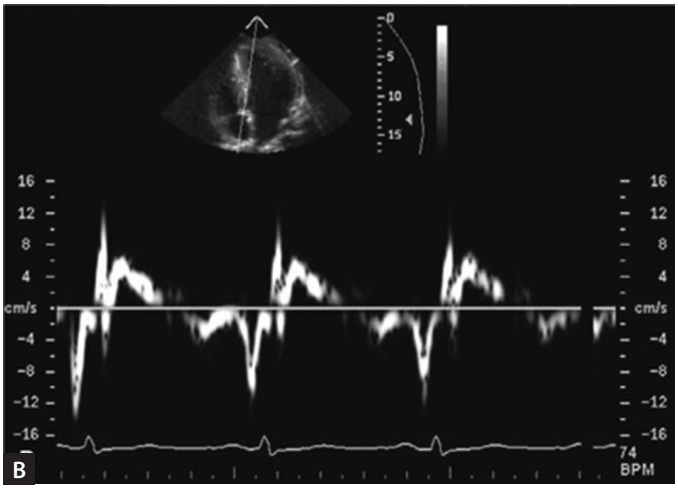


Fig. 25.6B

The most likely diagnosis is:

a. Asymmetric septal hypertrophic cardiomyopathy
b. Anterolateral infarction
c. Cardiac amyloidosis
d. Constrictive pericarditis

25. The image in Figure 25.7 was obtained from a 70-year-old patient presenting with chest pain. The longitudinal strain pattern suggests:

a. Anterior dyskinesis
b. Apical dyskinesis
c. Inferior dyskinesis
d. Posterior dyskinesis

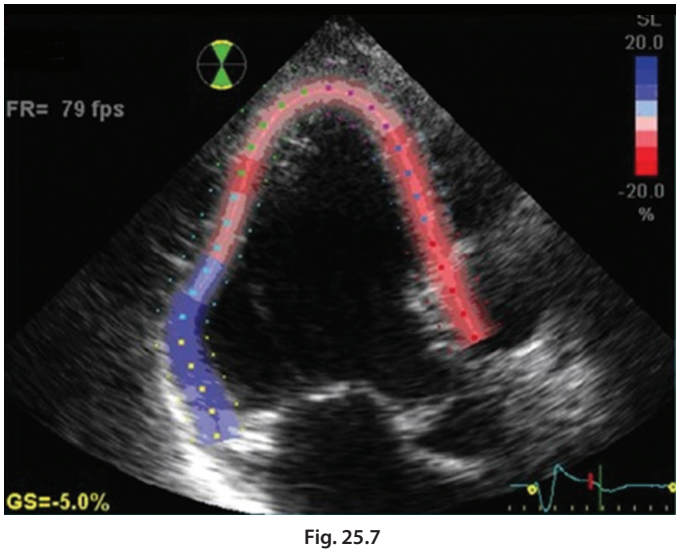


Fig. 25.7

24. a 25. d

Answers

1. d. Standard Doppler measures blood flow velocities on the basis of the Doppler effect. The change in frequency between transmitted sound and reflected sound is termed the "Doppler shift" and is used to calculate the velocity of the moving blood. Blood is a relatively weak reflector of sound waves and moves at a relatively high velocity; therefore, in standard Doppler, filters are used to exclude highly reflective and low-velocity objects, like myocardium so that the range of velocities to be measured is maximized. Conversely, since tissue moves at a slower velocity but has a higher reflectivity, DTI employs filters, which exclude low-intensity reflectors and higher velocities.
2. c. Based upon the information obtained from DTI about myocardial velocities, other variables related to myocardial motion can be determined. For example, the distance traveled by a measured point in the myocardium can be determined (velocity × time), and if two points are measured simultaneously, the velocity gradients between these two points can be determined. The change in distance of two points in the myocardium divided by the initial length or end diastolic length (end diastolic length—end systolic length/end diastolic length) is also known as myocardial strain. The strain rate (SR) is the first derivative of strain and is defined as the change in velocity between two points divided by the distance between the two points at the end of systole (L). SR = (V1 – V2)/L.
3. c. The standard Doppler equation is expressed as: $(2f_o \times v \times \cos \theta)/c$ where Δf frequency shift of the transmitted frequency, c the speed of sound in blood, and θ the angle of the beam in relation to direction of blood flow. If $\theta = 0$ (parallel to direction of movement), then the cosine of 0 is 1. As the angle or θ increases, the cosine becomes progressively less than 1 resulting in an underestimation of Doppler shift and therefore peak velocity. Tissue Doppler is also dependent on θ when velocities are measured and is limited to interrogating segments aligned in parallel with the Doppler angle of incidence. Tissue velocity imaging is unable to discriminate passive motion from active deformation; however, strain is a measure of active tissue motion. Because of this ability to measure active tissue motion, there is a close correlation between strain rate and indices of LV contractility.
4. b. The spiral architecture of the myocardial fiber bundles determines strain deformation in multiple directions. Also, it is important to recall that the angle of incidence of the Doppler beam on the area of interest contributes to an accurate estimation of velocity by the Doppler equation:
   Taking both the spiral architecture and the angle of incidence into account, changes in LV geometry during systole relate primarily to radial (short-axis), longitudinal (long-axis), and meridional (LV-torsion) strain. Therefore, radial strain (εr) of the anterior wall is best measured from the parasternal short-axis view (Fig. 25.8).

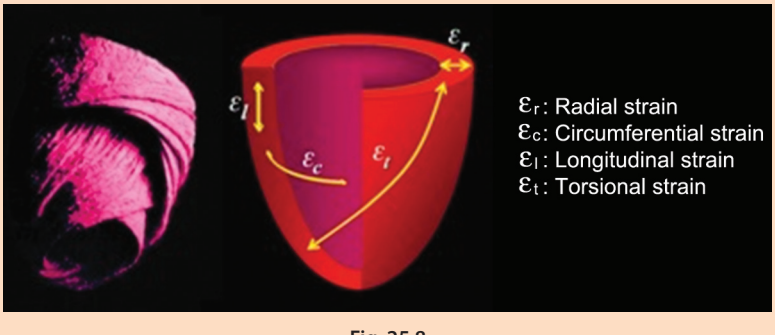


Fig. 25.8

5. d. The early diastolic velocity of the longitudinal motion of the myocardium (e′) reflects the rate of myocardial relaxation. Decreased e′ is one of the earliest signs of diastolic dysfunction and is present in all stages of diastolic dysfunction. Because e′ velocity is reduced and mitral E velocity increase with higher filling pressures, the ratio between E and e′ correlates well with LV filling pressures. This combination of early mitral E velocity and early diastolic longitudinal velocities of the myocardium has a linear relationship to the pulmonary capillary wedge pressure or mean left atrial pressure. This relationship persists even in patients with tachycardia as well as atrial fibrillation. There is debate to whether this relationship holds in the acutely decompensated patient with congestive heart failure.
6. d. One of the special characteristics of static B-scan ultrasound imaging is an appearance of speckle patterns within the tissue, which are the result of constructive and destructive interference of ultrasound back-scattered from structures smaller than a wavelength of ultrasound. This speckle pattern is unique for each myocardial region and is relatively stable throughout the cardiac cycle. Myocardial motion can be analyzed by tracking the movement of these speckles by filtering out random speckles and then performing an autocorrelation to estimate the motion of stable structures. Speckle-tracking technology has the advantage of measuring tissue velocities and deformation in an angle-independent fashion. It relies on a consistent and distinct grayscale pattern. This information is fed through a pattern recognition algorithm to tract the displacement of the speckles in both dimensions of the two-dimensional image. Because this analysis is not based on the Doppler shift of reflected sound waves, it is not angle dependent and can be performed on regular two-dimensional images.
7. c. Strain rate (ε) imaging simultaneously measures the velocities in two adjacent points as well as the relative distance between these two points. Expressed as: $\varepsilon = (V1 - V2)/L$. Positive radial strain rate represents active contraction. Negative values for radial strain represent either relaxation (if measured during diastole) or dyskinesis (if measured during systole).
8. a. The LV myocardium has a spiral architecture, with myocardial fibers that vary in orientation depending on where in the myocardium they are located. Fiber direction is predominantly longitudinal in the endocardial region, transitioning into a circumferential direction in the mid wall and becoming longitudinal again over the epicardial surface. In addition to radial and longitudinal deformation, there is torsional deformation of the LV during the cardiac cycle due to the helical orientation of the myocardial fibers. During systole, the basal segments of the LV myocardium rotate or twist in counterclockwise direction, whereas the apical segments twist in clockwise direction. During diastole, untwisting occurs in the opposite direction. Systolic torsion represents the net effect of basal and apical twist. Apical twisting is the main component of global LV systolic torsion, and in the next diastole, the apical untwisting also plays the dominant role, whereas basal rotation is of less importance.
9. c. Standard Doppler measurement of mitral inflow velocities can be used to assess diastolic function by measuring the early rapid filling wave (E) and the late filling wave due to atrial contraction (A). The velocities and ratios of E/A are used to determine diastolic function, but as they are reflective of the pressure gradient between the left atrium and the left ventricle, they are directly related to preload and inversely related to ventricular relaxation. Doppler tissue myocardial diastolic velocities are less load dependent. In adults, an early diastolic longitudinal (e′) velocity of >0.10 m/sec is associated with normal LV diastolic function. DTI measures only vector motion that is parallel to the ultrasound beam and is not able to differentiate between active motion (like myocardial contraction) and passive motion (like tethering). M-mode color DTI is acquired by color-coding images of tissue motion during an M-mode image acquisition. Different colors specify direction of motion and allow images to have both high temporal and spatial resolution.
10. c. Calculations of strain and strain rate from Doppler tissue data have several areas of possible error. Areas of echo dropout will be encoded slower than actual velocities. Deviation from

the intended angle of interrogation alters the type of strain being measured. Areas of interest closer to the pulse source will have higher fidelity measurements, as there is less echo dropout present.

11. c. Tissue Doppler can also identify abnormal regional strain, predominantly in areas of localized hypertrophy. In fact, it appears that the greater the extent of segmental wall thickness, the greater is the reduction in myocardial strain. These abnormalities can often be found in asymptomatic carriers of hypertrophic cardiomyopathy genetic mutations, even in the absence of phenotypic expression. Pulsed Doppler LV filling usually shows impaired relaxation or pseudonormal patterns and rarely the restrictive patterns because of the markedly increased wall thickness and impaired relaxation.
12. a. Glycemic control in diabetic patients has been associated with microvascular complications. Microvascular disease may lead to ischemia and subsequent impaired LV relaxation and increased myocardial stiffness. Advance glycation end products have been associated with microvascular complications of type 1 diabetes mellitus and may be a pathophysiologic mechanism for diastolic dysfunction in these patients. Type I diabetic patients have worse diastolic function with lower tissue Doppler e′. Furthermore, HgbA1C was correlated with E/e′. These results demonstrate that asymptomatic diastolic dysfunction is common in patients with type I diabetes mellitus and that its severity is correlated with glycemic control. Furthermore, data suggest that asymptomatic diabetic patients have increased LV filling pressure as measured by E/e′, and by a larger left atrial size.
13. d. In aortic stenosis, global LV dysfunction is common secondary to the increased afterload. This LV dysfunction may not be discernible based on standard two-dimensional echocardiography alone. Because the sensitivity of tissue Doppler imaging is superior, subclinical LV dysfunction has been detected by tissue Doppler imaging in patients with aortic stenosis despite good ejection fraction. In patients with aortic stenosis, the degree of abnormality in regional deformation correlates with aortic valve area. Once the aortic valve is replaced, e′ can normalize.
14. c. After an MI, E/e′ has been shown to be associated with an increased risk of death or need for heart transplant. Patients with an E/e′ ratio of >17 had a mortality rate of approximately 40% at 36 months compared with 5% in those with an E/e′ ratio of <17. In a study that included 250 nonselected patients who had an echocardiogram 1.6 days after an MI followed up for a median of 13 months, the most powerful predictor of survival was an E/e′ ratio of >15. E/e′ was a stronger predictor than other Doppler echocardiographic indices including the LV filling pulsed Doppler deceleration time. E/e′ has also correlated with increased LV end-diastolic volume post-MI and has been attributed to a relationship to LV remodeling and progressive LV dilation.
15. c. Several studies have shown an inverse relationship between e′ and LV relaxation in both patients with normal and elevated preload. Clinical studies suggest that e′ is a better discriminator between diastolic dysfunction and normal patients, compared to any other single or combined index of transmitral filling and pulmonary venous Doppler flows. LV torsion and untwisting also correlate well with the relaxation time constant. Isovolumic relaxation time represents the earliest phase of diastole. It is defined as the time from aortic valve closure to mitral valve opening.
16. b. DTI differs from standard Doppler by eliminating the high-pass filter and using low-gain amplification to display the velocities of the myocardium. Tissue Doppler-derived strain is limited to interrogating segments aligned in parallel with the Doppler angle of incidence. Data should be recorded at the highest possible frame rate to maximize temporal resolution. This is accomplished by reducing sector size and depth. Ideally three consecutive heartbeats should be recorded in each view, to account for beat-to-beat variability. Strain measurements may be obtained in patients with atrial fibrillation.

17. e. Tissue Doppler velocities may help to differentiate myocardial hypertrophy seen in athletes from hypertrophic cardiomyopathy, where these velocities are abnormally decreased. Similar findings have been reported in Fabry's disease, a cardiomyopathy secondary to α-galactosidase A deficiency. Mutation-positive Fabry's patients have significant reduction of e′ and higher E/e′ compared with normal control subjects, even before the development of LV hypertrophy. Tissue Doppler has been used to study myocardial performance in patients with Friedreich's ataxia. Asymptomatic patients who are homozygous for the GAA expansion in the Friedreich's ataxia gene have reduced myocardial velocity gradients during systole and in early diastole. Patients with a restrictive cardiomyopathy from an infiltrative disease process like cardiac amyloidosis will have impaired relaxation and therefore reduced e′ velocities.
18. a. Unlike tissue Doppler, which records myocardial motion and not necessarily contraction, strain rate measures the instantaneous velocities between two points within the myocardium. A strain rate of zero indicates akinesis. A strain rate of >0 indicates expansion, and a strain rate of <0 indicates compression. Velocities may be recorded in akinetic segments that are tethered by adjacent moving segments, in this example, from the apical and mid-lateral wall.
19. d. As the ventricle contracts, muscle fibers shorten in the longitudinal and circumferential directions and thicken or lengthen in the radial direction. Strain represents the change in segment length throughout a cardiac cycle. Strain rate or strain velocity is the local rate of myocardial deformation and can be derived from DTI velocities. DTI-derived strain rate is a strong index of LV contractility. In Figure 25.1, a parasternal short-axis image of the mid left ventricle is shown. The myocardium has been color coded by segment and by its percent strain value with a scale of 100% (red) and −100% (blue). The time plot at the bottom of the imaging graphs the percent radial strain of each color-coded segment. The color of the plot corresponds to the outlined color of the segment selected. Figure 25.1 shows that the best motion is seen in the mid-anterolateral wall, which has the darkest red coloring and is also plotted on the graph as the red line with a marked positive percent strain during systole. The mid-anteroseptal wall, colored white and outlined in orange, shows akinesis based upon the white color coding and the flat plot of the orange curve. Radial strain can provide quantitative data to assist in the interpretation of segmental wall motion and can be of particular use in the interpretation of stress echocardiograms.
20. a. Figure 25.2 shows strain rate imaging with regions of interest selected in the septum (yellow circle and corresponding plot) and lateral wall (blue circle and corresponding plot) in the apical four-chamber views. MVC = mitral valve closure, AVO = aortic valve opening, AVC = aortic valve closure, MVO = mitral valve opening. A strain rate of zero indicates akinesis. A strain rate of >0 indicates expansion, and a strain rate of <0 indicates compression. The strain rate of the selected area of the septum (yellow) shows that it maintains a strain rate of approximately zero throughout systole and diastole. This finding is consistent with akinesis and scar formation. The strain rate of the selected area of the lateral wall (blue), however, demonstrates a negative strain rate in systole (from MVC to AVC) signifying appropriate myocardial compression and a positive strain rate in diastole (from AVC to MVC) signifying appropriate myocardial expansion.
21. b. The common clinical presentation of dyspnea in an elderly patient with a history of heart disease with concurrent pulmonary pathology is a diagnostic dilemma that can be greatly clarified with echo Doppler tissue use. Specifically, Doppler and DTI can provide information regarding LV preload and relaxation. This information, in conjunction with standard information about biventricular size and function as well as assessment of right ventricular systolic pressure can provide a wealth of actionable information. Figure 25.3A shows an elevated E wave from standard Doppler interrogation of mitral inflow. Figure 25.3B shows decreased Doppler tissue velocities obtained from the lateral mitral annulus. The E/e′ ratio in this example is 18. E/e′ ratios of >15 have been correlated to pulmonary capillary pressures

greater than 18–20 mm Hg. An elevated E/e′ ratio has also been related to poor prognosis in both ischemic and nonischemic LV dysfunction.

22. b. Compared with the prior images, the early diastolic pulse wave of the mitral inflow E wave of the mitral inflow shows a markedly reduced velocity in early diastole after the patient was successfully treated with intravenous diuretics. This finding in combination with symptomatic improvement indicates that her LV end-diastolic pressure or preload has been reduced. This is further confirmed by the E/e′ ratio. Despite normal preload conditions after diuresis, both the early to late diastolic filling waves in the standard Doppler as well as the tissue Doppler findings suggest that the patient has underlying diastolic dysfunction. As the deceleration time is >160 milliseconds, this pattern is not consistent with a restrictive filling pattern. Although pulmonary venous filling patterns may give additional information about LV filling patterns, the current information about mitral flow velocity and tissue Doppler allows for the diagnosis of diastolic function.

23. b. Diastolic dysfunction in constrictive pericarditis results from increased pericardial constraint on the LV that is related to the thickness and rigidity of the pericardium. Patients present with signs and symptoms of right-sided heart failure, which are similar to those found in restrictive cardiomyopathy. Two-dimensional echocardiography may not demonstrate increased pericardial thickness and the typical interventricular septal bounce. Right and left ventricular Doppler filling patterns may demonstrate respiratory variability. However, these findings are not always present and are not specific. Acute respiratory illnesses can increase intrathoracic pressure swings, and the respiratory flow variability also increases. Excessive preload may attenuate the effect of intrathoracic pressure swings and decrease respiratory variability, whereas low preload can decrease the constraining effect of the pericardium also masking the characteristic Doppler signs of constriction. Tissue Doppler myocardial velocities are useful in differentiating restrictive cardiomyopathy from constrictive pericarditis. In restrictive cardiomyopathy patients, both relaxation and stiffness are abnormal. On the other hand, relaxation is preserved in pure constrictive pericarditis, in the absence of other myocardial disease. Patients with constrictive pericarditis and normal systolic function have normal or elevated e′ velocities (>8 cm/sec), reflecting their preserved ventricular relaxation. In this example, the mitral inflow demonstrates some respiratory variation and its morphology is suggestive of a restrictive filling pattern; however, Doppler tissue at the mitral annulus demonstrates preservation of relaxation making a cardiomyopathy such as cardiac amyloidosis and hypertrophic cardiomyopathy unlikely. The E/e′ ratio is approximately 4, which does not correspond to an elevated left ventricular end-diastolic pressure.

24. a. Figure 25.6 shows tissue Doppler in the lateral wall and in the septal wall. The significant difference between the A and B can be seen in the early diastolic velocity. The most common form of hypertrophic cardiomyopathy is characterized by a prominent increase in global or segmental LV wall thickness and histologically by myocardial fiber disarray. Diastolic function is characterized by increased LV chamber stiffness and decreased relaxation of variable severity due to the asynchronous deactivation of the muscle fibers. This asynchronous deactivation is manifested in Doppler tissue as a decreased velocity seen in hypertrophic segments (septum in this example) in early diastole when compared with segments that do not demonstrate hypertrophy (lateral wall in this example).

25. d. This apical three-chamber view of the left ventricle is analyzed using a two-dimensional speckle-tracking algorithm. As reviewed in question number 8, speckle-tracking technology has the advantage of measuring tissue velocities and deformation in an angle-independent fashion, which enables it to track the movement of the speckle in both dimensions of the two-dimensional image. Figure 25.7 clearly shows that the posterior wall of the left ventricle has been colored in blue, denoting a positive longitudinal strain rate in systole, which indicates an inappropriate expansion during this phase of the cardiac cycle. The rest of the ventricle is colored in shades of red, denoting a negative strain rate in systole, which indicates an appropriate longitudinal compression.

26

Echocardiography and Ultrasound with Contrast

1. The first published work in the field of ultrasound contrast occurred in 1968 written by authors Gramiak and Shah. What was the initial use of ultrasound contrast agents in clinical cardiology?
   a. Myocardial perfusion
   b. Doppler enhancement
   c. Cardiac chamber definition

2. Today, when the cardiac chambers are not adequately visualized, in both office- and hospital-based practices, cardiologists should establish policies and procedures for the appropriate use of FDA-approved ultrasound contrast agents. In the United States these agents include the following:
   a. Sonicated dextrose and sonicated sorbitol
   b. Agitated saline and indocyanine green
   c. PESDA and Berlex scan
   d. Optison and Definity

3. The first generation of ultrasound contrast agents exhibited limited *in vivo* persistence due primarily to the following instrumentation issue:
   a. Implementation of high mechanical indices(>1.0 MI)
   b. Preference of harmonic imaging software versus fundamental software
   c. Presence of high molecular weight, relatively nondiffusible gases (perflutren)
   d. Power Doppler applications for perfusion imaging

4. Today, what is the current FDA-approved application for the use of ultrasound contrast agents?
   a. Doppler signal enhancement
   b. Left ventricular opacification (LVO)
   c. Therapeutic applications
   d. Myocardial perfusion

5. The American Society of Echocardiography (ASE) issued a report in 2008 on the current and future applications of contrast ultrasound applications. The guidelines focused on several applications of ultrasound contrast agents which included the following:

1. c 2. d 3. a 4. b

a. Contrast-enhanced ultrasound imaging (CEUS) is indicated for use in difficult-to-image patients for LVO resulting in a reliable estimation of ejection fraction and regional wall motion abnormalities
b. CEUS is indicated for use with harmonic software resulting in quantification of myocardial perfusion
c. CEUS is indicated and should be used to triage patients on the basis of image quality for stress echocardiography or nuclear testing
d. CEUS is indicated as the first-line assessment when performing noninvasive imaging of the carotid arteries

6. In 2009, the European Association of Echocardiography (EAE) published evidence-based recommendations for ultrasound contrast agents. The EAE document recommended to:
   a. Expand clinical use to include vascular indications and drug delivery applications
   b. Limit the clinical uses of ultrasound contrast agents due to safety concerns
   c. Deny the relevance and clinical uses of ultrasound on the basis of the lack of clinical efficacy
   d. Confirm and sustain the ASE reports of 2008

7. What are the current indications/criteria for the use of ultrasound contrast agents in clinical practice?
   a. Doppler signal is inadequate for the quantification of pressures (tricuspid, aortic)
   b. Detection of left ventricular (LV) pseudoaneurysms
   c. Failure to visualize more than two LV endocardial regions
   d. Detection of the no-reflow phenomena in postmyocardial infarction patients

8. Based on expert opinions, approximately what percentage of transthoracic echocardiograms are considered technically inadequate on the basis of the ASE criteria?
   a. <5%.
   b. 10–30%.
   c. 30–50%.
   d. >75%.

9. In October of 2007, the FDA issued new product labeling changes for perflutren-containing ultrasound contrast agents. In May of 2008, the FDA reversed its decision and moved the new contraindications to the warning section. Therefore, as of May 2008, the new language in the product insert includes which of the following?
   a. Perflutren-based ultrasound agents are contraindicated in all cardiac patients
   b. Ultrasound contrast agents require a consent form for each use
   c. The use of ultrasound contrast agents should be considered experimental
   d. Patients with pulmonary hypertension or unstable cardiopulmonary conditions require monitoring for 30 minutes post-injection

10. In response to the decision of the FDA to institute labeling changes and the subsequent reversal and modifications implemented, an independent, grassroots organization along with the respective professional organizations (ASE and EAE) issued statements supporting the appropriate, safe use of ultrasound contrast agents. Subsequently, numerous editorials and peer-reviewed publications described the following:
    a. Ultrasound contrast agents should not be used in clinical medicine
    b. The safety of using ultrasound contrast agents has been shown to be superior to that of noninvasive imaging agents and procedures
    c. There remains a lack of peer-reviewed publications to understand the safety issues
    d. Contrast ultrasound agent usage exceeds the risk of performing similar noninvasive imaging tests (transesophageal echocardiography [TEE], nuclear imaging, and computed tomography [CT])

5. a 6. d 7. c 8. b 9. d 10. b

11. The safety issues regarding the clinical use of ultrasound contrast agents may be summarized as the following:
    a. Over the course of the last 2 years, the FDA identified a "safety" signal and therefore has subsequently restricted the use of ultrasound contrast agents for all clinical indications awaiting results of future clinical trails. Therefore, all ultrasound contrast agents remain under FDA review and should not be used clinically
    b. Based on recent peer reviewed publications in which more than 228,611 patients received ultrasound contrast agents, the observed risk to patients is notably less than that of other comparable imaging agents and/or noninvasive tests. Therefore, ultrasound contrast agents should be used for appropriate indications
    c. The clinical need to identify the LV endocardial surfaces has been eliminated through the use of three-dimensional and harmonic imaging systems
    d. TEE, contrast-enhanced CT, X-ray, and nuclear imaging modalities all provide similar clinical information, whereas imposing less risk to the patient than the appropriate use of a contrast-enhanced ultrasound examination

12. In 2009, the EAE published evidence-based recommendations regarding the clinical use of contrast echocardiography. The consensus document postulated the following:
    a. Contrast ultrasound may be used for additional clinical applications including myocardial perfusion imaging, viability, and detection of coronary flow in cardiac patients
    b. Ultrasound contrast agents should not be widely used because of safety, concerns
    c. Ultrasound contrast agents, when used for myocardial perfusion imaging, were inferior to the results obtained with nuclear imaging studies
    d. The EAE consensus document did not propose additional uses on the basis of peer reviewed publications and suggested using other noninvasive imaging systems

13. Contrast ultrasound has been used in carotid (vascular) applications. These agents are particularly useful due to the following:
    a. In the United States, vascular indications have received a CPT code, and accordingly, CMS provides reimbursement for "off-label" contrast-enhanced vascular applications
    b. Ultrasound contrast agents have not been deemed useful because the agents obscure the measurement of the near and far wall intimamedia-thickness (IMT) and consequently, do not adequately enhance the carotid artery lumen
    c. When performing enhancement of the carotid IMT (c-IMT) measurement, in luminal morphology identification (ulcers/plaques), and the detection of intraplaque angiogenesis is possible
    d. The documented European experience with contrast-enhanced vascular imaging failed to provide evidence of clinical benefit

14. Therapeutic uses of contrast ultrasound remain as a new application of ultrasound contrast agents and as such, represent a departure from diagnostic applications. In which of the following clinical applications, have there been clinical trials utilizing ultrasoundmediated therapy?
    a. Thrombolysis (deep vein thrombosis therapy).
    b. Cardiac stem cell transduction.
    c. Electrolysis for VEGF therapy.
    d. Nonviral, gene transduction for Parkinson disease.

11. b 12. a 13. c 14. a

15. Use of contrast agent in stress echocardiography:
    a. Is contraindicated.
    b. Requires prolonged monitoring.
    c. Results in an interaction of contrast agents and pharmacological stress agents.
    d. Requires no extra precautions beyond routine monitoring for stress echo.

16. This baseline apical four-chamber view of the left ventricle was obtained from examination of a patient (Fig. 26.1).

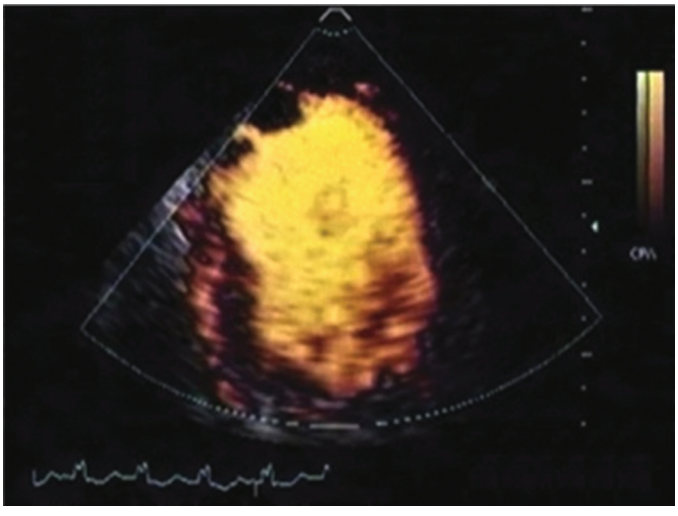


Fig. 26.1

The patient was referred for a dobutamine stress echo (DSE) and this image was obtained after injecting a contrast ultrasound agent to enhance the LV endocardial surfaces. Of note, these masses were not observed prior to the use of ultrasound contrast. What should one do next?

a. Continue the DSE, and alert the referring physician of the final results.
b. Call the referring physician and suggest a cardiac catheterization if the DSE result is positive for inducible ischemia.
c. Stop the DSE examination, call the referring physician, and initiate full anticoagulation, if there are no contraindications.
d. Pursue a malignancy work up following the completion of the DSE.

15. d 16. c

17. Figure 26.2 was obtained during an outpatient echocardiographic examination.

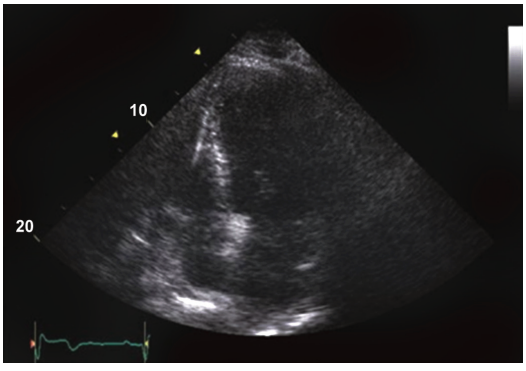


Fig. 26.2A

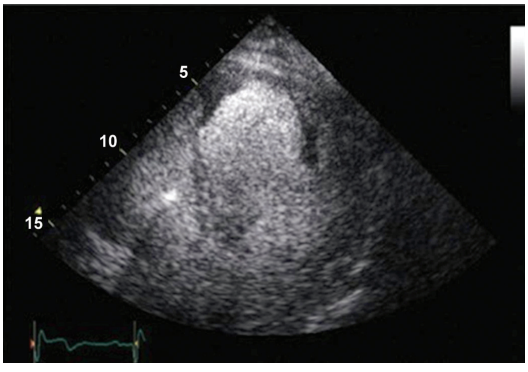


Fig. 26.2B

Fig. 26.2C

At the time of the study, scant past history was available. Because of the difficulty in obtaining a quality image of the ventricle, the patient received an ultrasound contrast agent. Figure 26.2A revealed a technically limited study. Figures 26.2B and C were viewed following the intravenous injection of a contrast agent. What should one consider as the next step?

a. Call the referring physician and suggest a contrast-enhanced magnetic resonance imaging (MRI) or CT examination to confirm the images.
b. Perform a TEE to confirm the images.
c. Proceed with the study and suggest serial follow-up in 3 months.
d. Call the referring physician, suggest full anticoagulation, and schedule serial two-dimensional (2D) echocardiograms to assess therapeutic efficacy.

17. d

18. This patient was referred for an echocardiogram because of the symptoms of shortness of breath (Figs 26.3A and B).

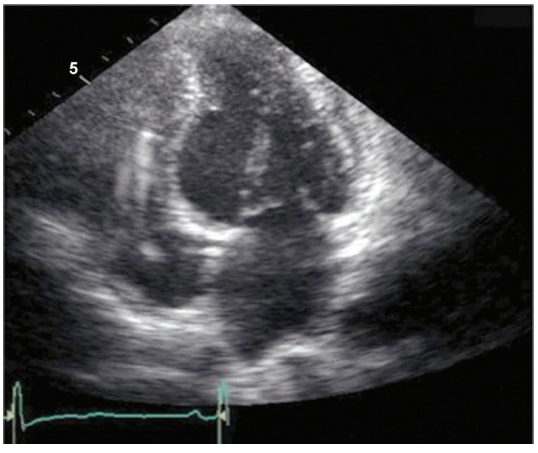


Fig. 26.3A

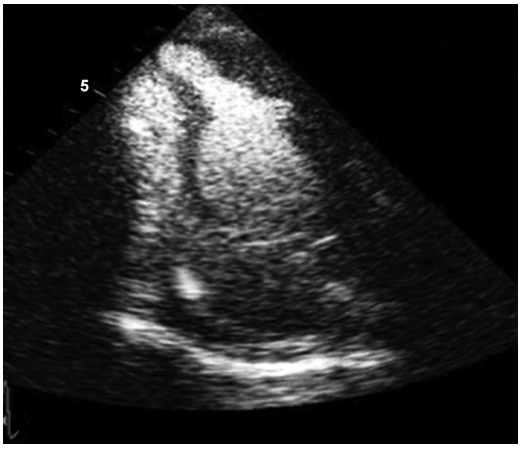


Fig. 26.3B

The initial image revealed an unusual apex. Because of the difficulty in identifying the true endocardial surfaces, an ultrasound contrast agent was indicated. Which of the following statements is correct?

a. The initial images were adequate to make the diagnosis.
b. The contrast-enhanced ultrasound images were diagnostic.
c. A TEE is needed to confirm the images.
d. A contrast-enhanced MRI or CT scan is indicated.

19. This outpatient examination revealed a strand-like mass in the apical region. In real-time, the linear object appeared to be quite mobile. To better define the apex, ultrasound contrast was used (Figs 26.4A and B).

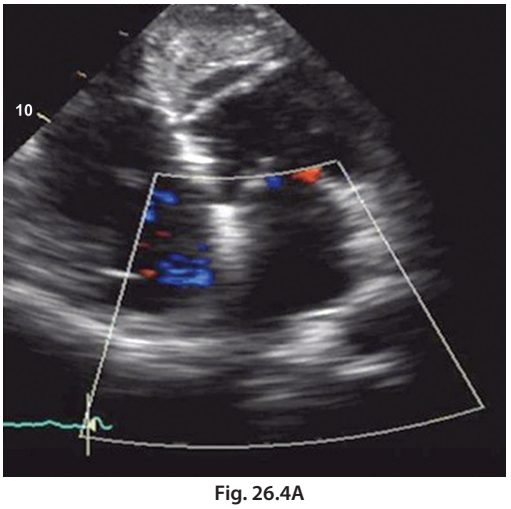


Fig. 26.4A

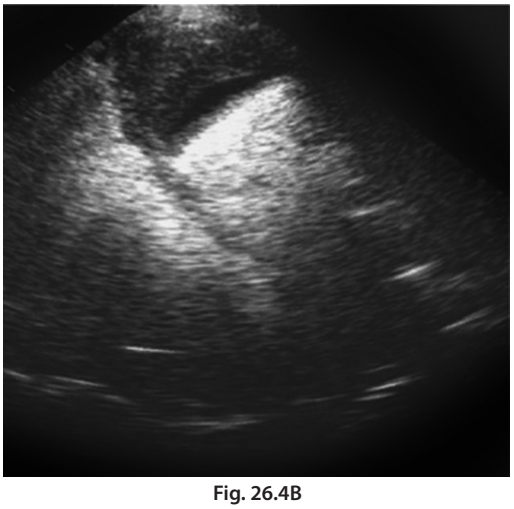


Fig. 26.4B

18. b

The likely diagnosis and/or procedures recommended include the following:

a. There is a false tendon at the apex.
b. A TEE or a contrast-enhanced MRI or CT scan is indicated to visualize the apex.
c. A new, soft thrombus is on the surface of an established apical thrombus.
d. The images represent an imaging artifact due to a technically difficult examination.

20. The series of images in Figure 26.5 was obtained from a patient who had a prior history of coronary artery disease and myocardial infarction. The contrast-enhanced images revealed an abnormality. What is the diagnosis/recommendation?

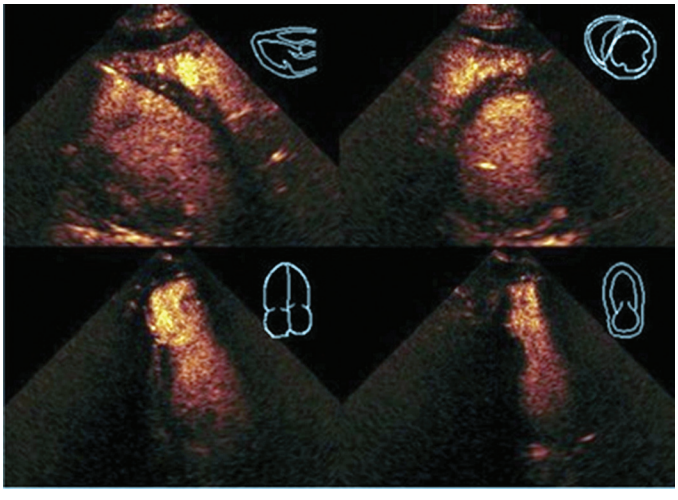


Fig. 26.5

a. Apical aneurysm.
b. Apical thrombus
c. Normal examination.
d. A TEE or contrast-enhanced MRI or CT scan should be obtained.

21. Figures 26.6A and B was obtained by the intravenous injection of an ultrasound contrast agent for luminal enhancement of a patient's carotid artery.

The use of contrast revealed the following observation:

a. The contrast agent produced shadowing of the far wall and no diagnostic information was obtained.
b. Unenhanced ultrasound images provide similar information and the added value of contrast is marginal.
c. The carotid artery revealed a significant, eccentric plaque in the common carotid artery.

19. c 20. a 21. c

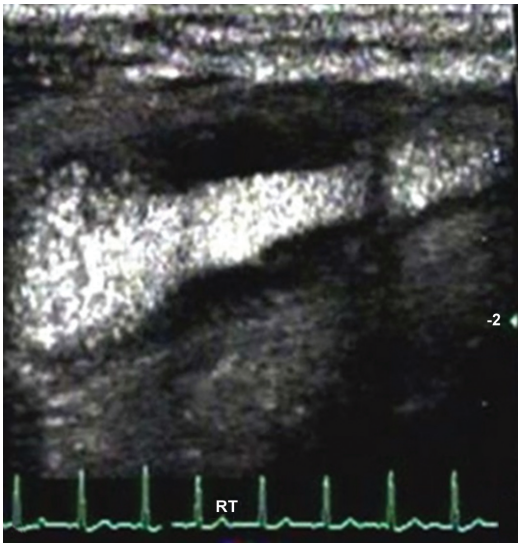


Fig. 26.6A

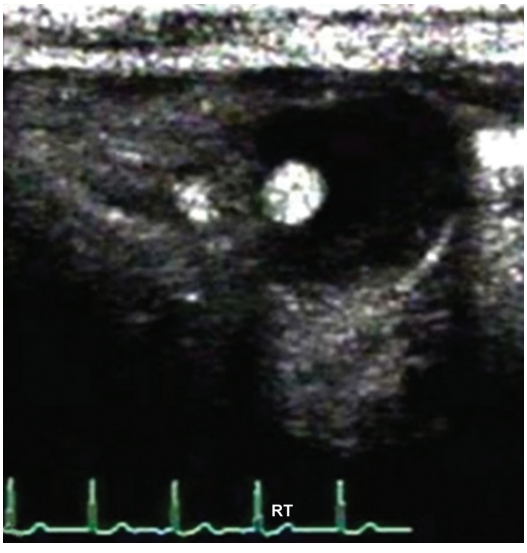


Fig. 26.6B

22. The use of ultrasound contrast agents has been shown to be valuable for identifying the carotid artery luminal surfaces including plaques, ulcers, enhancement of c-IMT, and adventitial and plaque vasa vasorum.
Figure 26.7 illustrates the presence of the following (the structure indicated by the arrow):

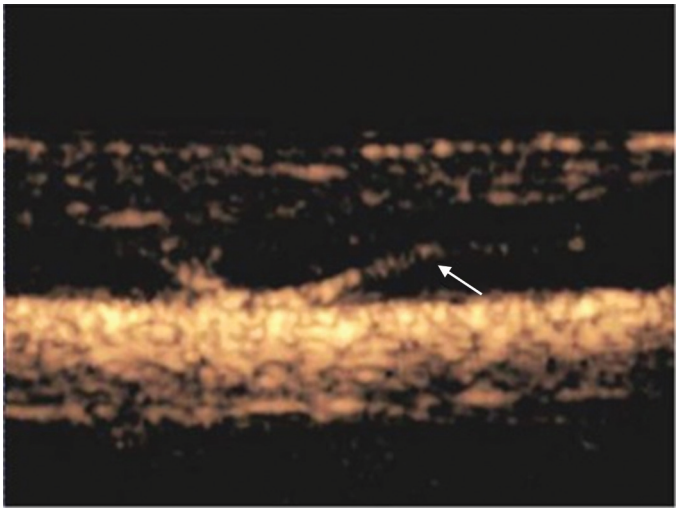


Fig. 26.7

a. Vasa vasorum within the arterial wall.
b. Carotid plaques.
c. Thickened IMT.
d. Imaging artifacts.

22. a

23. In this patient presented with heart failure, contrast was injected intravenously (four-chamber view is shown in Fig. 26.8).

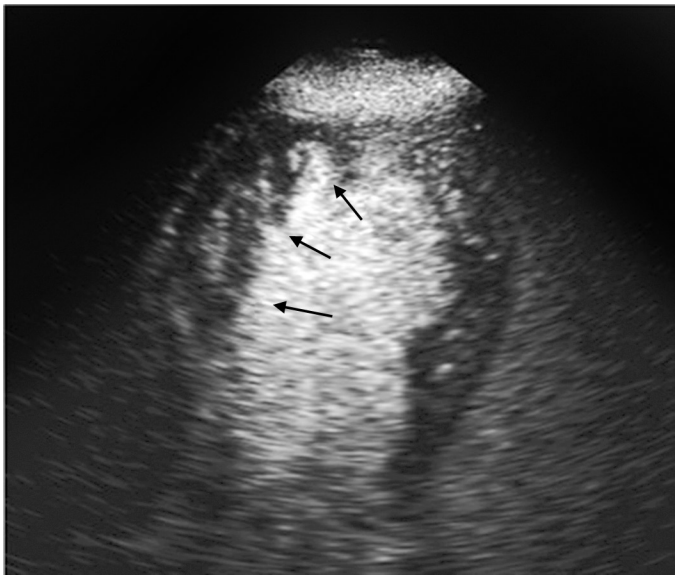


Fig. 26.8

What is the diagnosis?

a. Ischemic cardiomyopathy.
b. Apical hypertrophic cardiomyopathy.
c. Dilated cardiomyopathy.
d. Noncompaction cardiomyopathy.

24. Ultrasound contrast agents are used in vascular imaging for the detection of premature cardiovascular disease. What does the region highlighted by the arrow in Figure 26.9 show?

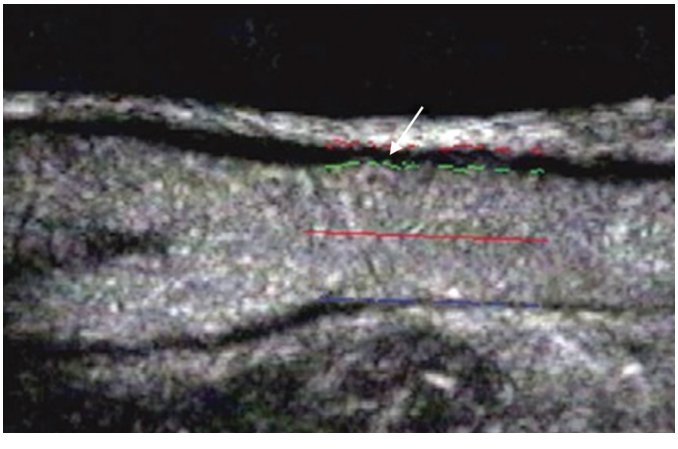


Fig. 26.9

23. d

a. Contrast ultrasound artifact (suggest contrast-enhanced MRI or CT image of the carotid artery).
b. Carotid ulceration highlighted by contrast ultrasound.
c. Carotid tumor with associated perfusion imaging.
d. Computed-aided, contrast-enhanced c-IMT measurements.

25. Contrast ultrasound can be used to highlight the carotid artery luminal surfaces (Fig. 26.10). After the use of intravenous ultrasound contrast, it is possible to identify the following as seen in this image.

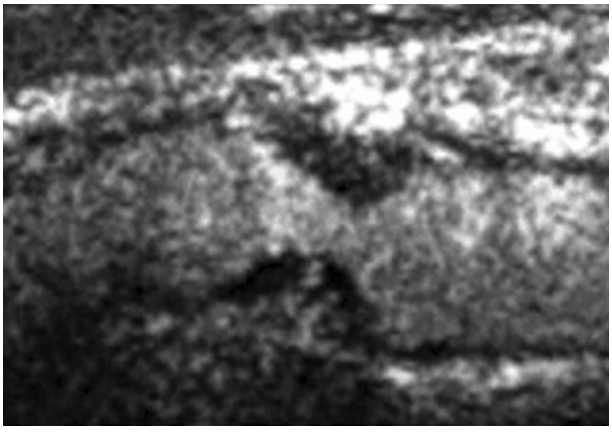


Fig. 26.10

a. Artifact of imaging.
b. Neurogenic carotid body tumor.
c. Dissection of the carotid artery.
d. Carotid artery stenosis.

24. d 25. d

Answers

1. c. The origins of Contrast-enhanced ultrasound imaging (CEUS) date to the earliest observations of Claude Joyner and publications of Gramiak and Shah in 1968. These authors used agitated solutions of saline and indocyanine green to identify the anatomic structures of the aortic root with M-mode ultrasound. Subsequent interest in the development of ultrasound contrast agents and clinical applications continues today, more than 40 years later.
   In the early developmental phase of CEUS, nearly all diagnostic imaging modalities utilized blood pool, enhancement agents to define anatomic or physiologic structures including tissue perfusion. Today, due primarily to the unique physical parameters of the microbubbles, serve as true, intravascular indicators, capable of providing unparalleled access to the inherent spatial and temporal heterogeneity of tissue perfusion. Importantly, the microbubbles serve a dual role, they are promoted as a diagnostic enhancement agent but also serve as therapeutic delivery agents, which when fully realized have the potential to dramatically alter treatment of numerous diseases.
2. d. The two currently approved ultrasound contrast agents available in the United States are Optison and Definity. Levovist, SonoVue, and Sonazoid are approved for clinical use in Europe, Japan, and several other continents/countries.
3. a. Although unknown to clinicians at the time, the use of high mechanical indices (31.0 MI) while useful in providing a higher signal to noise ratio for fundamental imaging and enhancing the 2D images, actually promoted ultrasound contrast agent destruction; hence, the observed reduced *in vivo* persistence of the first-generation agents. Today, implementation of sophisticated harmonic imaging systems and use of low mechanical indices prolongs persistence, leading to enhancement of the signal-to-noise ratio, and provides useful clinical information. The implementation of relatively persistent gases and the development of harmonic imaging systems significantly prolonged the efficacy of the second-generation agents. The development of "second" -generation agents coupled with the harmonic imaging system satisfied the efficacy requirements for widespread clinical utility. These agents generally utilized high molecular weight, low soluble gases that promoted *in vivo* persistence. The second-generation ultrasound agents, coupled with harmonic imaging systems, appeared to fulfill the required clinical expectations for safe, efficient, and economical noninvasive imaging of the left-sided cardiac chambers (i.e. LVO and myocardial perfusion). The "third" generation of contrast agents may be considered as "designer" contrast agents. This latest group often involves the application of specific labeling chemistries to perform quantitative physiologic localization of inflammation and related disease states. Ultimately, what could be considered the "fourth-generation" (therapeutic) contrast agents include systems that serve as therapeutic applications (site-specific drug/gene delivery systems).
4. b. There are two FDA-approved ultrasound contrast agents: Optison (GE Medical Diagnostics, Princeton, NJ) and Definity (Lantheus Medical Imaging, Billerica, MA). Several additional agents approved for clinical use in the world include Sonazoid, SonoVue, Echovist and Levovist. Most of these agents are perflurocarbon types. Ultrasound contrast agents are indicated for use in patients with suboptimal echocardiograms and to improve the delineation of the LV endocardial borders. The ASE in 2000 and 2008 and the EAE 2009 issued position papers focused on the indications for usage of ultrasound contrast agents in the clinics.
   Left ventricular endocardial border detection.

Fig. 26.11A

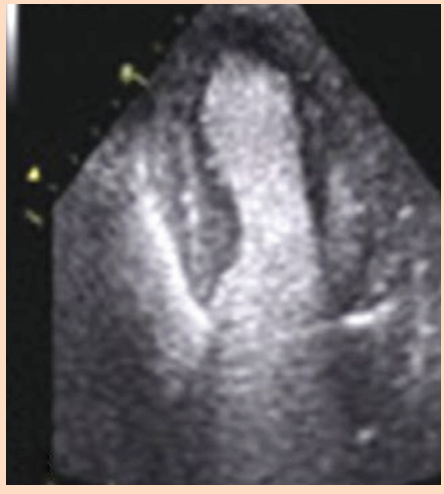


Fig. 26.11B

5. a. Based on the ASE Consensus Statement on the Clinical Applications of Ultrasonic Contrast Agents in Echocardiography (abstracted from the ASE document), the following criteria are listed for use:
Difficult-to-image patients presenting for rest echocardiography with reduced image quality
Enable improved endocardial visualization and assessment of left ventricular (LV) structure and function when ≥2 contiguous segments are not seen on non-contrast images
Reduce variability and increase accuracy in LV volume and LV ejection fraction (LVEF) measurements by 2-dimensional (2D) echocardiography
Increase the confidence of the interpreting physician in LV functional, structure, and volume assessments
All patients presenting for rest echocardiographic assessment of LV systolic function (not solely difficult-to-image patients)
Reduce variability in LV volume measurements through 2D echocardiography
Increase the confidence of the interpreting physician in LV volume measurement
Difficult-to-image patients presenting for stress echocardiography with reduced image quality
Obtain diagnostic assessment of segmental wall motion and thickening at rest and stress
Increase the proportion of diagnostic studies
Increase reader confidence in interpretation
Confirm or exclude the echocardiographic diagnosis of the following LV structural abnormalities, when nonenhanced images are suboptimal for definitive diagnosis
Apical variant of hypertrophic cardiomyopathy
Ventricular noncompaction
Apical thrombus
Complications of myocardial infarction, such as LV aneurysm, pseudo-aneurysm, and myocardial rupture
Assist in the detection and correct classification of intracardiac masses, including tumors and thrombi
For echocardiographic imaging in the ICU when standard imaging does not provide adequate cardiac structural definition.
For accurate assessment of LV volumes and EF

For exclusion of complications of myocardial infarction; i.e. LV aneurysm, pseudoaneurysm and myocardial rupture.
Enhance Doppler signals when a clearly defined spectral pattern is not visible and is necessary to the evaluation of diastolic and/or valvular function

6. d. Contrast echocardiography: evidence-based recommendations published by EAE (abstracted from the EAE 2009): Indications for resting left ventricular opacification contrast echo in patients with suboptimal images
(1) Enable improved endocardial visualization and assessment of LV structure and function when two or more contiguous segments are NOT seen on non-contrast images.
(2) Allow accurate and repeatable measurements of LV volumes, and ejection fraction by 2D echo.
(3) Increase confidence of the interpreting physician in the LV function, structure and volume assessments
(4) Confirm or exclude the echocardiographic diagnosis of the following LV structural abnormalities, when non-enhanced images are suboptimal for definitive diagnosis:
Apical hypertrophic cardiomyopathy
Ventricular non-compaction
Apical thrombus
Ventricular pseudoaneurysm
Indications for use of contrast in stress echocardiography
When two or more endocardial border contiguous segments of LV are not well visualized in order to:
Obtain diagnostic assessment of segmental wall motion and thickening at rest and stress
Increase the proportion of diagnostic studies
Increase reader confidence in interpretation

7. c. Based upon established guidelines, ultrasound contrast agents are indicated for use when two or more LV endocardial surfaces cannot be visualized in any image plane (see Figures 26.11A and B).

8. b. Today, with advanced ultrasound imaging systems including harmonic software modifications, experts agree that approximately 10–30% of all transthoracic echo images are considered technically difficult or uninterruptible. Based on published ASE guidelines, the echo study is classified as technically difficult if two or more endocardial regions are not visualized.
Importantly, in 2009, Kurt et al. performed a large cohort, prospective study, which was designed to assess the efficacy of the routine use of ultrasound contrast for LV chambers enhancement. The authors concluded that the use of ultrasound contrast agents significantly and positively impacted diagnostic accuracy and resource utilization, ultimately benefiting patient management. In their study, ultrasound contrast agents were indicated in 14.5% of the cohort (total population 3 4,362; 632 patients received ultrasound contrast). The impact of contrast usage resulted in a change in therapy, additional procedures, or both in 35.6%. Clearly, the highest benefit of the use of ultrasound contrast agents accrued to patients hospitalized in the SICU. In this critically ill population, the authors noted a change in therapy or procedures in 62.7% of the subjects. In addition, the authors commented on a reduction in subsequent testing, which included exposure to ionizing radiation and invasive imaging.

9. d. The two current ultrasound contrast agents that have been approved by the United States FDA include (1) Optison, approved in 1997 and (2) Definity in 2001. Following a series of self-reported adverse events over the last several years, the FDA officials responded in October 2007 issuing a "Black box" warning on both perflutren ultrasound contrast agents. This warning included language describing the risk of "serious cardiopulmonary reactions" within 30 minutes of administration of these agents. Several new contraindications were added to the package label including the following:

- worsening or clinically unstable heart failure; (2) AMI or acute coronary syndrome; (3) serious ventricular arrhythmia or high risk for arrhythmias due to QT prolongation; (4) respiratory failure; and (5) severe emphysema, pulmonary emboli, or other conditions that cause pulmonary hypertension. In lieu of these new contraindications, a 30-minute monitoring period was mandated for all patients who received these agents.
- Subsequent to the FDA's revised warnings, an international grassroots organization of physicians, sonographers, nurses, and interested parties appealed to the FDA to reconsider the new restrictions placed on the ultrasound contrast agents. Subsequently, recognized professional organizations (EAE and ASE) voiced strong concern over the new labeling limitations placed on the ultrasound contrast agents.
- In May of 2008, the FDA officials revised the October 2007 "Contraindications" and subsequently changed the language to a warning. The 30-minute monitoring period following contrast administration continued to apply to those patients with pulmonary hypertension or who were deemed critically ill.

10. b. In direct response to the FDA labeling changes of ultrasound contrast agents, clinicians responded with peer-reviewed publications, which revealed the relative safety of using ultrasound contrast agents. As of May 2009, more than 228,611 patient experiences have been summarized in the literature. Further, the clinical community, grassroots organizations, and professional societies continue to provide leadership in producing scientific/clinical data highlighting the important clinical utility and safety of ultrasound contrast agents.
A summary of the clinical safety publications are as follows:
    - Erb JM, Shanewise JS. Intraoperative contrast echocardiography with intravenous Optison does not cause hemodynamic changes during cardiac surgery. J Am Soc Echocardiogr. 2001;14:595–600.
    - Herzog CA. Incidence of adverse event associated with use of perflutren containing contrast agents for echocardiography. JAMA. 2008;299:2023–5. Hennepin County MC Registry.
    - Kusnetzky LL, Khalid A, Khumri TM, Moe TG, Jones PG, Main ML. Acute mortality in hospitalized patients undergoing echocardiography with and without an ultrasound contrast agent: results in 18,671 consecutive studies. J Am Coll Cardiol. 2008;51:1704–6.
    - Main ML, Ryan AC, Davis TE, Albano MP, Kusnetzky LL, Hibberd M. Acute mortality in hospitalized patients undergoing echocardiography with and without an ultrasound contrast agent (multicenter registry results in 4,300,966 consecutive patients). Am J Cardiol. 2008;102:1742–6.
    - Wei K, Mulvagh SL, Carson L, et al. The safety of Definity and Optison for ultrasound image enhancement: a retrospective analysis of 78,383 administered contrast doses. J Am Soc Echocardiogr. 2008;21:1202–6.
    - Dolan MS, Gala SS, Dodla S, et al. Safety and efficacy of commercially available ultrasound contrast agents for rest and stress echocardiography a multicenter experience. J Am Coll Cardiol. 2009;53:32–8.
    - Gabriel RS, Smyth YM, Menon V, et al. Safety of ultrasound contrast agents in stress echocardiography. Am J Cardiol. 2008;102:1269–72.
    - Main ML, Exuzides A, Colby C, et al. Abstract presented March 2009, American College of Cardiology Safety Studies OptisonTM does not increase mortality in critically ill patients: a retrospective matched case-control. J Am Coll Cardiol. 2009.
    - Anantharam B, Chahal N, Chelliah R, Ramzy I, Gani F, Senior R. Safety of contrast in stress echocardiography in stable patients and in patients with suspected acute coronary syndrome but negative 12 hours troponin. Am J Cardiol. 2009;104:14–8.

11. b. Ultrasound contrast agent safety status (2009):
    - The October 2007 FDA product label changes were substantially revised in May 2008.
    - Multiple, clinical safety studies reported in 2008–09 consistently revealed the fact that there existed no identifiable "safety signal" in more than 228,611 patients.

- Further reversal of the October 2007 product label changes awaits completion of the FDA mandated risk management plans.

12. a. In 2009, the EAE published a position paper on the clinical use of contrast echocardiography for the assessment of myocardial perfusion. The paper postulated that on the basis of present evidence, Myocardial Contrast Echocardiography (MCE) may now be used clinically both at rest and during stress for the detection of coronary artery disease, acute coronary syndrome, and myocardial viability. Coronary flow reserve may also be performed using quantitative MCE.
13. c. The vascular applications of ultrasound contrast agents are legion. Similar to the current clinical indications for echocardiography applications, ultrasound contrast agents provide enhanced images of the large vessels, and specifically, the aorta, carotid arteries, and peripheral venous systems. Recent reports have documented the added value of ultrasound contrast agents in providing a valuable alternative to more invasive imaging technologies. The clinical applications for vascular applications are not yet approved in the United States; however, these applications are approved in Europe.

    Subsequently, investigators identified the presence of angiogenesis within the human carotid plaque. The published literature now reflects and international appreciation of the use of ultrasound contrast agents for detection and quantification of the vasa vasorum (angiogenic) vessels associated with atherosclerosis. It is now recognized that the initial vessel wall inflammation identified in such diverse disease states as diabetes, atherosclerosis, cancer, and inflammatory states have as a unifying requirement, a blood supply.
14. a. A clinical trial was initiated using ultrasound contrast agents for the dissolution of venous thrombi. The results are yet to be published. The therapeutic application of ultrasound contrast agents provides a distinct demarcation between diagnostic imaging and medical therapeutics. The key to this therapeutic application lies in the fact that the microbubble shell integrity can be externally altered via externally applied acoustic pressure leading to enhanced disruption of thrombi, and intriguingly enough, provides a mechanism to produce site-specific drug and gene delivery systems; providing access to a nonviral delivery system. Leading scientists have successfully demonstrated nonviral transduction through sonoporation in a variety of preclinical scenarios. Clearly, the exciting scientific developments are beyond the scope of this brief mention but command attention for the future applications of ultrasound contrast agents.
15. d. Several large studies clearly established the safety of contrast agents in stress echocardiography. In fact, contrast agents are used more in high-risk stress echo patients. In a recent study, it was shown that despite the use of contrast agents in higher risk patients compared with noncontrast stress echo studies, there was no difference in the side-effect profile.
16. c. Following the intravenous injection of an ultrasound contrast agent, this baseline apical four-chamber image revealed several masses in the apical region in a patient who had suffered a prior myocardial infarction. When seen in real-time, the dyskinetic apical segments likely served as a source for reduced blood flow, which may have lead to the formation of a mural thrombi. When confronted with these findings, it is reasonable to stop the DSE, call the referring physician, and begin full anticoagulation. If one chooses to continue the DSE, there may be an ill-defined risk of dislodging the mobile thrombi.
17. d. Note the presence of a large mass in the apical region of the left ventricle. Based on this finding, the patient may require full anticoagulation and subsequent follow up with contrast-enhanced echocardiograms. Generally, when LV masses are identified, it is prudent to ascertain the clinical history. The presence of a significant regional wall motion abnormality coupled with a history of a prior myocardial infarction, is consistent with the finding of apical thrombi. Although additional testing could be performed, the contrast-enhanced 2D echocardiogram provided a safe and cost-effective method for diagnosing this mass.

18. b. The appropriate and judicious use of ultrasound contrast in this case confirmed the diagnosis of an apical hypertrophy ("spade heart"). Although additional imaging modalities may be used to corroborate the findings, the use of a contrast-enhanced ultrasound examination provides a rapid, economical, and low-risk procedure. A TEE and/or a contrast-enhanced CT scan provide alternatives; however, the contrast-enhanced transthoracic echocardiogram provided diagnostic information without incurring additional risk of ionizing radiation exposure to the patient.
19. c. The images-reveal a mobile thrombus attached to the surface of a previous apical thrombus. When these baseline images were viewed without the use of an ultrasound contrast agent, it appeared that the band-like structure was a false tendon. However, following the use of an ultrasound contrast agent, it became obvious that the band was the "leading edge" of a newly developed apical thrombus.
20. a. The presence of an apical aneurysm was clearly demonstrated following the clinically indicated use of ultrasound contrast agents. When viewed in multiple planes and in real-time, the region of interest (apex) revealed a dyskinetic segment with outward motion and systolic expansion. These findings are consistent with the diagnosis of an apical aneurysm.
21. c. The contrast-enhanced carotid artery revealed a significant eccentric, carotid artery atherosclerotic plaque. The ultrasound contrast agent (white) appears to fully opacify the carotid artery lumen, and the unenhanced (black) regions represent the vessel wall and accompanying plaque.
22. a. The contrast-enhanced vascular image revealed vessel wall angiogenesis (vasa vasorum). The lumen is enhanced (white) following the intravenous injection of an ultrasound contrast agent. The extra-luminal structures represent the vasa vasorum. These images represent a physiologic response to vessel wall inflammation through the induction of angiogenesis (vasa vasorum). The vessel wall hypoxia (ischemia) likely triggered subsequent signaling of VEGF proteins and the growth of the vasa vasorum.
23. d. The contrast-enhanced image shows contrast microbubbles traversing the myocardial structure and delineating trabeculation in the inner third of the myocardium. This is characteristic of a noncompacted myocardium. Noncompaction is a congenital disorder of persistence of fetal spongiform myocardium. Normally this differentiates into normal myocytes. The persistence of the spongiform structure weakens the myocardium resulting in dysfunction.
24. d. The contrast-enhanced carotid image associated with the green computer line outlines the near wall c-IMT. Today, there are numerous commercially available, computer-aided algorithms for c-IMT detection. Although the near-wall c-IMT can be difficult to visualize, the use of ultrasound contrast agents provides an opportunity to fully analyze the entire carotid vascular system.
25. d. The use of ultrasound contrast agents revealed severe carotid stenosis due to the presence of atherosclerosis. The use of contrast ultrasound also provides a clearer definition of the luminal characteristics of the carotid artery and related atherosclerotic plaques. Of note, intraplaque angiogenesis (vasa vasorum) was identified following the intravenous use of ultrasound contrast agents.

27

Echocardiography for Systolic Function

1. The change in left ventricular (LV) function attributable to cell therapy is sought in a post-infarct patient. Which of the following echocardiographic measures is the most feasible and closest analog of systolic elastance as a marker of myocardial contractility?
   a. Ejection fraction (EF)
   b. Systolic strain rate
   c. Myocardial performance ("Tei") index
   d. Systolic strain
   e. dP/dt measured from the mitral regurgitant jet

2. A patient after inferior infarction is thought on clinical grounds to have right ventricular (RV) infarction. Which parameters give a reliable assessment of RV function?
   a. 2D RV EF
   b. Myocardial performance (Tei) index
   c. Tricuspid annular plane displacement (TAPSE)
   d. RV S'
   e. None of the above are reliable

3. The development of end-systolic cavity obliteration during stress echocardiography reduces the development of ischemia, likely because of reduced wall stress. Wall stress is:
   a. Proportionate to transmural pressure and chamber size
   b. Inversely proportionate to transmural pressure and chamber size
   c. Proportionate to wall thickness
   d. The same as systolic strain
   e. Readily measured on a regional basis

4. Visual assessment of EF is sometimes required (e.g., in an emergency). What are the potential limitations of visual EF?
   a. Inability to interrogate multiple imaging planes simultaneously
   b. Image quality
   c. Extremes of heart rate
   d. Experience of the reviewer
   e. All of the above

1. b 2. e 3. a 4. e

5. A patient presenting with chest pain undergoes an echocardiogram during pain. The presence of segmental wall motion abnormality is:
   a. A marker of abnormal myocardium
   b. Indicative of a high likelihood of myocardial ischemia
   c. Identified with thickening of <50% or excursion <5 mm
   d. Uninterpretable in the setting of left bundle branch block (LBBB)
   e. Useful in a diagnostic sense but not prognostically

6. After implantation of a biventricular pacing device, a 55-year-old patient with dilated cardiomyopathy continues to complain of functional class III symptoms and there is no reduction of LV volumes. What factors are important in considering device optimization?
   a. There is no evidence to support its use
   b. The role of mechanical dyssynchrony is in question since publication of the prospect results
   c. The iterative technique for aortic valve (AV) optimization is based on observation of the LV filling curve at various pacing settings
   d. Site of previous infarction
   e. Site of the LV lead

7. Following anterior myocardial infarction (MI), a 70-year-old man has an EF of 40% with an end-systolic volume (ESV) of 95 ml (50 ml/m^2). In what range is his 5-year mortality?
   a. 10%
   b. 15%
   c. 20%
   d. 30%
   e. 50%

8. In the course of auditing the activity of your echocardiography laboratory, you find that 18% of studies have had a previous echocardiogram. On investigating the matter further, you find that the majority are for inpatients with worsening heart failure (HF). Which of the following are true regarding repeat echocardiograms?
   a. Repeat echo is a class I indication from the ACC/AHA guidelines
   b. 95% confidence intervals for EF are ±11%
   c. 95% confidence intervals for LV mass (LVM) are ±60 g
   d. All of the above
   e. None of the above

9. LV strain has been proposed as a simple quantitative tool for assessing LV function. Which of the following is associated with reduced strain, irrespective of myocardial status?
   a. Decreased afterload
   b. Decreased preload
   c. Decreased heart rate
   d. All of the above
   e. None of the above

10. Measurement of midwall shortening provides information that is inconsistent with endocardial shortening in:
   a. Normal hearts
   b. Dilated cardiomyopathy
   c. Concentric remodeling
   d. Eccentric LV hypertrophy (LVH)
   e. Concentric LVH

11. Accurate measures of LV volumes are needed in the course of follow-up of patients with asymptomatic mitral regurgitation (MR). Which is the most accurate option?
   a. 2D echocardiogram
   b. 2D echocardiogram with contrast
   c. 3D echocardiogram
   d. 3D echocardiogram with contrast
   e. Transesophageal echocardiogram

5. c 6. c 7. d 8. d 9. b 10. e 11. d

12. Given its high workload and distance from nutrient supply, the subendocardium is an important site of pathology. Which techniques could be used to assess subendocardial function?
    a. Longitudinal, circumferential, and transverse strain
    b. Integrated backscatter
    c. Myocardial contrast echocardiography with high MI
    d. None of the above
    e. All of the above

13. Which of the statements regarding the application of new technologies is true?
    a. Systolic velocity is a useful marker of regional systolic function
    b. 3D measurements will be useful for the assessment of diastolic function
    c. Deformation analysis is useful for the assessment of myocardial viability
    d. None of the above
    e. All of the above

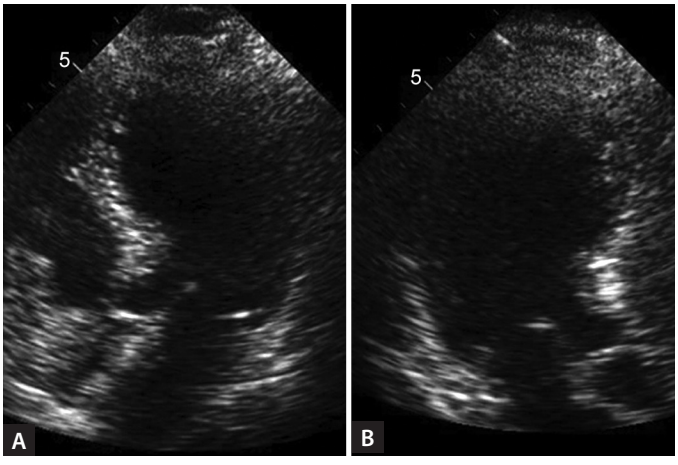
14. Which of the following statements is true regarding the application of new technologies to the different stages of HF?
    a. Myocardial deformation is of value in the detection of stage B HF
    b. 3D measurements are of most value in stages C and D
    c. Tissue velocity is of use in all stages
    d. None of the above
    e. All of the above

15. A patient with hypertension has septal and posterior wall thickness of 12 and 13 mm, respectively, with an end-diastolic dimension of 52 mm. How would you characterize these LV dimensions?
    a. Normal LV geometry
    b. Concentric remodeling
    c. Concentric hypertrophy
    d. Eccentric hypertrophy
    e. None of the above

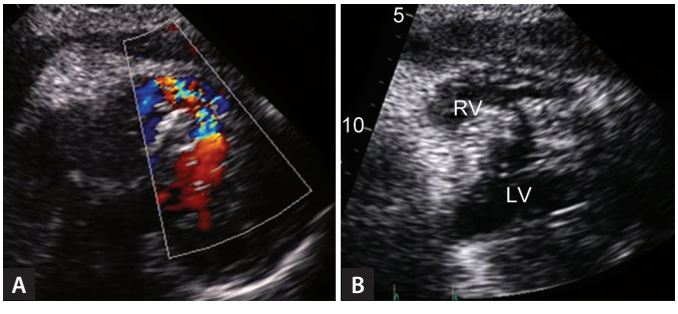
16. A 48-year-old woman presents to the hospital with chest pain following a motor vehicle accident. She has anterior ST segment elevation and an echocardiogram is performed because of pulmonary congestion. Color Doppler of the LV outflow tract shows aliasing. Echocardiographic images in the apical four- and two-chamber views are provided in Figures 27.1A and B.
    The likely diagnosis is:
    a. Hypertrophic cardiomyopathy (HCM)
    b. Large anteroseptal MI
    c. Stress (Takotsubo) cardiomyopathy
    d. Multivessel ischemia
    e. Cardiac contusion

17. A systolic murmur is heard in a 67-year-old man, 3 days following MI. The echocardiogram in Figures 27.2A and B show:
    a. Papillary muscle rupture
    b. Postinfarct ventricular septal defect (VSD)
    c. Congenital (perimembranous) VSD
    d. Congenital (muscular) VSD
    e. Ischemic MR

12. a 13. c 14. e 15. c 16. c 17. b



Figs 27.1A and B

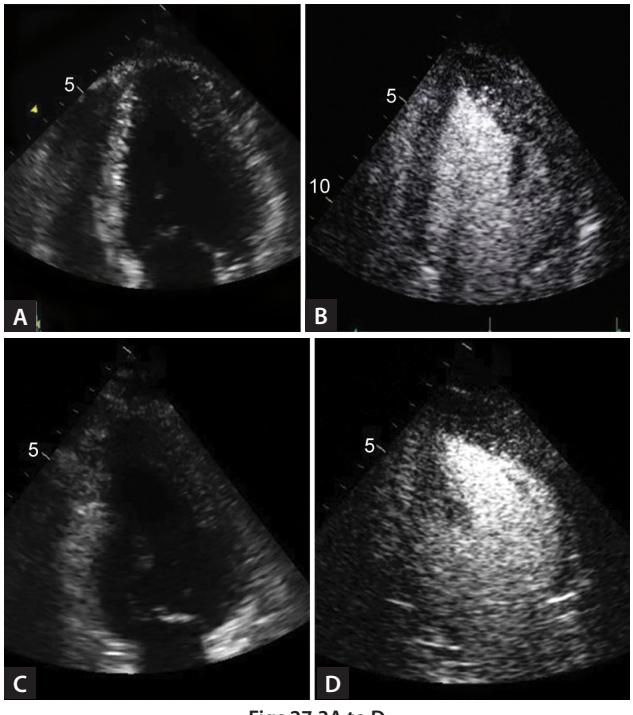


Figs 27.2A and B

18. A 27-year-old man is found to have anterolateral T-wave inversions when an ECG is performed during a routine insurance physical examination. The echocardiogram with and without contrast in Figures 27.3A to D shows:
    a. Apical tumor (fibroma)
    b. Apical muscular band
    c. Apical HCM (Yamaguchi variant)
    d. Apical foreshortening
    e. Noncompaction cardiomyopathy

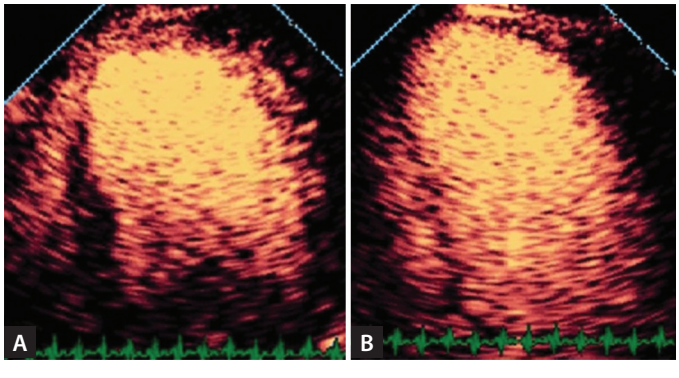
19. A 68-year-old woman presents with HF. There is no family history, she has previously been well and takes no medication. The ECG shows low voltage but is otherwise unremarkable. The echocardiogram shows low tissue velocity (E' 4 cm/sec) with left atrial enlargement and a pseudonormal filling pattern.
    The likely diagnosis is:
    a. Fabry disease
    b. Hypertensive heart disease
    c. HCM
    d. Amyloidosis
    e. Sarcoidosis

18. c 19. d



Figs 27.3A to D

20. A 48-year-old man with renal impairment has presented late after an MI. There are no Q waves and preservation of R waves on the ECG but an apical wall motion abnormality. Coronary angiography has been withheld because of concerns regarding possible nephrotoxicity, so a myocardial contrast perfusion study is performed with a destruction-replenishment protocol (Figs 27.4A and B).
The findings suggest:
   a. LCX scar
   b. Medical management is appropriate
   c. RCA scar
   d. Stunned myocardium in the LAD territory
   e. LAD scar



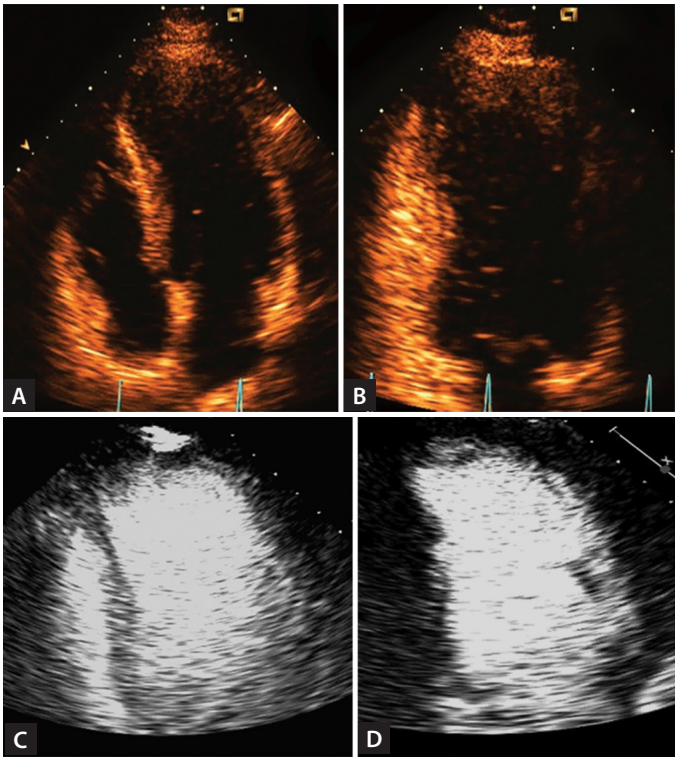
Figs 27.4A and B

20. d

21. This 2D echocardiogram (apical four-chamber view in Video 10-6) was obtained following an out-of-hospital cardiac arrest in a 37-year-old man, who has continued to have episodes of ventricular tachycardia in the coronary care unit.
The findings suggest:
    a. RV infarction
    b. Pulmonary embolism (McConnell's sign)
    c. Arrhythmogenic RV dysplasia
    d. Pulmonary hypertension and cor pulmonale
    e. Cardiac rotation with off-axis imaging

22. A 72-year-old patient becomes hypotensive following presentation with a myocardial infarction.
The findings of this subcostal image suggest:
    a. RV infarction
    b. Pulmonary embolism (McConnell's sign)
    c. Arrhythmogenic RV dysplasia
    d. Pulmonary hypertension and cor pulmonale
    e. Cardiac rotation with off-axis imaging

23. A routine echocardiogram is performed 5 days following primary angioplasty to the left anterior descending coronary artery (Figs 27.5A to D).

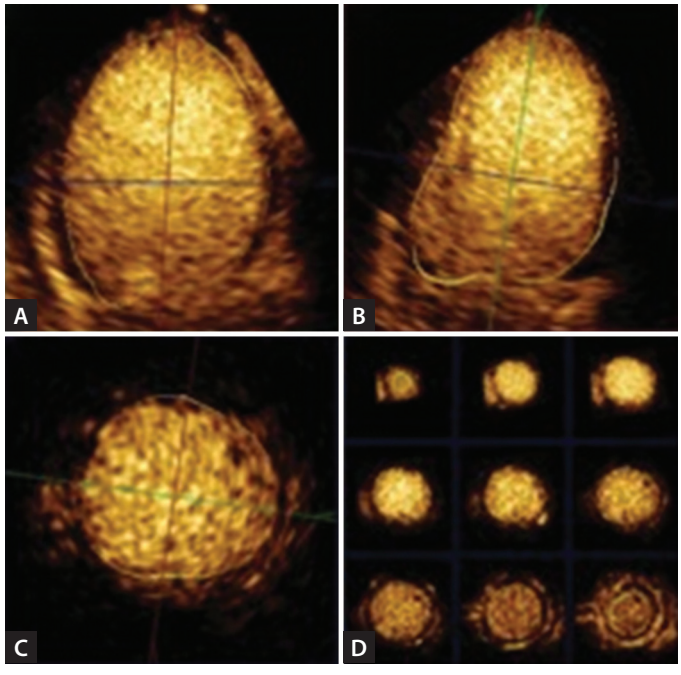


Figs 27.5A to D

21. c 22. a

The findings suggest:
a. Subacute rupture
b. Apical muscle band
c. Apical scar
d. Apical thrombus
e. Multivessel coronary artery disease

24. A resting 3D echocardiogram was performed on a 62-year-old patient with type 2 diabetes who presented with dyspnea (Figs 27.6A to D).



Figs 27.6A to D

The findings suggest:
a. Normal LV function
b. Diffuse LV dysfunction
c. Left anterior descending scar
d. Right coronary scar
e. Left circumflex scar

23. d 24. c

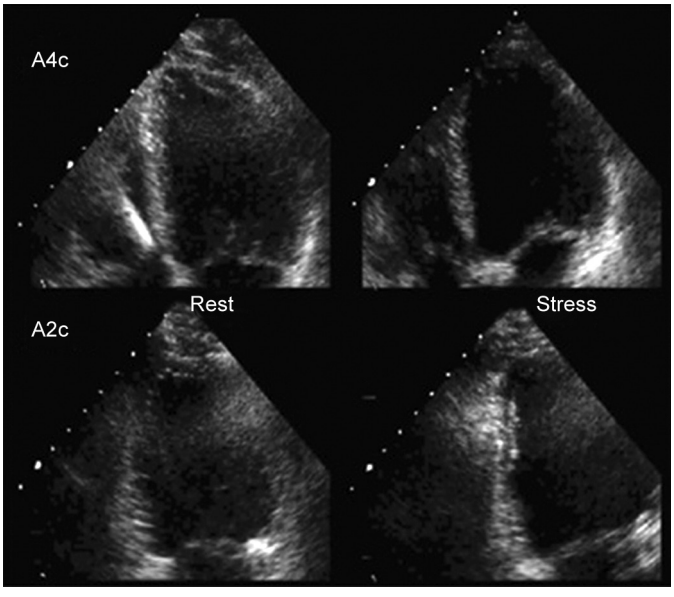


Fig. 27.7

25. An asymptomatic patient with normal LV function but severe MR has bileaflet prolapse. She is uncertain as to whether to proceed to mitral repair and undergoes an exercise echocardiogram.

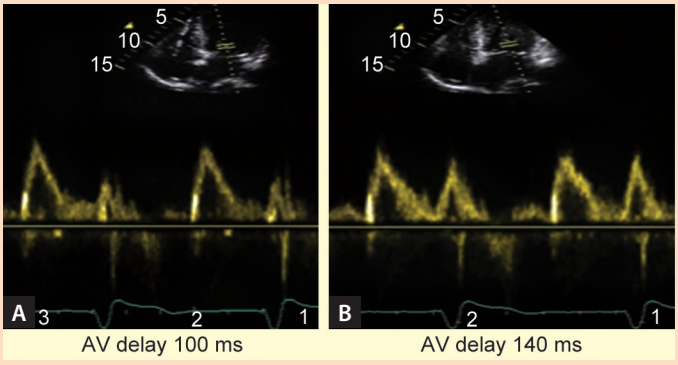
    The apical four- and two-chamber views in Figure 27.7 and Video 10-10, before and after exercise findings, suggest:

    a. Normal LV response to stress
    b. LAD scar
    c. Loss of contractile reserve (CR)
    d. Right coronary scar
    e. Left circumflex scar

25. c

Answers

1. b. Contractility is a term that is often misused to describe systolic function. In fact, it is a parameter that reflects systolic function independent of loading. Changes in cardiac function can be attributed to alterations in contractility, if heart rate, conduction velocity, preload, and afterload are held constant. In a study of closed-chest dogs during five different inotropic states, simultaneous LV volume and pressure (obtained from a combined conductance/pressure catheter) and septal tissue velocity measurement showed strain rate to correspond to the contractility marker, dP/dt. It is important to recognize that strain rate for this purpose relates to tissue velocity–based deformation, which is obtainable at high frame rate (usually >100/sec), and not speckle-based strain rate, which is derived as the maximal gradient from the strain curve, but is constrained by a lower acquisition rate (usually 70/sec). Although tissue velocity imaging strain rate has problems (related to signal noise and the directional component of Doppler) that are avoided by 2D strain, the ability to obtain accurate strain rate is an important limitation of speckle strain and needs to be kept in mind in relation to the potential application of these methods.
   In contrast, EF, strain, and the Tei-index are load-dependent variables. Although LV dP/dt can be measured from the MR jet, this is restricted to situations where the MR signal is available and may be compromised in severe MR, as the calculation assumes left atrial pressure is zero.
2. e. The diagnosis of RV infarction should be suspected with hemodynamic changes in a patient after inferior MI, and echocardiography is confirmatory in a qualitative sense. The problem relates to quantitation—the right ventricle is a nongeometric chamber, and 2D volumes are often underestimated because images are frequently off-axis. Depending on whether ESV and EDV are underestimated to the same degree (they may not be), 2D-EF may even vary according to view. TAPSE and RV S′ reflect longitudinal displacement and offer a means of overcoming the geometric limitations of EF calculation. Both may be influenced by the site of MI. The Tei-index is also a reasonable choice, as it is independent of RV geometry and it is not purely a measure of systolic function.
   RV systolic function is notoriously difficult to quantify! There is evidence that the use of 3D can overcome the complexities that derive from its crescentic and irregular shape, and very likely RV evaluation will become an important indication for 3D echocardiography.
3. a. The measurement of wall stress is one of the Holy Grails of hemodynamic assessment, and should be matched to systolic strain—although there are sufficient ranges of error with the measurement of both as to make this correlation difficult with current technologies.
   Wall stress is proportionate to transmural pressure and chamber size and inversely related to wall thickness. From a noninvasive standpoint, although volume and wall thickness can be measured, chamber pressure is more difficult as peripheral and central pressure may be significantly different. The use of tonometry (with a transfer function) may overcome the latter, although this method is not in routine use in most echocardiography laboratories.
   Although global equations for stress are described, regional stress varies in accordance with regional curvature. These calculations may be difficult because curvature assessment is problematic—possibly another matter that might be addressed by the use of 3D echocardiography. Nonetheless, wall stress appears to be a determinant of local remodeling, and the development of cell therapies will eventually mandate an approach to the measurement of this entity.
4. e. As in other qualitative assessments in echocardiography, reviewer experience is an important determinant of accuracy—an expert eye has been shown to be analogous to the trackball for EF measurements. Like all 2D assessments, it is dependent on image quality. Extremes of heart rate can make the assessment challenging and the tomographic approach to the postinfarct ventricle is important. However, visual EF should not be considered the "standard of care." Current guidelines propose the biplane Simpson method as the methodology of choice for



Figs 27.8A and B

volume and EF measurement. An increasing literature supports the use of 3D echocardiography for LV volume and EF measurements. In particular, when echocardiographic measurements of EF may be a component of major decisions, such as suitability for implantable defibrillator or cardiac resynchronization devices, the accuracy and reproducibility of 3D imaging may be attractive.

Although quantitation is accepted as the preferred method, potential problems with respect to spatial and temporal resolution need to be considered. Concerns about spatial resolution can be addressed by appropriate depth and zoom; LV opacification should be considered if two or more myocardial segments are inadequately visualized. Temporal resolution is an issue to the extent that the time course of contraction is neglected by assessment of only end-diastolic and end-systolic images, and global strain or similar parameters may help address this.

5. c. Wall motion abnormalities are usually identified with thickening of <50% or excursion of <5 mm. They are not necessarily a marker of an abnormal myocardium (normal inferior and posterior walls in particular may be hypokinetic) and do not necessarily indicate ischemia (they may be preexisting). Wall thickening (rather than motion or timing) is interpretable with an LBBB. The extent and severity of wall motion abnormality have similar prognostic value to EF.
6. c. There is good evidence to support the benefit of device optimization—both on the basis of its performance in the landmark CRT studies and on the basis of recent publications. The most feasible (and probably most effective) is the iterative technique for AV optimization. This involves pulsed Doppler mitral inflow estimation, with shortening and lengthening of AV delay and observation of the morphology of the transmitral-filling wave. If AV delay is too short, ventricular activation will occur before completion of the mitral A wave. If AV delay is too long, ventricular systole will encroach on diastolic filling time. At the optimal setting of paced AV delay, the time-velocity integral of transmitral flow will be optimized, with no truncation of the mitral A wave (Figs 27.8A and B).

The iterative method for optimization of atrioventricular delay using pulsed Doppler of mitral inflow. The initial AV delay setting of 100 milliseconds shows truncation of the mitral A wave. Optimization at 140 milliseconds avoids truncation of the mitral A wave and maintains an optimal time-velocity integral. Further lengthening of AV delay would be at the cost of delayed systole encroaching on passive filling.

Patient selection for CRT is based on clinical, ECG, and EF criteria. Enthusiasm for using measures of mechanical synchrony has abated since the report of the prospect trial. However, although this trial showed the most common echocardiographic markers to not only be poorly

predictive of outcome but also of limited reproducibility, it has been criticized extensively on methodological grounds. Echocardiographic parameters may yet return as a means of reducing the number of symptomatic or physiologic nonresponders to CRT, which currently exceeds 30%.

The site of previous infarction and position of the LV lead are pertinent to response but less so to optimization. The adverse effects of extensive scarring and lead malposition on CRT response need to be considered in patient selection for CRT—after device implantation, they may be impossible to overcome.

7. d. The assessment of LV volumes carries incremental prognostic information to EF alone. Angiographic data have shown that in patients with mild LV dysfunction, ESV of <95 ml is associated with a 5-year mortality of 10%, but more dilated ventricles are associated with a much worse outcome (30%), and similar findings have been described with echocardiography. In the context of these findings, it is extraordinary that clinical guidelines (e.g., criteria for timing of surgery in regurgitant valve disease) are still based on LV dimensions. The evidence of incremental information based on LV volumes is an argument for more accurate LV volume calculations (e.g., with 3D echocardiography).

It is important that these studies have assessed systolic rather than diastolic volume, which may be increased in the setting of MR, which is widely recognized as a determinant of outcome.

8. d. Repeat 2D echocardiography, although often performed for the reassessment of LV function, is not a sensitive or reliable tool for this purpose. The 95% confidence intervals for EF are ±11% and those for LVM are ±60 g. Both are large changes in biological terms, meaning that minor changes (such as may occur from year to year in the progression of HF—may be 5%, or in response to antihypertensive therapy over a year or two—may be 20 g) are well under the limits of variability of the measurement. The resulting changes are more meaningful in populations than they are in individuals, and the high-level support for appropriateness is perhaps more based on faith than on evidence.

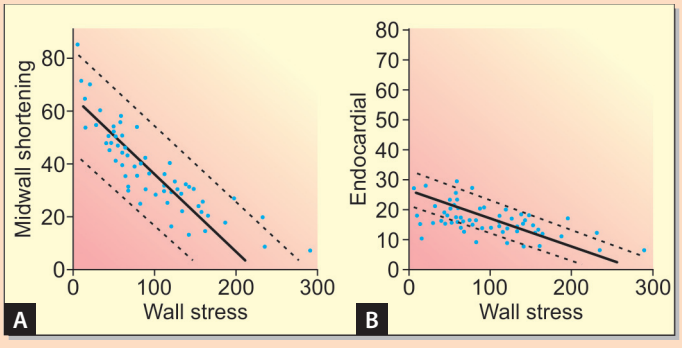
Sources of variability include not only intra- and inter-observer variation, acquisition issues (equipment and sonographers), regression to mean, and biological variation. As some of this variation arises from differences in imaging axis between studies, it is potentially reducible using 3D imaging techniques, and there is some evidence to support this.

9. b. Strain can be considered as an analog of regional EF, as it reflects shortening from the beginning to the end of systole. Reduced preload—which is associated with reduced LV cavity size—will reduce strain, reflecting the lower position of the ventricle on the Frank-Starling curve as well as the lower deformation of an already empty LV cavity. Conversely, reduction of afterload is associated with increased strain, reflecting the lower impedance to LV ejection. Higher heart rate is associated with a reduction of LV filling and reduced strain. These observations are important in understanding the strain and strain rate response to dobutamine stress. Strain rate (which is time dependent) shows a linear increment with dobutamine, whereas strain increases initially but decreases toward peak dose, as the stroke volume falls at higher heart rate.

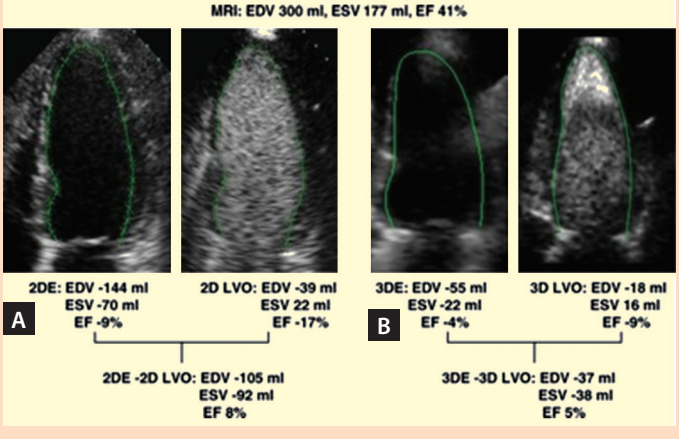
10. e. Endocardial shortening exceeds that in the midwall and is influenced by LV geometry. Midwall measurements are thought to be a better reflector of contractility, perhaps because the circumferential stress vector and the direction of fiber shortening are parallel (midwall fibers are circumferential). This appears to be important in concentric LVH—for example, about one-third of patients with aortic stenosis and normal endocardial shortening have reduced midwall shortening (Figs 27.9A and B).

Aurigemma GP, Gaasch WH. Quantitative evaluation of Left Ventricular Structure, Wall Stress, and Systolic Function. In: Otto CM, editor. The Practice of Clinical Echocardiography, Third Edition. Philadelphia: WB Saunders, 2007;187–211.

11. d. The current guidelines use M-mode LV dimensions as the marker of LV size in the serial assessment of the LV in regurgitant valve lesions. This has the benefit of an established evidence base but the disadvantage of potentially misleading data from off-axis imaging. The tendency to underestimate LV volumes using 2D imaging is reduced by the use of LV opacification, probably because the sonographer becomes more able to identify the true apex and avoid foreshortening. Probably for similar reasons, 3D echocardiography also avoids the underestimation of LV volumes. The combination of 3D imaging and LV opacification offers LV volumes that are closest to those provided by cardiac magnetic resonance imaging (MRI) (Figs 27.10A and B).



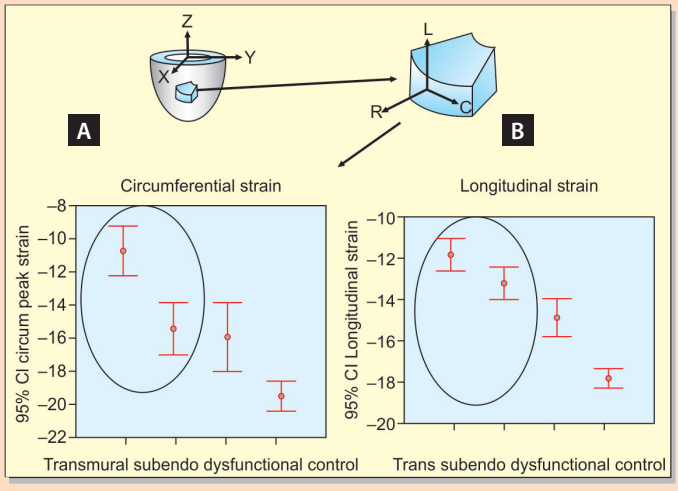
Figs 27.9A and B



Figs 27.10A and B

Comparison of LVEDV measurements with 2D and 3D echocardiography with and without contrast, with measures compared with MRI EDV of 300 ml. The underestimation by 2D echocardiography is substantially reversed by the use of 3D echocardiography or contrast and minimized by the combination of both.

12. a. The ability to derive strain from 2D images (rather than tissue Doppler, which is directional) has enabled strain assessment not only in the longitudinal plane but also in the radial and circumferential planes. Subendocardial dysfunction causes a reduction of longitudinal function (as subendocardial fibers have a longitudinal orientation). Infarctions of relatively limited extent may cause a reduction in longitudinal strain, and the susceptibility of this to worsening strain in proportion to the infarct extent is not completely clear. However, papers in



Figs 27.11A and B

the field are in agreement that the degree of reduction of circumferential and transverse strain is related to the transmural extent of subendocardial dysfunction (Figs 27.11A and B).

Derivation of longitudinal, circumferential, and transverse strain as the association of these with scar extent, defined by contrast-enhanced MRI.

Real-time perfusion imaging has been used to delineate the extent of subendocardial scar, as flow and function can be appreciated in the same sequence (triggered imaging provides perfusion data alone). A recent study has used contrast to delineate the LV cavity during image acquisition with low-energy ultrasound, which emphasizes the increased density of subendocardial scar.

Calibrated integrated backscatter offers a means of defining the reflectivity of myocardium relative to an external frame of reference (e.g., pericardium). Although this technique has been used to define scar and viable tissue, an isotropy makes this difficult to interpret in other than the parasternal long-axis views.

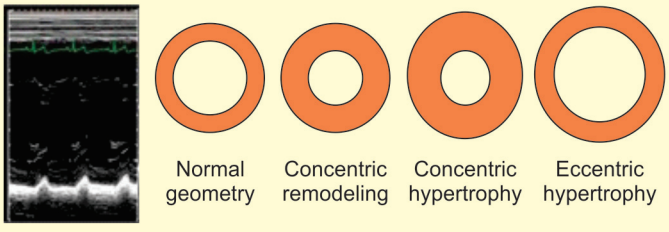
13. c. There has been such a prolific expansion of new technologies that it is difficult to keep track of which modality can help with which clinical question. Generally, tissue velocity has been useful for timing (e.g., synchrony) and measurement of global phenomena (e.g., E' velocity as a surrogate of tau, the relaxation time constant), but it is subject to tethering by adjacent segments, so it is not a good marker of segmental function. Accurate volumetric measurements are possible with 3D, but at a low temporal resolution—although there are no data to confirm this, it seems unlikely that this modality will be useful for the assessment of diastolic function, where the time for volume changes is critical. Deformation analysis with speckle strain can provide information on the transmural distribution of scar, and the response to low-dose dobutamine has been quantified with both tissue velocity and speckle strain.

14. e. The ongoing adverse outcomes associated with HF have spurred an increasing interest in recognition of the earlier stages of HF and attempts to prevent progression. The main contribution of tissue velocity has been to the assessment of tissue E', which is a sensitive marker of myocardial impairment that may be reduced even in the presence of risk factors, and in the estimation of LV filling pressure, which may support the diagnosis of later stage HF. Myocardial strain may be a sign of preclinical dysfunction in early stage disease, although its ability to quantify scar may also make it helpful in later disease. The main contributions of LV volume calculation are of most value in late stage disease, where the LV cavity is dilated and EF is reduced.

15. c. Relative wall thickness (RWT) = $2 \times PWd/LVd$
= $2 \times 13/52 = 0.5$

LVM = $1.04\,([LVd + IVS + PW]^3 - LVd^3) - 13.6$
= $1.04\,(7.7^3 - 5.2^3) - 13.6$
= 342 g (or 190 g/m^2 for BSA 1.8)

LVM and LV geometry are both important determinants of outcome. In this patient, both LVM and relative wall thickness are increased, indicating concentric LVH. Concentric remodeling (wall thickening without increased mass) is also associated with adverse outcome (Fig. 27.12).



RWT	< 0.45	≥ 0.45	≥ 0.45	< 0.45
LVMI (g/m^2)	≤131 (men) or ≤100 (women)	≤131 (men) or ≤100 (women)	>131 (men) or >100 (women)	>131 (men) or >100 (women)

Fig. 27.12

16. c. The history of chest pain onset following emotional stress is the classical presentation of stress cardiomyopathy (Takotsubo syndrome, TTS). TTS mimics acute ST segment elevation myocardial infarction with normal epicardial coronary arteries and spontaneously resolves with a favorable prognosis. The most common trigger is severe emotional stress, and women are more often involved than men. The distribution is atypical for coronary territories—although the wall motion abnormalities involve the apex, they involve the entire mid-apical LV (which includes right and circumflex coronary territories) but not the base. The presence of flow acceleration in the LV outflow tract reflects distortion of the LV anatomy rather than HCM.

17. b. The development of a systolic murmur postinfarction may be due to MR or a VSD. In contrast to congenital VSDs, postinfarct VSDs are identified within areas of wall motion abnormality and are often irregularly shaped. Cardiac MRI is an alternative diagnostic approach, but the defects are normally readily visualized by transthoracic echocardiography. The use of 3D echocardiography may minimize the possibility of missing multiple defects, which may be important in planning device closure.

18. c. The pattern of apical thickening is typical of apical HCM. Like other localized abnormalities (e.g., papillary muscle structure), these may be more readily recognized with contrast (or MRI). This condition is most commonly discovered in middle-aged men as an incidental finding of giant negative T waves (1–4 mV) in the left precordial leads at electrocardiography. Although changes in T-wave morphology can be abrupt, the findings usually evolve over several years. The prognosis of apical HCM is generally benign, although HF may occur because of atrial fibrillation and LV aneurysm.
The alternative responses (apical fibroma or muscular band) would be expected to be more localized. Apical foreshortening is a potential consideration, but the ventricular length seems

normal. Noncompaction cardiomyopathy is associated with apical thickening but does not encroach on the cavity and is characterized by deep apical trabeculations.

19. d. The findings suggest an infiltrative cardiomyopathy. The lack of ECG changes despite severe wall thickening is inconsistent with hypertensive heart disease and HCM. Of the infiltrative conditions, sarcoid is usually patchy and the presentation of Fabry disease might be expected at a younger age.

    The diagnosis is most likely amyloidosis. Cardiovascular manifestations include congestive HF, vascular and conduction abnormalities, and autonomic dysfunction. In the early stages, the disease is characterized by LV thickening in the absence of a history of hypertension or ECG evidence of LVH. The typical restrictive filling pattern is seen in late stage disease and earlier disease may just show a pseudonormal pattern. The "ground glass" consistency to the myocardium may be hard to recognize with harmonic imaging and suspicion of this should lead to the use of fundamental imaging. Cardiac MRI and scintigraphy are alternative diagnostic approaches.

20. d. Despite the apical wall motion abnormality, bubbles return to this area after the flash indicating an intact microcirculation. Myocardial contrast echocardiography has been used to define the transmural extent of infarction and to differentiate stunned from necrotic myocardium. Its accuracy in the prediction of functional recovery is comparable to dobutamine stress echocardiography, perfusion scintigraphy, and cardiac MRI.

    In the absence of stress testing, it is unclear whether this is ischemic and medical management may not be the best option. Although there is contrast attenuation in the RCA and LCX segments, these are still thickening.

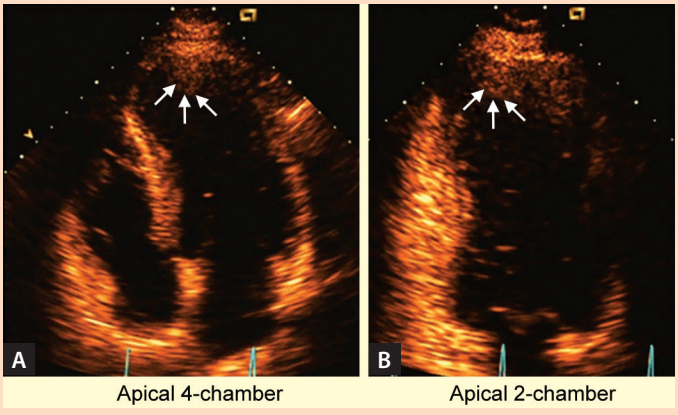
21. c. Video 10-6 demonstrates preservation of the basal RV with dilatation and dysfunctions of the midwall and apex. McConnell's sign involves preserved apical function in acute pulmonary embolism and RV infarction or cor pulmonale usually involves the full length of the free wall of the right ventricle.

    Arrhythmogenic RV dysplasia is an inherited cardiomyopathy characterized by ventricular arrhythmias and structural abnormalities of the right ventricle, due to progressive replacement of the RV myocardium with fatty and fibrous tissue. It is characterized by RV dilatation with wall thinning and trabeculation and can be identified by cardiac MRI or echocardiography. The echocardiographic criteria are reduced RV function, increased RV dimensions (especially the right ventricular outflow tract [RVOT]; an RVOT long-axis diastolic dimension of >30 mm being present in 89%), and RV morphologic abnormalities (trabecular derangement in 54%, hyperreflective moderator band in 34%, and sacculations in 17%).

22. a. The images in Video 10-7 demonstrate RV enlargement with reduced function and septal motion consistent with ventricular interaction. In this setting, the most likely explanation is RV infarction.

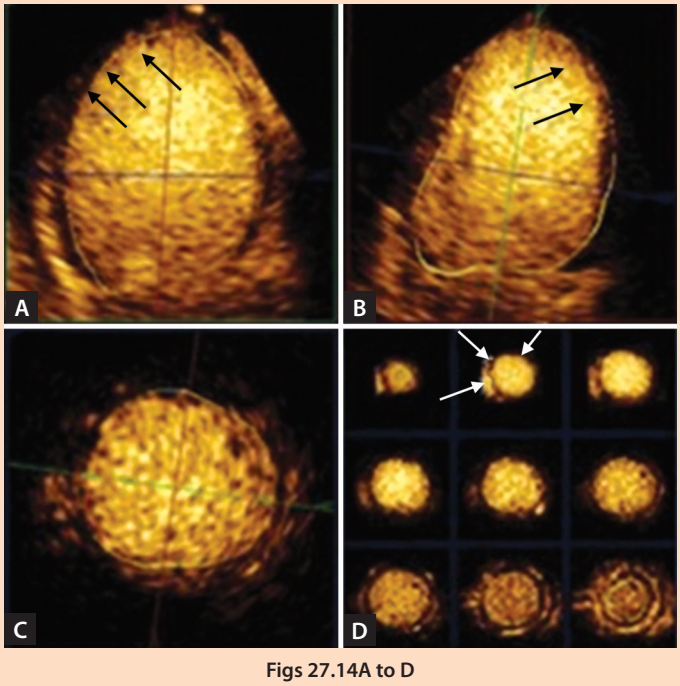
    RV infarction is associated with increased in-hospital mortality, so this is an important condition to recognize. When hemodynamic compromise occurs in the setting of inferior infarction, RV dimensions, shape, and global and regional function should be examined carefully. Inferior vena cava congestion often occurs in the setting of reduced RV compliance.

23. d. The view demonstrates a wall motion abnormality restricted to the apex and without thinning. The LV opacification images show a persistent apical filling defect, likely representing an early thrombus. These findings may be highly labile in the early period after infarction—cross-sectional studies early after anterior infarction have identified thrombi in 2% of infarcts, especially with a reperfusion time of >3 hours. Contrast echocardiography is the most accurate echocardiographic method of detecting LV mural thrombus, irrespective of physician experience. In an audit of 409 patients undergoing echocardiography for detection of LV thrombus, 46% were nondiagnostic. A contrast-enhanced study gave definitive information on the presence or absence of an LV thrombus in 90% of these patients (Figs 27.13A and B).



Figs 27.13A and B

24. c. The display shows reconstructed images equivalent to the apical four- and two-chamber views, with a short-axis view at the junction of the mid and basal segments. Figure 27.14D shows a sequence of nine short-axis images from the apex to the base. The left ventricle is enlarged but the wall motion abnormality is restricted to the LAD territory (arrows).
25. c. Traces of the resting dimensions have been superimposed on the postexercise image to show LV enlargement and LV dysfunction postexercise (Fig. 27.15). Subclinical LV dysfunction may be identified on the basis of a reduced EF response or LV dilatation with exercise.



Figs 27.14A to D

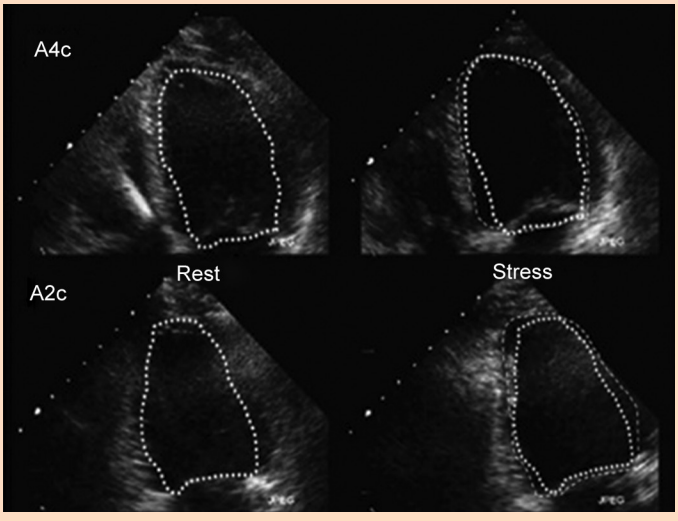


Fig. 27.15

The move toward earlier mitral surgery may be problematic in patients with anterior or bileaflet prolapse, because of a greater risk of failed repair. In this situation, the assessment of CR may permit the detection of subclinical myocyte contractile abnormalities that are apparent experimentally as lower developed force and a negative force-frequency relation, reflecting decreases in peak calcium transients. Initial work with CR in chronic MR documented that preserved CR (a >4% increment of EF) predicted preserved LV function after mitral surgery. Subsequent work showed CR in asymptomatic severe MR to predict clinical outcome and LV function over 3 years. In particular, follow-up EF was preserved in medically treated patients with intact CR but progressively deteriorated in patients without CR. A simpler approach may be the performance of myocardial imaging to identify subclinical dysfunction in this setting.

28

Echocardiography for Distolic Function

1. The best two-dimensional (2D) and Doppler echocardiographic finding to differentiate restrictive cardiomyopathy from constrictive pericarditis would be to evaluate:
   a. Mitral inflow pattern
   b. Pulmonary venous flow pattern
   c. Atrial size
   d. Inferior vena cava dilatation
   e. Early diastolic mitral annular velocity

2. Echocardiography is performed on a 59-year-old male patient 3 months after having a large posterolateral wall infarction due to an acute stent thrombosis in his proximal circumflex coronary artery. Which of the following is associated with a better prognosis?
   a. Presence of moderate-to-severe mitral regurgitation (MR) (ERO = 0.3 cm^2)
   b. Left ventricular ejection fraction of 33%
   c. E/E′ = 21
   d. Deceleration time of 123 ms
   e. Lateral wall e′ of 7 cm/sec

3. How will the pulmonary venous Doppler flow pattern immediately change in the case of left atrial stunning (e.g. after cardioversion for paroxysmal atrial fibrillation)? S1: first velocity of systolic pulmonary venous flow; S2: second velocity of systolic pulmonary venous flow; D: diastolic velocity of pulmonary venous flow; AR: atrial reversal of pulmonary venous flow:
   a. The systolic filling fraction (S1) will increase
   b. The systolic filling fraction (S2) will increase
   c. A decrease will be seen of the diastolic filling fraction (D)
   d. A decrease will be seen of the systolic filling fraction, particularly S1
   e. An increase in the AR velocity

4. Which of the following statements are true about the pulmonary venous flow pattern?
   a. Peak AR >35 cm/sec suggests elevated left ventricular (LV) filling pressures
   b. The pulmonary S wave is related to LV relaxation
   c. The S/D ratio provides an accurate estimation of LV filling pressures in patients with preserved and reduced systolic function
   d. Pulmonary venous AR duration < mitral inflow A duration indicates an increased LV end-diastolic pressure
   e. Pulmonary venous flow AR can be obtained in only 50% of patients

1. e. 2. e. 3. d. 4. a.

5. In patients with atrial fibrillation, LV filling pressures could be best estimated using which of the following statements?
   a. E/e′ ≥11 correlates well with elevated pulmonary capillary wedge pressure (PCWP)
   b. Deceleration time in patients with a normal ejection fraction
   c. Left atrial size. Higher left atrial size (>34 ml/m^2) will reflect chronically elevated filling pressures
   d. Peak velocity of the diastolic pulmonary venous flow, which will reflect atrial pressure in these patients
   e. Impossible; there is no A wave and the variability in cycle length precludes any accurate estimation

6. A 61-year-old male patient with a history of hypertension complains of exercise intolerance. His lung function tests are normal. His heart rate (HR) at rest is 60 bpm. He has a normal ejection fraction, mild LV hypertrophy, no valvular pathology. Doppler echocardiography data are included in Table 28.1 below.

Table 28.1

E-wave velocity	48 cm/sec
A-wave velocity	60 cm/sec
Deceleration time	300 m/sec
e′ velocity	8 cm/sec
Tricuspid regurgitation (TR) jet velocity	2.5 m/sec
E/e′ ratio	6

Based on this information:
   a. The cause of his symptoms is unlikely cardiac. Refer him to internal medicine
   b. Consider a coronary angiography. Dyspnea is sometimes a symptom of underlying coronary artery disease
   c. We can conclude that the patient has elevated filling pressures and should be given a diuretic
   d. Consider a diastolic stress test
   e. BNP is 500 pg/ml

7. The patient in Question no. 6 above undergoes stress testing with a supine bike protocol. Doppler echocardiography is performed 2 minutes after peak exercise (HR = 136 bpm, ~85% MPHR). Findings are included in Table 28.2.

Table 28.2

E-wave velocity	130 cm/sec
A-wave velocity	70 cm/sec
Deceleration time	160 m/sec
e′ velocity	8 cm/sec
Tricuspid regurgitation (TR) jet velocity	3.7 m/sec
E/e′ ratio	16

5. a. 6. d.

Which statement is true?

a. This patient has stage 1 diastolic dysfunction with exercise
b. These findings raise concern for pulmonary embolism
c. More information is needed to make any definite statement concerning the patient's diastolic function
d. Normal values for this patient's age and gender given the fact that he just underwent stress testing and his HR is increased
e. This patient has elevated LV filling pressures with exercise

8. A dialysis patient undergoes cardiac catheterization. His ventricular angiogram shows normal systolic function. The pulmonary capillary wedge tracing shows significant v-waves. However, the ventriculogram and a carefully performed echocardiogram do not show significant MR. What is the most likely explanation?
   a. MR can be very dynamic. In addition, there could be a very excentric jet
   b. Stage 3 diastolic dysfunction due to LV hypertrophy and volume overload
   c. Atrial rhythm disturbance
   d. Loss of left atrial reservoir function
   e. Congenital anomaly

9. When performing pulsed wave Doppler imaging in the apical four-chamber view to acquire mitral annular velocities, which of the following is true?
   a. The sample volume should be positioned at or 1 cm within the septal and lateral insertion sites of the mitral leaflets
   b. The sample volume should be small enough (usually 2–3 mm) to evaluate the longitudinal excursion of the mitral annulus in both systole and diastole
   c. In general, the velocity scale should be set at ~30 cm/s above and below the zero-velocity baseline
   d. Angulation up to 40 degree between the ultrasound beam and the plane of cardiac motion is acceptable
   e. Spectral recordings are ideally obtained during inspiration and measurements should reflect the average of three consecutive cardiac cycles

10. Impaired elastic recoil is most consistent with which of the following?
    a. Decrease in the isovolumic relaxation time (IVRT)
    b. Decrease in left atrial pressure
    c. Impaired late diastolic filling
    d. Impaired active relaxation
    e. Decrease in the early diastolic intraventricular pressure gradient

11. Which statement is false? First-degree AV block:
    a. May have the same effect on the mitral inflow pattern as sinus tachycardia
    b. May lead to a pattern consistent with delayed relaxation even if there is no underlying diastolic dysfunction
    c. May lead to diastolic MR in the presence of restrictive filling
    d. May hamper evaluation of LV diastolic function when only pulsed Doppler interrogation of the mitral inflow is performed
    e. Will decrease the LV diastolic filling period. Therefore, it may have an adverse effect on filling pressures and cardiac output in patients with severe systolic dysfunction

7. e. 8. d. 9. a. 10. e. 11. b.

12. Color Doppler M-mode (CMM) echocardiography provides information on flow propagation (Vp) which is unique in that it is relatively independent of which of the following?
    a. Cardiac output
    b. LV compliance
    c. Left atrial size
    d. Loading conditions
    e. HR

13. What is the strongest determinant of mitral deceleration time?
    a. Left atrial mechanical function
    b. LV operating stiffness
    c. Left ventricular end-diastolic pressure (LVEDP)
    d. Ejection fraction
    e. Left atrial reservoir function

14. In patients with dilated cardiomyopathy, pulsed wave Doppler mitral flow velocity variables and filling patterns correlate with which of the following?
    a. Cardiac filling pressures and functional class, but not prognosis
    b. Prognosis, but not filling pressures or functional class
    c. Cardiac filling pressures, functional class, and prognosis, but less so than does LV ejection fraction
    d. Cardiac filling pressures, functional class and prognosis better than does LV ejection fraction
    e. Cardiac filling pressures, functional class, and prognosis, but to a lesser degree than in patients with LV ejection fraction >50%

15. Which statement is most correct with respect to the application of the Valsalva maneuver in the assessment of diastolic function?
    a. The lack of reversibility in E/A ratio with Valsalva in patients with advanced diastolic dysfunction indicates irreversible restrictive physiology and implies a very poor prognosis
    b. The Valsalva maneuver is a sensitive and specific way to differentiate normal from stage 1 diastolic function
    c. The Valsalva maneuver should be used in every patient when assessing diastolic function
    d. In cardiac patients, a decrease of ≥50% in E/A ratio is highly specific for increased LV filling pressures

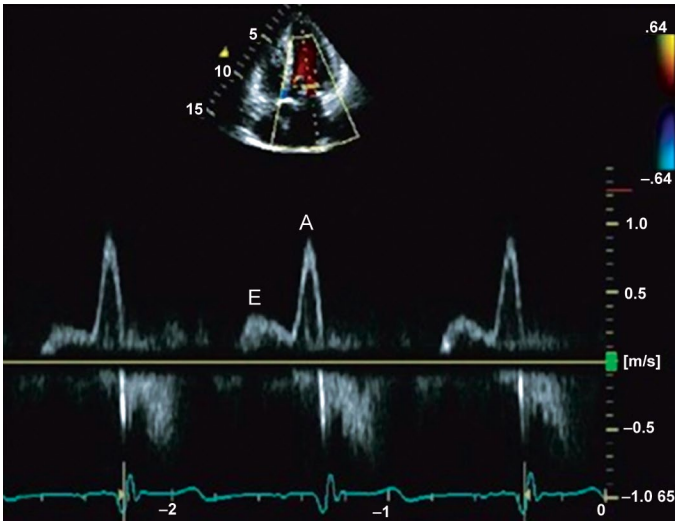


Fig. 28.1A

12. d. 13. b. 14. d. 15. d.

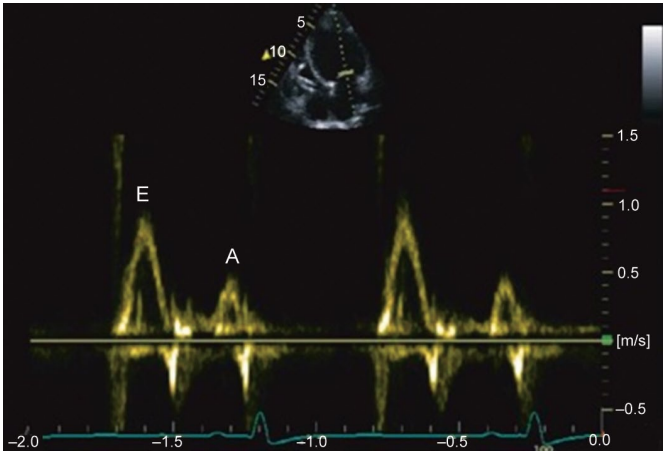


Fig. 28.1B

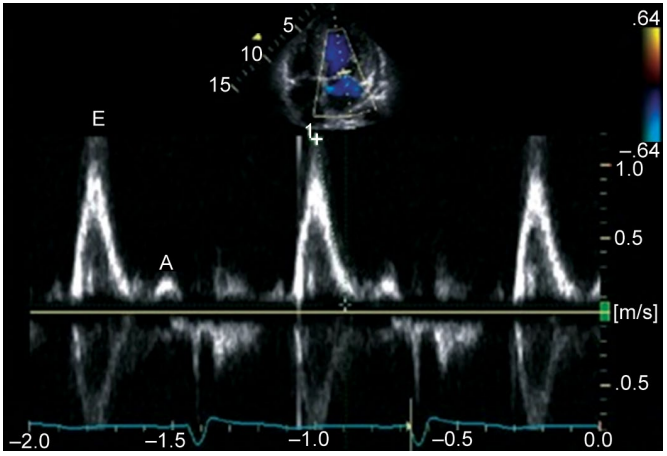


Fig. 28.1C

16. Figures 28.1A to C represents three different pulsed wave Doppler recordings of mitral inflow velocity in a 63-year-old male with a diagnosis of cardiac amyloidosis. The Doppler recordings were acquired at different stages in the progression of his disease. Atrial fibrillation is a common complication in these patients. At what stage in his disease would sudden onset of atrial fibrillation most likely cause a marked increase in symptoms in this patient?
    a. Around the time of the Doppler recording represented in Figure 28.1A
    b. Around the time of the Doppler recording represented in Figure 28.1B
    c. Around the time of the Doppler recording represented in Figure 28.1C
    d. No matter how advanced the diastolic dysfunction, atrial fibrillation is always highly symptomatic in cardiac amyloidosis
    e. More information is needed to answer this question

16. a.

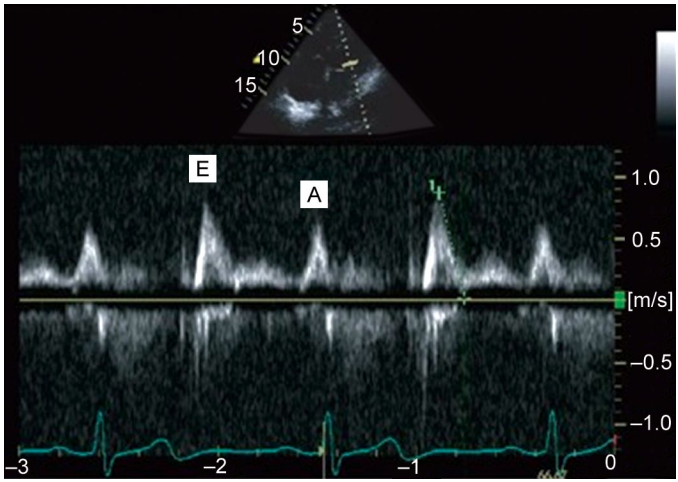


Fig. 28.2

17. Based on Figure 28.2, what could you say about the underlying diastolic function in this patient?
    a. The transmitral gradient suddenly increases in mid-diastole because of a decrease in LV compliance
    b. This type of inflow pattern is sometimes seen in young individuals and can be explained by vigorous LV relaxation
    c. This finding represents a very early stage of diastolic dysfunction
    d. This patient has markedly delayed relaxation. Preload reduction will reveal stage 1 diastolic dysfunction
    e. The Doppler tracing is suggestive of atrial mechanical dysfunction, possibly due to a recent episode of atrial tachyarrhythmia

18. A 53-year-old male with hypertension but no other cardiac events in the past complains of exercise intolerance. An echocardiogram shows a normal LV systolic function (ejection fraction = 60%), mild concentric LV hypertrophy and no valvular dysfunction. Based on the Doppler recording of his mitral inflow pattern in Figure 28.3, which additional echocardiographic parameter is most helpful in confirming whether his symptoms should be attributed to elevated filling pressure?

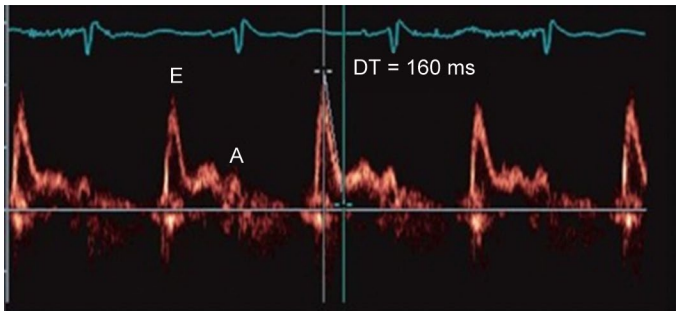
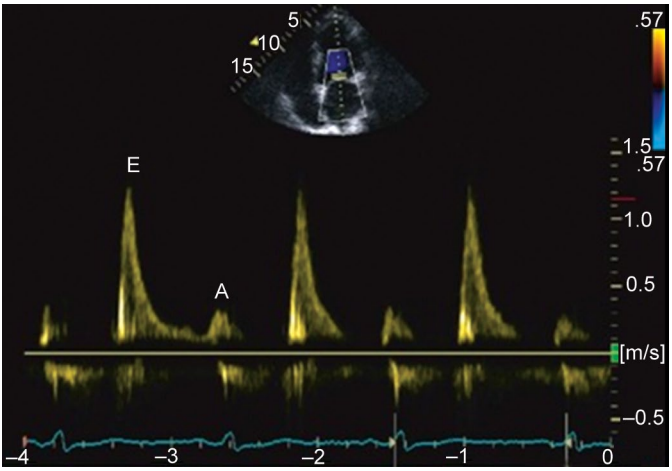


Fig. 28.3

17. d.

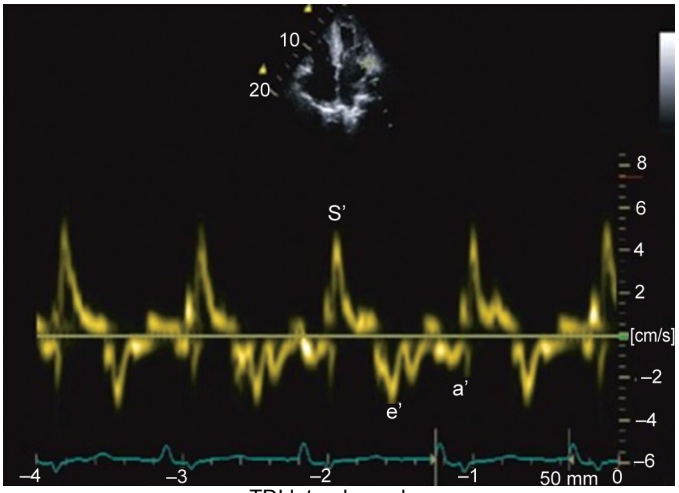
a. Left atrial volume index of 28 ml/m^2
b. Tissue Doppler early diastolic velocity of the mitral annulus of 12 cm/s
c. Tissue Doppler-derived early diastolic velocity of the mitral annulus of 6 cm/s
d. Difference in duration of pulmonary venous flow AR and mitral inflow of 15 msec
e. Transmitral flow propagation velocity assessed by color M-mode of 60 cm/s

19. A patient with severe LV dysfunction due to long-standing untreated hypertension is referred for initiation of medical therapy. Based on the Doppler findings in Figures 28.4A and B, one should be extra cautious when starting what medical therapy?



Mitral inflow

Fig. 28.4A



TDI lateral annulus

Fig. 28.4B

18. c.

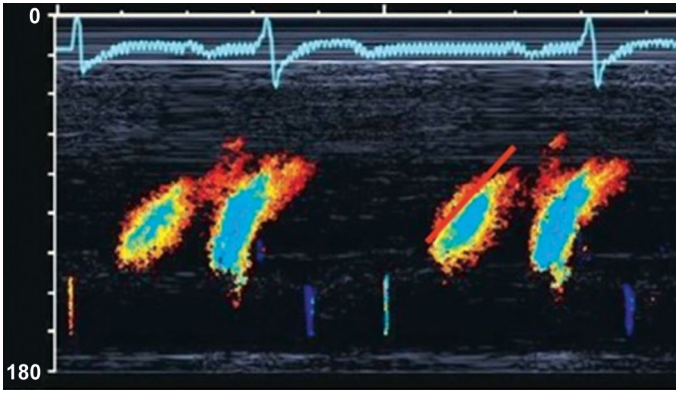
a. Diuretics
b. Nitrates
c. Angiotensin-converting enzyme (ACE) inhibitors
d. Beta-blocking agents
e. Hydralazine

20. Figure 28.5 represents the transmitral flow propagation velocity (Vp) assessed by color M-mode (red line) in a patient with an acute myocardial infarction due to thrombotic occlusion of his midleft anterior descending artery (LAD) 3 months ago. If it was possible to measure the intracavitary LV pressure with a high-fidelity pressure wire and compare measurements with values obtained prior to his infarction, what observation would be most likely?
a. A decreased early diastolic pressure gradient between the tip of the mitral valve and the apex
b. A higher absolute value for dP/dt
c. A lower end-diastolic LV pressure
d. A lower early diastolic pressure measured at the LV apex
e. A lower late diastolic pressure measured at the LV apex

21. A 61-year-old female with ischemic cardiomyopathy is referred for cardiac resynchronization therapy. Just before implantation of her biventricular device, she undergoes transthoracic echocardiography. Six months later, a new echocardiogram is obtained. Based on the LV Doppler filling pattern shown in Table 28.3 and Figures 28.6A and B, which statement is correct?

Table 28.3

Baseline	6-month follow-up
E = 78 cm/s	E = 111 cm/s
A = 72 cm/s	A = 28 cm/s
E/A = 1.1	E/A = 3.6
DT = 180 ms	DT = 126 ms
Vp = 28 cm/s	Vp = 25 cm/s



Color M-mode

Fig. 28.5

19. d. 20. a.

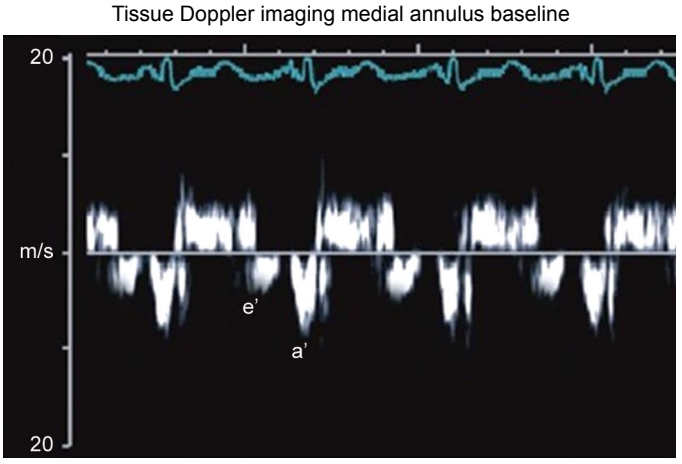


Fig. 28.6A

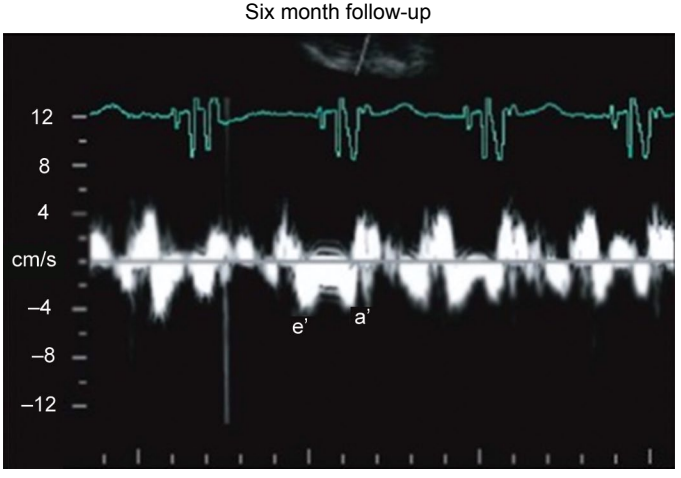
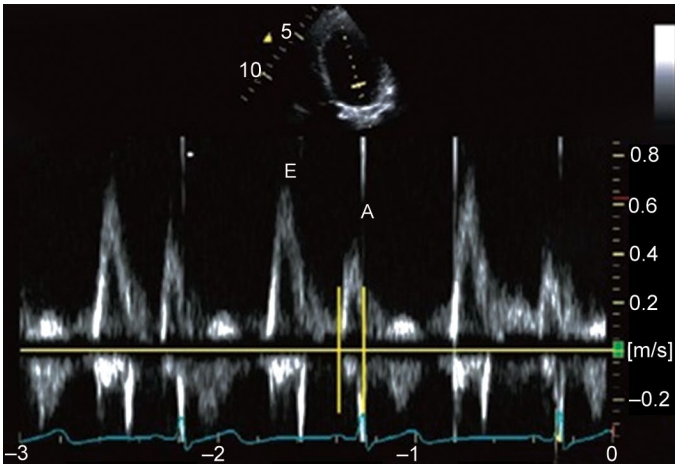


Fig. 28.6B

a. LV relaxation has improved
b. LV filling pressures are decreased
c. Left atrial contractility has increased
d. LV stiffness increased
e. There is less dyssynchrony

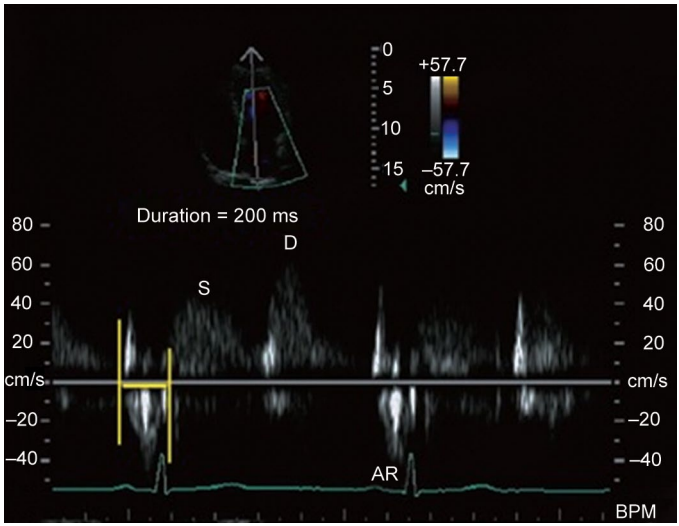
21. d.

22. The Doppler findings in Figures 28.7A and B are most likely to be found in which clinical scenario?
    a. 35-year-old male athlete
    b. 50-year-old woman with 2+ MR
    c. A 60-year-old man with advanced hypertensive heart disease
    d. 50-year-old man with recently diagnosed hypertrophic cardiomyopathy
    e. 50-year-old woman with constrictive pericarditis



A duration = 100 msec
Mitral inflow

Fig. 28.7A



AR duration = 180 msec
Pulmonary venous flow

Fig. 28.7B

22. c.

23. The mitral inflow pattern shown in Figure 28.8 is by itself suggestive of elevated filling pressures if:
    a. The patient has an ejection fraction of 25%
    b. The patient has an ejection fraction of 60%
    c. The patient has a dilated left atrium and history of atrial fibrillation
    d. The patient has mitral valve prolapse and moderately severe MR
    e. The maximal jet velocity of the tricuspid regurgitant jet is 3.5 m/sec.

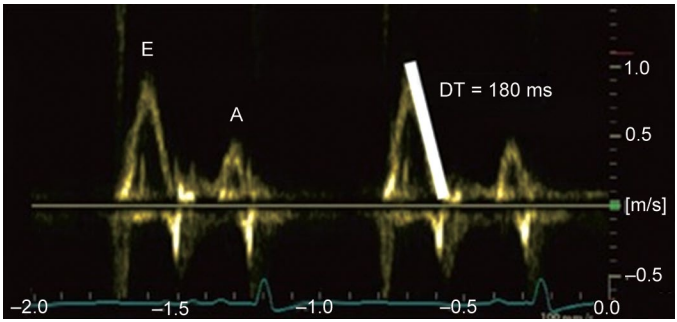


Fig. 28.8

24. A 56-year-old patient was referred to you because of increasing shortness of breath. Pulsed-wave Doppler echocardiography in the hepatic veins reveals the tracing in Figure 28.9.
    What is the most appropriate statement?
    a. There is evidence for an increased right ventricular end-diastolic pressure (RVEDP)
    b. There must be severe tricuspid regurgitation
    c. This pattern can be seen in patients with constrictive pericarditis
    d. There is a right ventricular relaxation abnormality
    e. Chronic obstructive pulmonary disease can be the cause of this finding

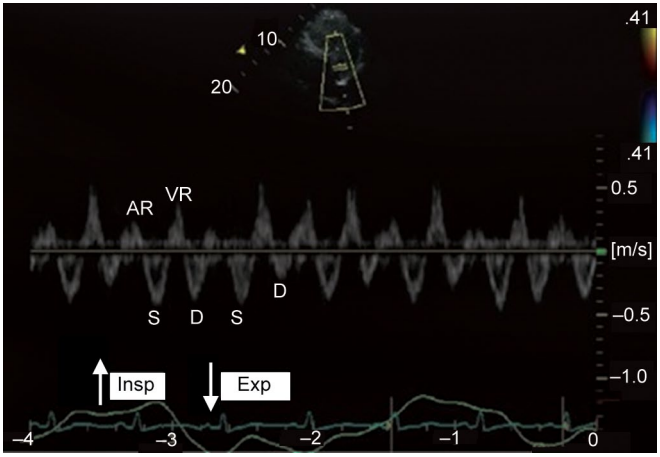


Fig. 28.9

23. a. 24. c.

25. The mitral inflow filling pattern shown in Figure 28.10 should be considered abnormal for which of the following patients?
    a. A 41-year-old male with normal ejection fraction and an elective PCI of the RCA 2 years earlier
    b. A 46-year-old female with a bicuspid aortic valve and moderately severe aortic insufficiency
    c. A 28-year-old athlete complaining of atypical chest pain
    d. A 37-year-old obese female complaining of shortness of breath
    e. A 65-year-old male without medical history

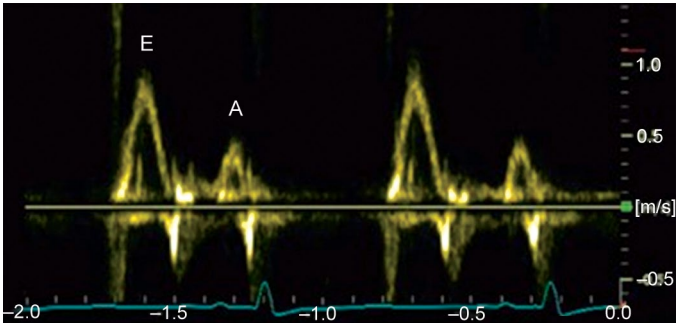


Fig. 28.10

25. e.

Answers

1. e. Differentiating restrictive from constrictive pericarditis by echocardiography can be challenging. Mitral inflow, pulmonary venous flow, or tricuspid inflow does not always exhibit the typical respiratory changes displayed in textbook cases. The inferior vena cava is typically dilated in patients with constriction, but this can also be true in patients with advanced restrictive cardiomyopathy.

   Atrial size will usually be increased in patients with restrictive cardiomyopathy but constrictive pericarditis will also eventually result in (particularly right-sided) dilatation. Apart from 2D features that give clues to the differentiation of diseases, tissue Doppler imaging (TDI) can provide important specific information. In patients with restrictive cardiomyopathy, myocardial relaxation (e') will be severely impaired; whereas patients with constriction usually have preserved annular vertical excursion. Radial left ventricular (LV) expansion is decreased in both groups: in restrictive cardiomyopathy because of the infiltrative disease process and in constrictive pericarditis because of the pericardial constraint. A septal e' velocity ≥ 7 cm/s has been shown to be highly accurate in differentiating patients with constrictive pericarditis from those with restrictive cardiomyopathy. Of note, the lateral annular e' velocity could be decreased if the constrictive process involves the lateral mitral annulus. Figures 28.11A and B illustrates typical tissue Doppler tracings from a patient with constrictive pericarditis as opposed to a patient with restrictive cardiomyopathy.
2. e. Regional ischemic injury will decrease the longitudinal systolic and diastolic excursion of the affected wall. Therefore, a lower value of e' in the lateral wall of this patient is not an entirely unexpected finding (lateral e' should normally be ≥ 10 cm/sec). It is now recommended (and this is of particular importance in patients with regional wall motion abnormalities) to acquire and measure tissue Doppler signals at least at the septal and lateral sides of the mitral annulus and calculate their average to measure E/e'. The other possible answers each have been shown to carry important prognostic information in patients with a history (recent or not) of myocardial infarction.
3. d. There are two systolic velocities (S1 and S2), mostly noticeable when there is a prolonged PR interval since S1 is related to atrial relaxation. S2 should be used to compute the ratio of peak systolic to peak diastolic velocity. S1 velocity is primarily influenced by changes in

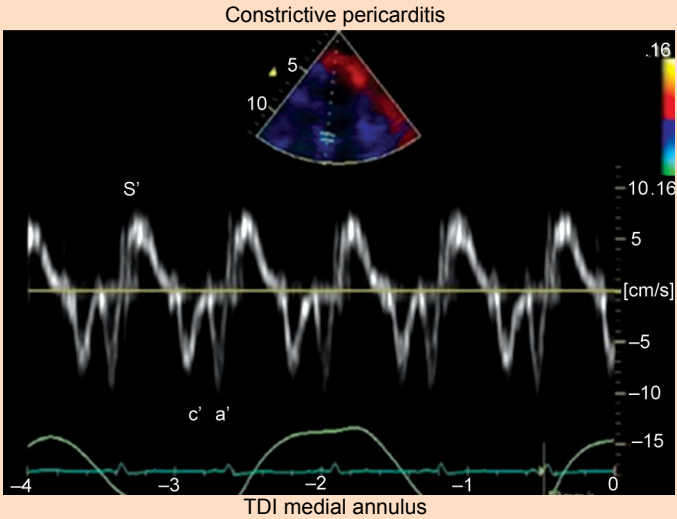


Fig. 28.11A

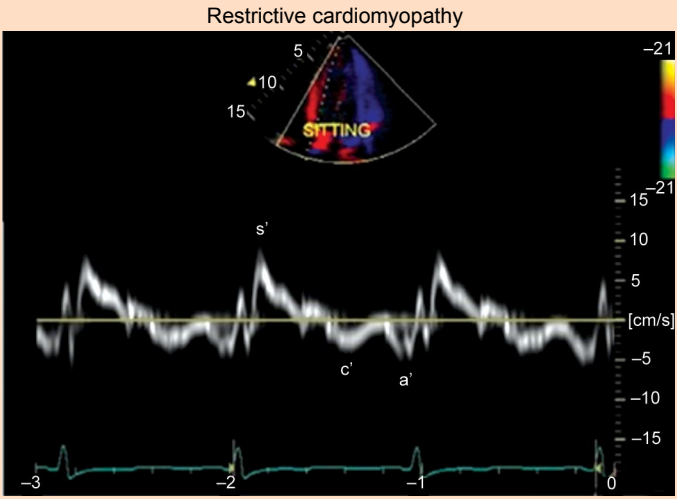


Fig. 28.11B

left atrial pressure and left atrial relaxation or contraction, whereas S2 is related to stroke volume and pulse wave propagation in the pulmonary arterial tree. The diastolic velocity D is influenced by changes in LV filling and compliance and changes in parallel with mitral E velocity. Pulmonary venous atrial flow reversal (AR) velocity and duration are influenced by LV late diastolic pressures, atrial preload, and left atrial contractility. Atrial fibrillation or atrial stunning will result in a blunted S wave, mainly due to a loss of S1 with a decreased systolic fraction and absence of AR velocity (Fig. 28.12).

4.a. AR may increase with age, but AR > 35 cm/s is usually consistent with elevated LV filling pressures particularly at end diastole. The pulmonary D wave is related to LV relaxation. Young and healthy individuals can therefore exhibit large D waves indicating forceful elastic recoil of the LV rather than high left atrial pressure. The pulmonary S wave is related to LV contractility, atrial function, atrial pressure, and mitral regurgitation. Mitral and pulmonary vein inflow patterns are not very reliable for assessment of LV filling pressures in patients with an overall normal systolic function. ARdur–Adur > 30 ms is, therefore, a more robust marker of elevated LV end-diastolic pressure (LVEDP) in this group of patients. Pulmonary venous atrial reversal can be obtained in more than 70% of patients. A commercially available contrast injection can help enhance the Doppler tracing.

5. a. Although sometimes challenging, an estimate of LV filling pressures can be obtained in patients with atrial fibrillation using the E/e' ratio. Different studies have shown good correlations in this population between filling pressures and the E/e' ratio (a ratio ≥ 11 predicting LVEDP ≥ 15 mm Hg), the mitral deceleration time (< 150 ms in the presence of LV systolic dysfunction) or the deceleration time (not the peak velocity) of the pulmonary venous diastolic velocity (≤ 220 ms associated with higher filling pressures).

6. d. This patient has evidence of stage 1 diastolic function with normal to low LV filling pressures at rest with a BNP of 100 pg/ml; however, it can be useful to evaluate LV filling pressure not only at rest but with exercise as well. The E/e' ratio will remain unchanged in subjects with normal myocardial relaxation because both E and e' velocities increase proportionally. However, in patients with impaired myocardial relaxation, the increase in e' with exercise is much less than that of mitral E velocity such that the E/e' ratio increases. Besides filling pressures, stress echocardiography also allows evaluation of systolic function in patients with coronary artery disease, of MR severity in patients with mitral valve disease, and of pulmonary artery pressures.

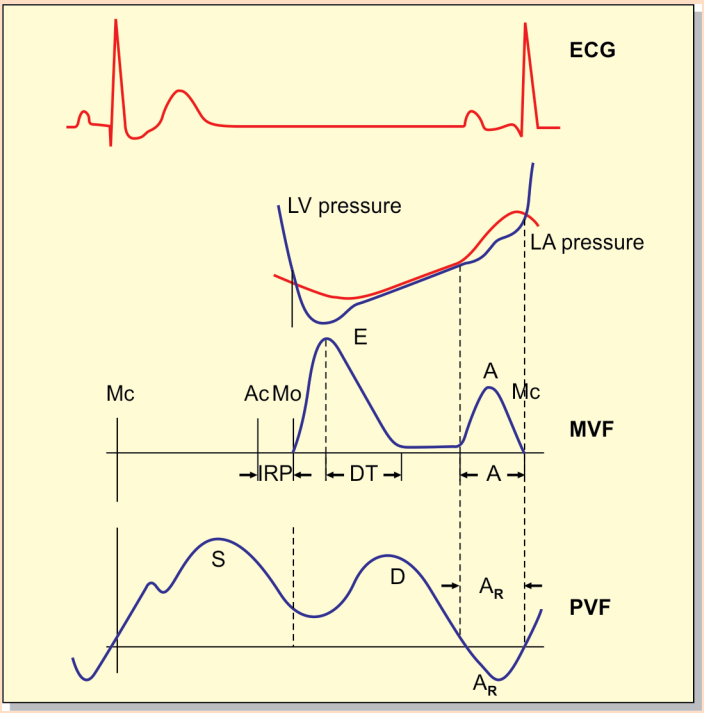


Fig. 28.12

7. e. The stress test has provided evidence that the underlying relaxation abnormality can account for the patient's symptoms of dyspnea with exertion. With exercise, there is an increase in LV filling pressures (E/E' = 28). Many patients with diastolic dysfunction have exercise intolerance due to the rise in filling pressures needed to maintain adequate LV filling and stroke volume. Although the clinical implications of this finding have not yet been fully elucidated, one could consider starting therapy with a β-blocker, thereby preventing exercise-induced tachycardia and maximizing the diastolic filling period in these patients.
8. d. The presence of v-waves in absence of significant MR in this type of patient suggests severely decreased left atrial compliance. Classically, the left atrium has been ascribed to three different functions throughout the cardiac cycle: (1) reservoir function during ventricular systole and isovolumic relaxation (reflected by the pulmonary venous S wave); (2) conduit phase from the moment the mitral valve opens until onset of atrial contraction (reflected by the pulmonary venous D wave); and (3) contractile phase during atrial systole (reflected by the pulmonary venous AR wave and the mitral A wave).
9. a. The sample volume should be positioned at or 1 cm within the septal and lateral insertion sites of the mitral leaflets, and adjusted as necessary (usually 5–10 mm) to cover the longitudinal excursion of the mitral annulus in both systole and diastole. Attention should be directed to Doppler spectral gain settings because annular velocities have high signal amplitude. Most current ultrasound systems have tissue Doppler presets for the proper velocity scale and Doppler wall filter settings to display the annular velocities. In general, the velocity scale should be set at ~20 cm/s above and below the zero-velocity baseline, though lower settings may be needed when there is severe LV dysfunction, and annular velocities are markedly reduced (scale set to: 10–15 cm/s). Minimal angulation (<20°) should be present between the ultrasound beam and the plane of cardiac motion.

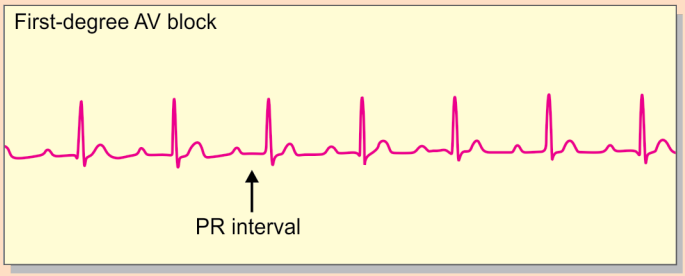
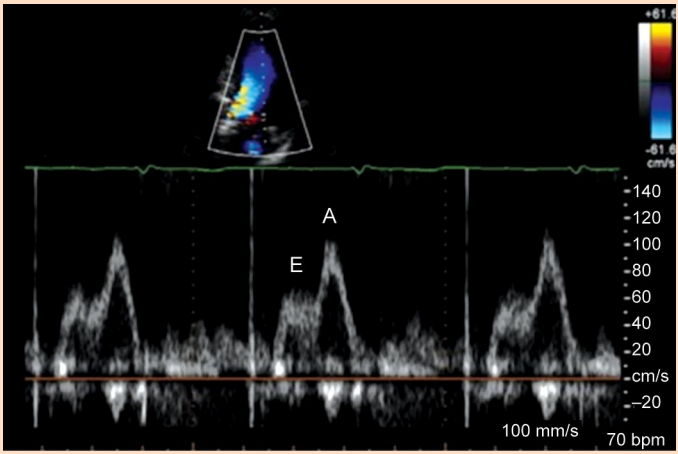


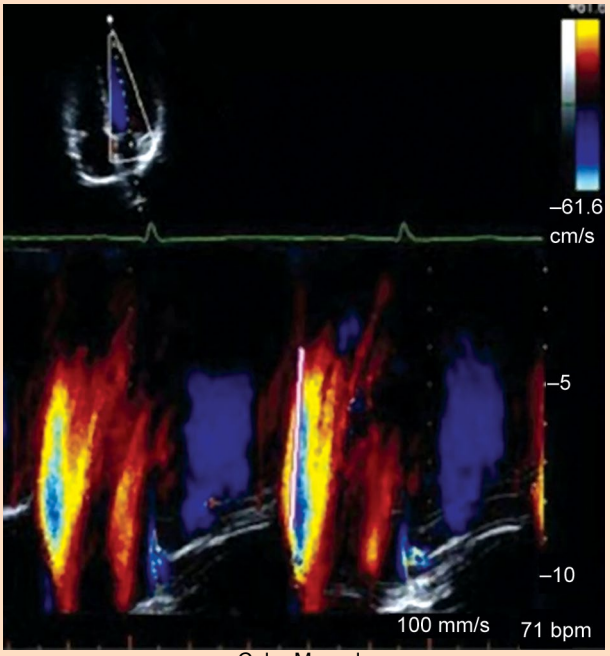
Fig. 28.13A



E-A fusion
Mitral inflow

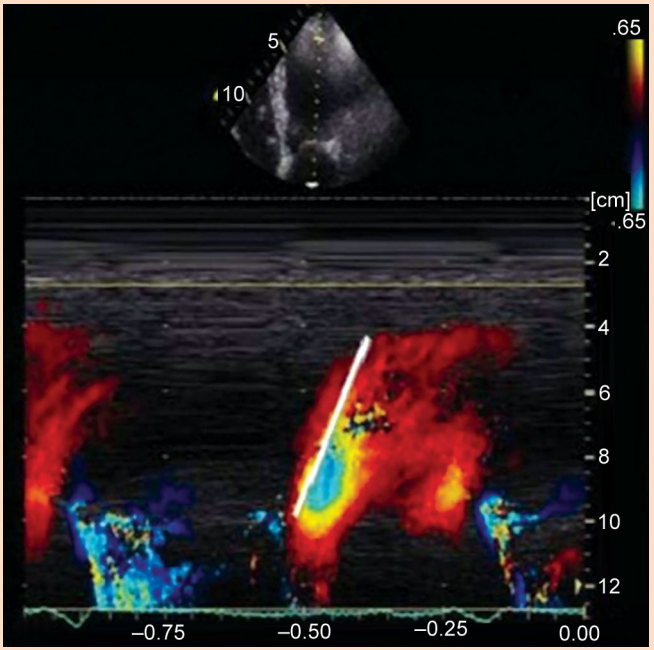
Fig. 28.13B

10. e. Elastic recoil does not directly affect active relaxation as suggested by answer D, but in combination with active relaxation, it is the driving force of early (and not late) diastolic filling. It acts by rapidly lowering the intraventricular pressure (thus creating a negative pressure gradient which results in diastolic "suction" of blood out of the left atrium). A decrease in recoil forces will increase the time needed to lower the ventricular pressure below the level of the left atrial pressure, resulting in an increase (not a decrease) of the isovolumic relaxation time (IVRT). Elastic recoil permits ventricular filling at low left atrial pressures. If elastic recoil is disturbed, ventricular filling can only be achieved by increasing the left atrial pressure.
11. b. First-degree AV block may lead to fusion of the E and A wave and therefore has a similar effect on mitral inflow as sinus tachycardia. A fused mitral inflow pattern can make an accurate interpretation of diastolic function impossible if no other information is available. In the presence of severely elevated LV filling pressures, first-degree AV block may lead to diastolic MR, as atrial contraction is not immediately followed by ventricular contraction, which is mandatory for complete mitral valve closure. Under these conditions, the atrioventricular pressure gradient may temporarily reverse during atrial relaxation, leading to diastolic MR. Fusion of E and A wave (leading to a decreased LV diastolic filling period) and diastolic MR may in turn have an adverse effect on cardiac output and filing pressures in patients with severe systolic dysfunction. Cardiac resynchronization therapy with restoration of optimal



Color M-mode

Fig. 28.14A



Color M-mode

Fig. 28.14B

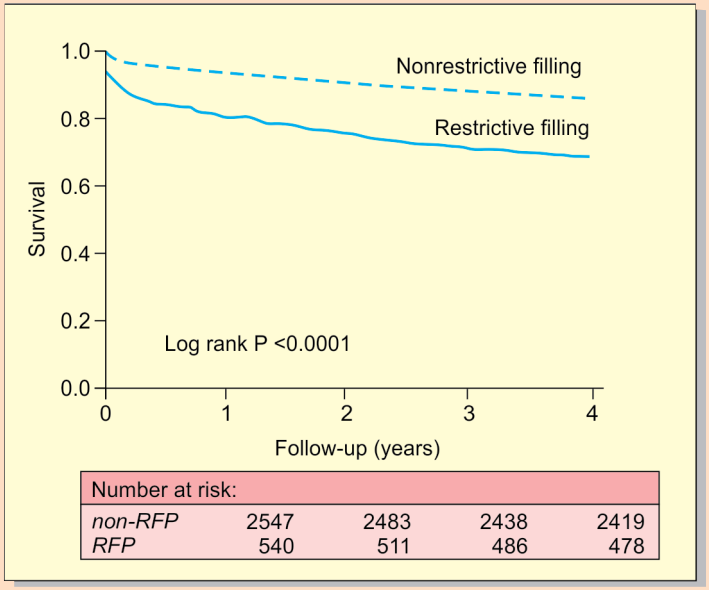


Fig. 28.15

atrioventricular mechanical timing may improve LV filling in these patients. See Figs 28.13A and B for an illustration of the impact of PR prolongation on the mitral inflow pattern.

12. d. CMM echocardiography provides a spatiotemporal map of blood distribution (v(s,t)) within the heart with a typical temporal resolution of 5 ms, a spatial resolution of 300 microns and a velocity resolution of 3 cm/s. Assessment of diastolic flow propagation has offered novel information about LV filling dynamics. Vp is unique in that it appears to be relatively independent of loading conditions and therefore may overcome one of the main limitations of Doppler-based techniques. The earliest CMM velocities often occur during isovolumic relaxation. After the mitral valve opens, there is a rapid initial component (phase 1), often followed by a slower component (phase 2). Finally, the last component in late diastole is associated with atrial contraction. Please see Figs 28.14A and B determination of the Vp slope (white line).
13. b. E-wave deceleration time is mostly influenced by the operating stiffness of the LV. Changes in LV compliance (i.e. the relationship between LV pressure and volume) and also changes in ventricular relaxation or early (instead of late) diastolic ventricular pressures will affect the deceleration time. Left atrial mechanical function and ejection fraction are not or weakly and indirectly correlated with deceleration time (Fig. 28.15).
14. d. In patients with dilated cardiomyopathies, pulsed wave Doppler mitral flow velocity variables and filling patterns correlate better with cardiac filling pressures, functional class, and prognosis than with LV ejection fraction. Patients with impaired LV relaxation are the least symptomatic, while a short IVRT, short mitral deceleration time and increased E to A wave velocity ratio characterize advanced diastolic dysfunction, increased left atrial pressure and a worse functional class. A restrictive filling pattern is associated with a poor prognosis, especially if it persists after preload reduction. Likewise, a pseudonormal or restrictive filling pattern associated with acute myocardial infarction indicates an increased risk of heart failure, unfavorable LV remodeling, and increased CV mortality, irrespective of ejection fraction (Fig. 28.16).

Pattern	Baseline Valsalva	Assessment
Normal		Normal
Stage 1A		Normal filling pressures
Stage 1B		↑LV A wave, ↑EDP
Stage 2		Pseudonormal
Stage 3		Reversible restrictive
Stage 4		Irreversible restrictive

Fig. 28.16

Event-Free Survival in Patients with Restrictive and Nonrestrictive Filling Patterns (From Meta-Analysis Research Group in Echocardiography (MeRGE) AMI Collaborators. Independent prognostic importance of a restrictive left ventricular filling pattern after myocardial infarction: an individual patient meta-analysis: Meta-Analysis Research Group in Echocardiography Acute Myocardial Infarction. Circulation. 2008;117:2591–2598, with permission).

15. d. In cardiac patients, a decrease ≥50% in E/A ratio with application of the Valsalva maneuver is highly specific for increased LV filling pressure. However, a smaller magnitude of change does not always indicate normal diastolic function. One major limitation of the Valsalva maneuver is that not everyone is able to perform this maneuver adequately and it is not standardized. The Valsalva maneuver is performed by forceful expiration (about 40 mm Hg) against a closed nose and mouth. A decrease of 20 cm/s in mitral peak E velocity is usually considered an adequate effort in patients without restrictive filling. Lack of reversibility with Valsalva is imperfect as an indicator that the diastolic filling pattern is irreversible. In a busy clinical laboratory, the Valsalva maneuver can be reserved for patients in whom diastolic function assessment is not clear after mitral inflow and annulus velocity measurements. The Valsalva is obviously of little use in patients with stage 1 diastolic dysfunction but is useful to differentiate stage 2 diastolic function from normal (Fig. 28.16).

16. a. According to the stage of the disease progress, a spectrum of filling abnormalities can be seen in cardiac amyloidosis that varies from delayed relaxation (Fig. 28.1A) to pseudonormal (Fig. 28.1B) to restrictive filling (Fig. 28.1C). Panels B and C in Fig. 28.1 represent these more advanced stages in the disease process where the operating stiffness of the LV becomes increasingly high due to a gradual loss in LV compliance. This is reflected in a short deceleration time (Fig. 28.1C). In spite of the high left atrial pressure (suggested by a high E-wave velocity), atrial contraction itself hardly contributes to LV filling in the most advanced stages of diastolic dysfunction, as suggested by the diminutive A wave in restrictive filling. In contrast, although

patients with delayed relaxation may be asymptomatic at rest or with mild exercise, their LV has become more dependent on atrial contraction (low E/A ratio). As such, these patients are most likely to feel a change in symptoms with sudden onset of atrial fibrillation due to loss of the atrial kick.

17. d. The Doppler tracing in Fig. 28.2 shows transmitral flow during diastasis, often referred to as a mitral "L-wave." The result is a triphasic mitral inflow pattern that can be seen in patients with structural heart disease–particularly if the HR is relatively slow. It represents an advanced stage of diastolic dysfunction that is characterized by elevated filling pressures and loss of compliance (notice the high peak of early rapid filling and the short initial deceleration time) in combination with very delayed relaxation. The markedly prolonged relaxation, although not immediately obvious, results in a sudden decrease in LV diastolic pressure during mid-diastole, allowing further LV filling during mid-diastole. This explains the L-wave. Preload reduction will decrease left atrial pressure as well as the operating stiffness of the LV and may unmask the underlying relaxation abnormality.

18. c. New recommendations for the assessment of LV filling pressures in patients with preserved EF and reduced EF have been published by the American Society of Echocardiography and the European Association of Echocardiography (Figs 28.17A and B).
Elevated LV filling pressures in a patient with a normal EF can be confirmed with a decreased early diastolic velocity of the mitral annulus derived by tissue Doppler echocardiography (e') < 8 cm/s, reduced color M-mode slope of < 40 cm/s, difference in duration of pulmonary venous AR and mitral inflow A wave duration of > 30 msec, a change in mitral inflow E/A ratio of 0.5 with the Valsalva maneuver, or an increased left atrial volume index > 34 ml/m^2.

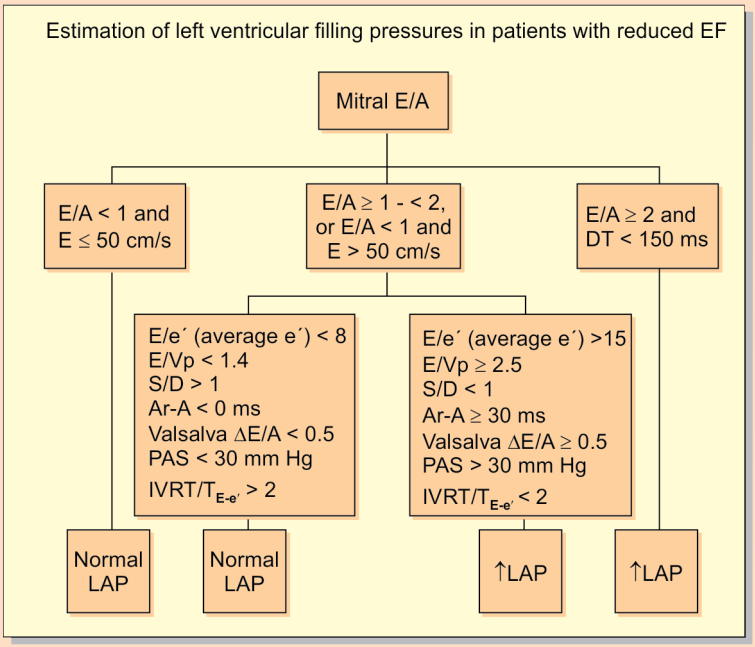


Fig. 28.17A

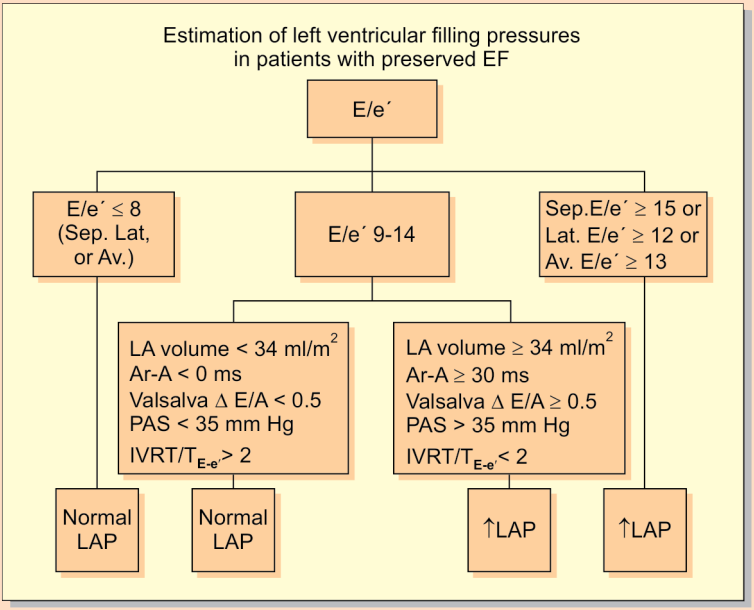


Fig. 28.17B

As left atrial pressure increases, pulmonary vein flow velocity will show blunted systolic flow, and the presence or absence of this finding will therefore also point in the direction of elevated filling pressures. In addition, a prominent pulmonary venous flow AR (> 35 cm/s) will also indicate high LVEDP.

Left atrial volume reflects the cumulative effect of filling pressures over time. A dilated left atrium (> 34 ml/m^2), without a clear history of atrial fibrillation or valvular dysfunction, is suggestive of chronically elevated filling pressures.

19. d. Although we have no information on the exact severity of his LV dysfunction nor his present hemodynamic state, Doppler findings show stage 3 or 4 diastolic dysfunction. Although these patients have a better long-term outcome if treated with beta blocking agents, the echocardiographic findings also indicate that the current operating stiffness of the heart is probably very high. The cardiac output in these patients can therefore be very dependent on HR, as it is almost impossible to increase cardiac output by an augmentation of their stroke volume which will increase their filling pressures even much more. Remember cardiac output = HR multiplied by stroke volume. Careful titration of the β-blocker therapy dose in these patients is therefore warranted.

20. a. Normal LV apical function is highly important in preserving the normal systolic twisting (torsion) and diastolic untwisting motion of the heart. A loss of apical untwisting (in this case due to ischemic injury) will likely have an adverse impact on the elastic recoil forces that generate LV suction, allowing LV filling during early diastole at low left atrial pressure. In normal conditions, a negative gradient from base to apex (with the lowest pressure in the apex) can be observed at early diastole, leading to an acceleration of blood toward the LV apex. In this patient, however, LV apical scar can disturb this mechanism, leading to a decrease and not an increase in the early diastolic pressure gradient (diastolic suction).

21. d. Note that color M-mode Vp and tissue Doppler E' are essentially unchanged. A higher 6 months E/e' ratio and E/Vp ratio both indicate increased LV filling pressures. A lower A-wave velocity indicates reduced left atrial contractility. The shorter deceleration time indicates increased LV operating stiffness. The association between tissue Doppler e' and LV relaxation has been observed in bot h animal and human studies.
22. c. The Doppler findings demonstrate a large (> 30 ms) difference between the duration of the mitral A-wave velocity and the duration of the late diastolic pulmonary venous flow reversal (AR), suggesting elevated end-diastolic LV filling pressures. This is usually seen in patients with stage 2 or stage 3 diastolic function. Of the four conditions stated earlier, the most likely is the 60-year-old man with advanced hypertensive heart disease. The other conditions including constrictive pericarditis would not cause stage 2 diastolic function.
23. a. The mitral inflow pattern can be used with relative accuracy to assess filling pressures in patients with depressed LV systolic function. In this population, changes in the inflow pattern will reflect changes in preload (e.g. due to volume overload or changes in medical therapy). Confusion between normal and pseudonormal filling should be absent as diastolic function is intrinsically disturbed in the presence of advanced systolic dysfunction.
    In contrast, additional information is needed in the presence of preserved ejection fraction as this Doppler pattern could equally represent normal or pseudonormal filling. As mentioned earlier, the echocardiographer should assess tissue Doppler derived e', Vp obtained by color M-mode Doppler, measure left atrial size, and finally evaluate the effect of Valsalva to detect an underlying relaxation abnormality in the case of pseudonormal filling. Left atrial dilatation can merely represent atrial remodeling independent of filling pressures in the setting of atrial fibrillation. Moderate and severe MR usually leads to an elevation of peak E velocity, representing the increased flow rate during diastole with a normal deceleration time. However, particularly with chronic MR, the left atrial will dilate and the increased left atrial compliance may be sufficient to maintain filling pressures at a normal level.
    Finally, a high velocity tricuspid regurgitant jet may be suggestive of (but is not specific for) elevated left-sided filling pressures. Many other conditions may lead to pulmonary hypertension in the presence of normal diastolic function. (Refer to the answer to question 18; Nagueh et al.)
24. c. In normal patients, hepatic vein Doppler velocities reflect changes in pressure, volume, and compliance of the right atrium. Typically, hepatic vein Doppler velocities consist of four elements: (1) systolic forward flow (S), (2) diastolic forward flow (D), (3) systolic flow reversal (VR), and (4) atrial flow reversal (AR). In patients with normal hemodynamics, S is typically larger than D and there are no significant systolic or diastolic reversals. Typically, with myopathic conditions, flow reversals are accentuated with inspiration due to increased systemic venous return to the right heart. Diastolic flow reversal is seen most commonly in patients with pulmonary hypertension and constrictive pericarditis, and it is respiratory variation that helps to differentiate them from each other. In patients with constrictive pericarditis, there are increased right ventricular and right atrial pressures; and characteristically, these patients demonstrate augmentation of diastolic flow reversals with expiration. Patients with pulmonary hypertension typically do not have augmentation of diastolic flow reversals with respiration. In addition, constrictive pericarditis can be differentiated from restrictive cardiomyopathy with hepatic venous Doppler recordings. In patients with restrictive cardiomyopathy, inspiratory diastolic flow reversal is larger than expiratory. Alternatively, patients with severe tricuspid regurgitation, which by definition

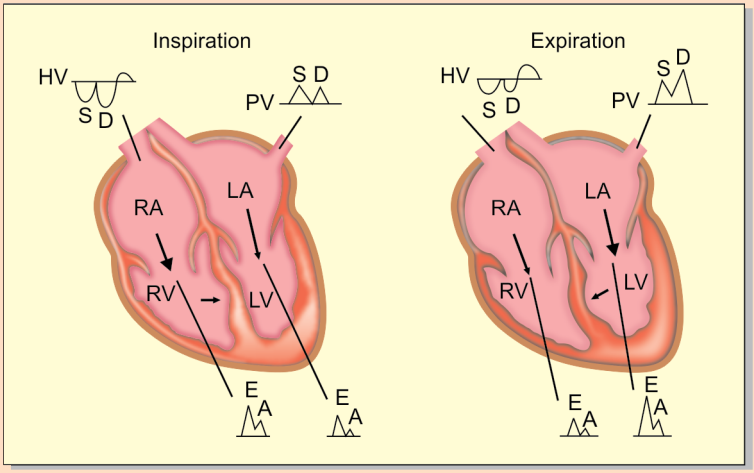


Fig. 28.18

is occurring during systole, will typically demonstrate prominent systolic flow reversals (Fig. 28.18).

25. e. Cutoff values for differentiating normal from abnormal cases should consider the age group from which the study sample is selected. In this case, E/A ratio is almost 2, which falls outside the range of normal values for patients older than 60 years.

29

Echocardiography for Stress

1. The statement that best describes the ischemic cascade is:
   a. Wall motion abnormalities are preceded by electrocardiographic changes
   b. Angina occurs prior to the development of wall motion abnormalities
   c. Hemodynamic changes occur after electrocardiographic changes
   d. Perfusion abnormalities precede the onset of wall motion abnormalities
   e. Wall motion abnormalities precede diastolic dysfunction
2. The statement that best describes the accuracy of stress echocardiography is:
   a. The sensitivity and specificity of exercise stress echocardiography to detect flow-limiting coronary artery stenosis is significantly lower compared to scintigraphic imaging
   b. The specificity of stress echocardiography using vasodilators is lower than exercise and dobutamine stress echocardiography
   c. During dobutamine stress echocardiography, the addition of atropine increases its specificity
   d. The accuracy of stress echocardiography may be affected by the presence of significant aortic regurgitation
   e. The accuracy of stress echocardiography to detect single-vessel disease is greater than its accuracy to detect multivessel disease
3. Stress echocardiography and myocardial perfusion stress imaging are stress testing modalities based on different pathophysiologic concepts and techniques. The statement that best describes the relationship between both modalities is:
   a. The sensitivity of stress echocardiography to detect single-vessel coronary artery disease is lower compared to myocardial perfusion stress imaging
   b. The specificity of stress echocardiography to detect flow-limiting stenosis is lower than myocardial perfusion stress imaging
   c. Stress echocardiographic interpretation is less subjective than myocardial perfusion stress imaging
   d. The cost of both modalities is comparable
4. The following can decrease the specificity of stress echocardiography:
   a. Concomitant use of beta-blockers at the time of testing
   b. Concentric left ventricular hypertrophy
   c. Delay on image acquisition
   d. Inadequate exercise with suboptimal peak heart rate
   e. Hypertensive response

1. d 2. d 3. a 4. e

5. The most appropriate indication to stop a dobutamine stress echocardiogram (echo) is:
   a. Chest pain
   b. T-wave inversions
   c. Bigeminy
   d. New wall motion abnormality
   e. Up-sloping ST-segment depressions

6. The statement that best describes inducible ischemia on a dobutamine stress echo is:
   a. Normal resting wall motion that becomes hyperkinetic on stress
   b. Akinetic segment that becomes dyskinetic on stress
   c. Biphasic response
   d. Hypokinetic segment that becomes hyperkinetic on stress
   e. Monophasic response

7. The sensitivity and specificity of stress echocardiography to detect ischemia is greatest in which coronary artery distribution?
   a. Left anterior descending artery
   b. Left circumflex artery
   c. Obtuse marginal branch
   d. Right coronary artery
   e. Septal perforators

8. Which of the following statements about the prognostic value of stress echocardiography is correct?
   a. Left ventricular ejection fraction is not important if peak wall motion score index is increased
   b. Development of wall motion abnormalities at lower heart rates does not have prognostic implications
   c. Assessment of myocardial viability has no prognostic value
   d. The event rate of a patient with intermediate pretest probability of coronary artery disease and a negative stress echo is < 1%/year
   e. The event-free survival for diabetics and nondiabetics with a normal stress echo is similar

9. The role of stress echocardiography in risk stratification of patients undergoing noncardiac surgery includes:
   a. Stress echo has a high positive predictive value
   b. The territory of ischemia by stress echocardiography predicts the area of perioperative infarction
   c. The negative predictive value of stress echocardiography is high
   d. The perioperative event rate in patients undergoing exercise stress echocardiography is usually higher than those undergoing dobutamine stress echocardiography
   e. The positive predictive value of stress echocardiography is better than stress myocardial perfusion imaging

10. The use of contrast agents in stress echocardiography is best described by the following:
    a. Contrast increases intra- and interobserver variability of wall motion interpretation
    b. The use of contrast in stress echocardiography is currently approved by the Food and Drug Administration
    c. Dobutamine is the preferred method of stress for contrast myocardial perfusion imaging
    d. The presence of a significant intracardiac shunt is an absolute contraindication for the use of echo contrast
    e. Contrast should be used in all patients undergoing stress echocardiography

5. d 6. c 7. a 8. d 9. c 10. d

11. The following statement about viability assessment by stress echocardiography is correct:
    a. The accuracy of exercise and dobutamine stress echocardiography is similar for the prediction of left ventricular function improvement, after revascularization in ischemic cardiomyopathy
    b. The detection of inotropic contractile reserve relies on the intact metabolism within the myocytes to assess viability
    c. In ischemic cardiomyopathy, biphasic response during dobutamine stress echocardiography is a better predictor of left ventricular function improvement than a monophasic response
    d. The sensitivity of dobutamine stress echocardiography to detect viability is superior to that of Thallium redistribution studies
    e. Dobutamine stress echocardiography can differentiate scar in the epicardium versus endocardium similar to magnetic resonance imaging

12. The following portends a benign prognosis during stress echocardiography:
    a. Transient left ventricular cavity dilatation
    b. Presence of wall motion abnormality at heart rates less than 100 bpm
    c. Presence of wall motion abnormalities in both left and right ventricle
    d. Drop in systolic blood pressure of 40 mm Hg during dobutamine stress echocardiography, without wall motion abnormalities
    e. Peak wall motion score index >1.7

13. Myocardial contrast echocardiography is a rapid and easy-to-perform technique for the assessment of myocardial perfusion. The statement that best describes the use of myocardial perfusion echocardiography on stress testing is:
    a. High-power imaging allows continuous imaging and wall motion analysis
    b. The accuracy of nuclear scintigraphy and dobutamine stress echocardiography to detect flow-limiting coronary artery stenosis is superior to myocardial perfusion stress echocardiography
    c. Attenuation artifacts do not affect myocardial perfusion stress echocardiography
    d. The incidence of ventricular and supraventricular arrhythmias during dobutamine myocardial contrast stress echocardiography is lower than for dobutamine stress echocardiography
    e. Myocardial perfusion during dobutamine stress imaging can detect subendocardial ischemia even when transmural wall thickening is normal

14. Traditionally, the assessment of inducible ischemia by stress echocardiography has been based on the evaluation of systolic function post stress, either by subjective visual analysis or by quantitative techniques, such as tissue Doppler and strain. Recently, there is increasing interest in the assessment of diastolic echocardiographic parameters during stress echocardiography. The statement that best describes the application of diastology to stress echocardiography is:
    a. The passive nature of diastole makes its use in stress echocardiography a less sensitive technique than the assessment of systolic function
    b. Relaxation abnormalities caused by inducible ischemia resolve earlier than systolic abnormalities
    c. Unlike systolic function, the accuracy of diastolic function during stress echocardiography is not affected by the presence of cardiomyopathy or hypertensive heart disease
    d. Regional diastolic abnormalities cannot be seen in the presence of a normal Early mitral valve inflow wave (E)/Early mitral annulus tissue Doppler wave (E') ratio
    e. Worsening left ventricular filling parameters during stress echocardiography correlate with lower exercise tolerance

11. c 12. d 13. e 14. e

15. A 52-year-old female with a history of dyslipidemia and ex-smoker was referred for stress echo due to exertional dyspnea and a recent episode of syncope. She exercised for 6 minutes and had to stop due to shortness of breath. She reached 86% of her maximum predicted heart rate. What would be the cause of this patient's symptoms (Fig. 29.1)?
    a. Severe proximal right coronary artery stenosis
    b. Severe proximal left circumflex artery stenosis
    c. Severe multivessel disease
    d. Dynamic pulmonary hypertension

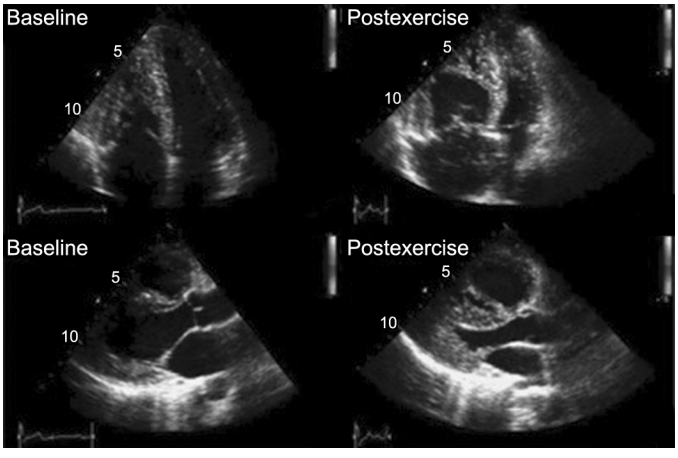


Fig. 29.1

16. A 50-year-old female with a history of dyslipidemia was referred for stress testing due to dyspnea on exertion. The resting echocardiogram showed left ventricular hypertrophy. She exercised for 4 minutes. Her heart rate and blood pressure changed from 69 bpm and 120/70 mm Hg to 111 bpm and 120/60 mm Hg, respectively, at peak exercise. A continuous-wave Doppler was done through the aortic valve post stress. Based on Figure 29.2, what would be the best next step in the management of this patient?
    a. Coronary angiography with revascularization
    b. Perform dobutamine stress echocardiography
    c. Perform pharmacologic nuclear stress imaging
    d. Medical therapy with beta blockers
    e. Valve replacement

17. A 70-year-old male with a history of hypertension was admitted with chest pain and mild elevation of cardiac enzymes but no electrocardiographic changes. A dobutamine stress echo was performed. Based on Figure 29.3, which one is the most accurate statement?
    a. Severe triple-vessel disease will be seen in coronary angiography
    b. Peak wall motion score index confers a bad prognosis
    c. Dobutamine stress echocardiography is consistent with ischemic response
    d. Dobutamine stress echocardiography shows a biphasic response
    e. Improvement in wall motion is likely

15. d 16. d 17. e

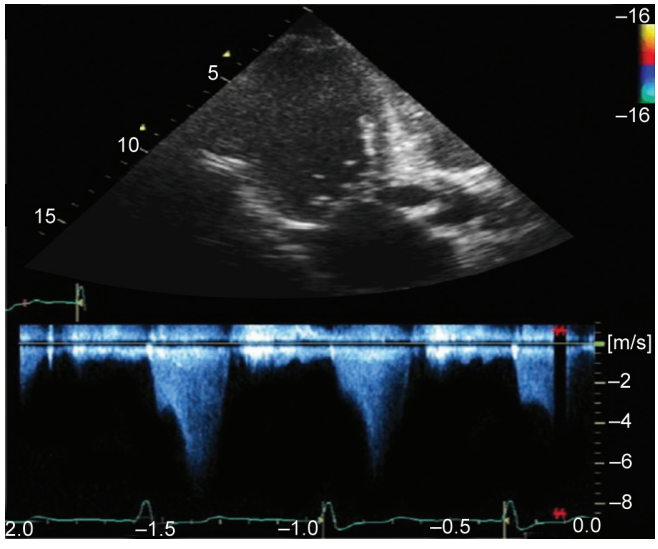


Fig. 29.2

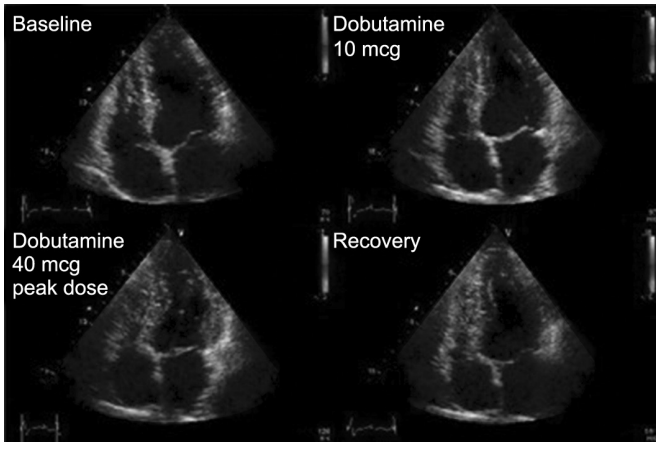


Fig. 29.3

18. A 58-year-old male with a history of hypertension and smoking presented with recurrent retrosternal chest pain for the last 3 weeks. Electrocardiogram and cardiac enzymes were normal. An exercise stress echo was performed. Which of the following statements best describes the findings on coronary angiography (Fig. 29.4)?
    a. Left anterior descending artery stenosis of 70% without distal collateral circulation
    b. Left anterior descending artery stenosis of 70% with distal collateral circulation
    c. Right coronary artery stenosis of 70% without distal collateral circulation
    d. Left circumflex artery stenosis of 70% without distal collateral circulation
    e. Left circumflex artery stenosis of 70% with distal collateral circulation

18. a

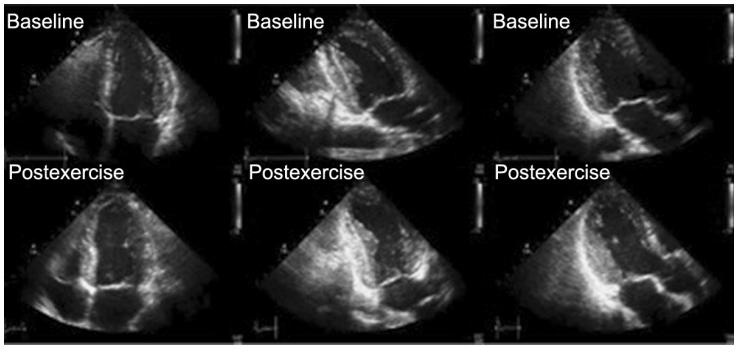


Fig. 29.4

19. A 71-year-old female with a history of diabetes and hypertension presented with dyspnea on exertion. A dobutamine stress echo was performed. Which of the following statements would best describe the findings on coronary angiography (Fig. 29.5)?
    a. Flow-limiting left anterior descending artery stenosis
    b. Flow-limiting left circumflex artery stenosis
    c. Flow-limiting right coronary artery stenosis
    d. Multivessel coronary artery stenosis
    e. Flow-limiting diagonal branch stenosis

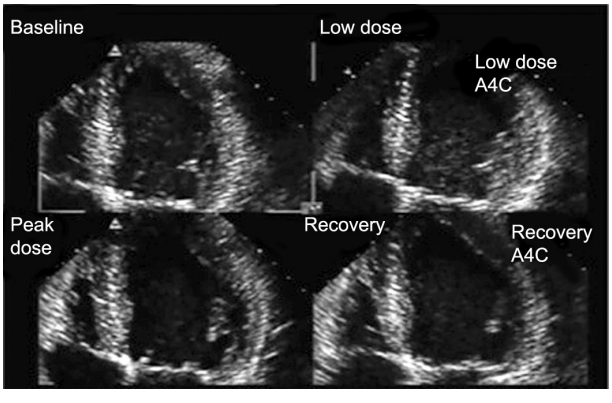


Fig. 29.5

20. A 56-year-old asymptomatic male with a history of dyslipidemia and tobacco use was referred for a stress echo prior to elective cholecystectomy. The patient underwent dobutamine stress echo without chest pain or electrocardiographic changes. Based on the findings, which of the following is the most appropriate statement (Fig. 29.6)?
    a. This patient is at high risk for perioperative cardiac events
    b. This patient is at low risk for perioperative cardiac events
    c. Coronary angiogram and revascularization should be considered
    d. Myocardial perfusion imaging should be considered
    e. Computed tomography for calcium scoring should be considered

19. d 20. b

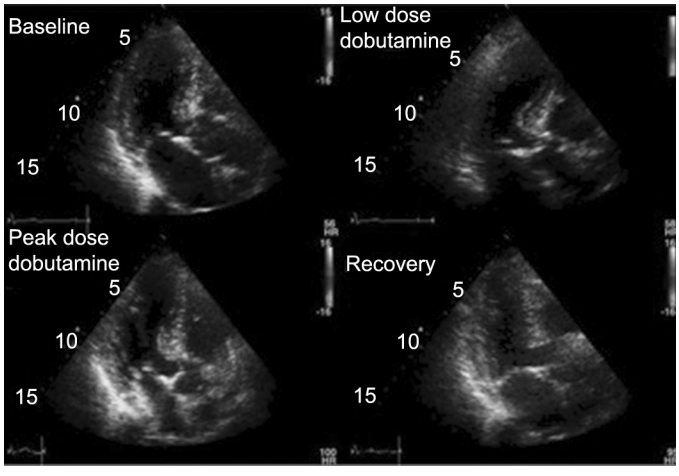


Fig. 29.6

21. A 55-year-old female with a previous history of hypertension and alcohol abuse presented with dyspnea, lower extremities edema, orthopnea, and paroxysmal nocturnal dyspnea. She was admitted and appropriate medical therapy was initiated. She was ruled out for acute coronary syndrome. A dobutamine stress echo was performed. Based on the findings in the dobutamine stress echo, which of the following statements is correct (Fig. 29.7)?
    a. A biphasic response is seen in this patient
    b. The probability of left ventricular functional recovery without revascularization is high
    c. The probability of left ventricular functional recovery with revascularization is high
    d. The probability of left ventricular functional recovery is low
    e. The peak wall motion score index in this patient predicts a high event rate

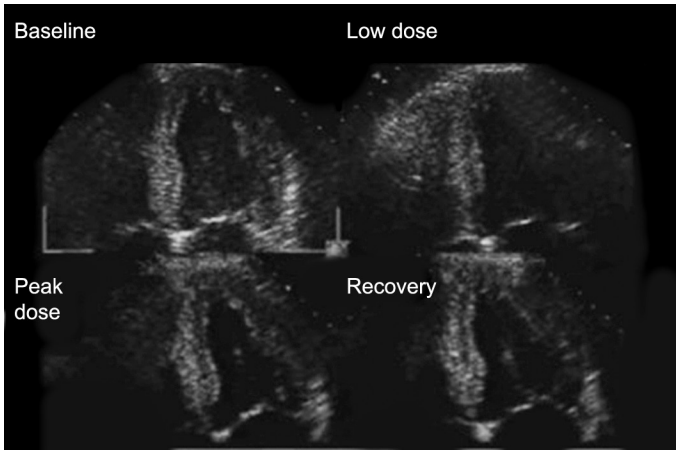


Fig. 29.7

21. b

22. A 56-year-old male complaining of dyspnea on exertion and only able to walk two blocks is referred for exercise stress echo. Based on the findings on the stress echo in Figure 29.8, what would be the next step in the management of this patient?
    a. Mitral valve repair
    b. Mitral valve replacement
    c. Monitor with serial echocardiography
    d. Work-up for pulmonary embolism
    e. Mitral valve repair after left ventricular function improves

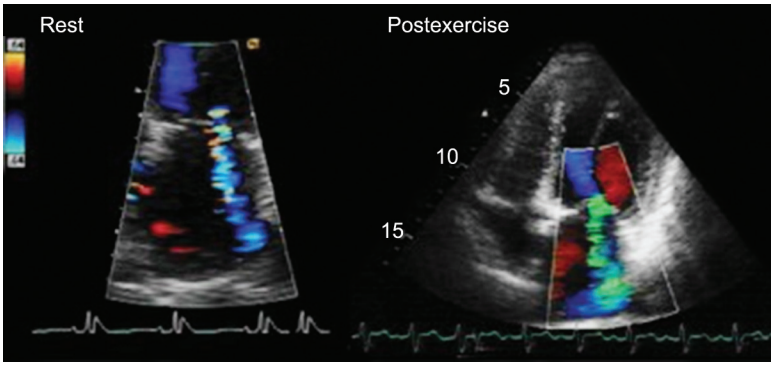


Fig. 29.8

23. A 79-year-old female was referred for a stress echo due to chest pain. She underwent dobutamine stress echo without chest pain or electrocardiographic changes. Which statement best describes the findings in Figure 29.9?

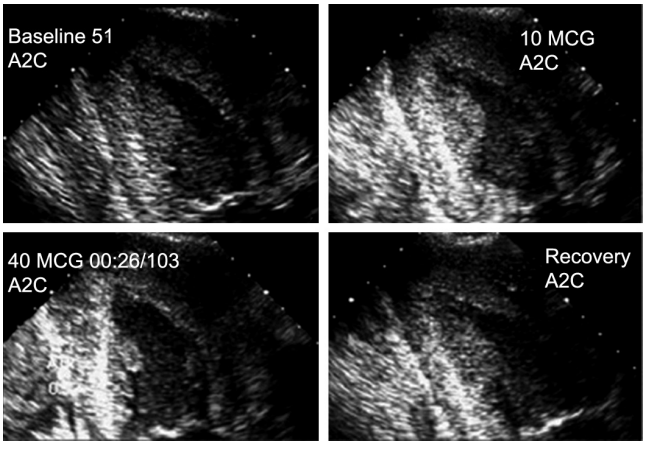


Fig. 29.9

    a. No ischemia
    b. Anterior wall ischemia
    c. Lateral wall ischemia
    d. Apical ischemia
    e. Inferior and posterior wall ischemia

22. a 23. e

24. A 72-year-old male was referred for an exercise stress echo due to chest pain. Which statement best describes the stress echo findings in Figure 29.10?
    a. No ischemia
    b. Anterior wall ischemia
    c. Lateral wall ischemia
    d. Anteroseptal ischemia
    e. Inferior/posterior wall ischemia

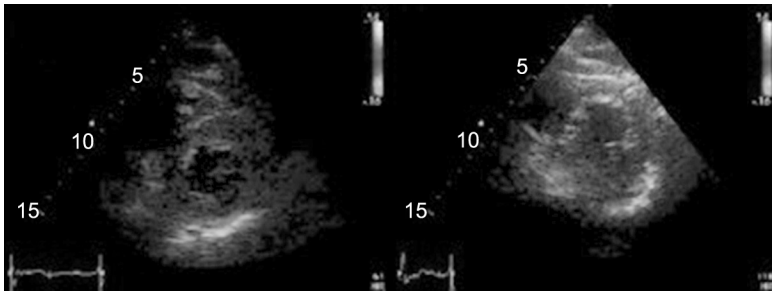


Fig. 29.10

24. d

Answers

1. d. The use of stress echocardiography to diagnose flow-limiting coronary artery disease is based on a sequence of events known as the ischemic cascade, shown in Figure 29.11. The decrease in blood flow initially produces a perfusion abnormality, diastolic and systolic dysfunction, in that order, and then hemodynamic abnormalities occur. Electrocardiographic changes and symptoms occur late in the ischemic cascade, hence the lower sensitivity of these parameters to identify ischemia.

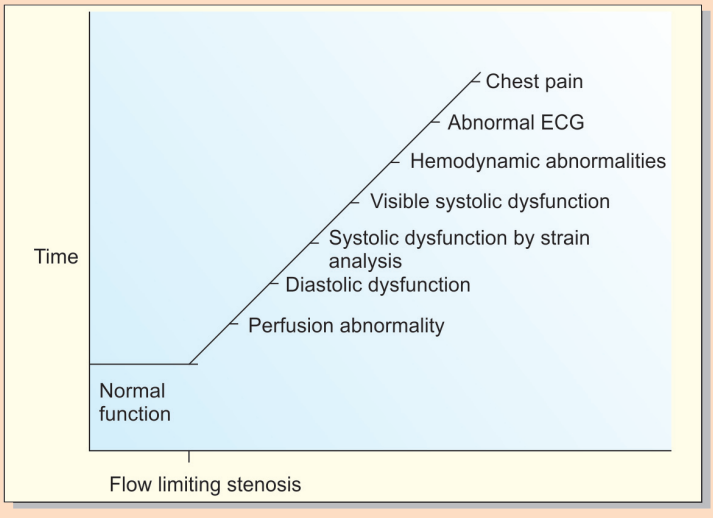


Fig. 29.11

2. d. The overall sensitivity and specificity of stress echocardiography is comparable to scintigraphic imaging. The sensitivity and specificity of stress echocardiography depends on multiple factors including significant coronary artery disease, pretest probability of coronary artery disease, mode of stress used, number of vessels involved, and medications used at the time of testing. The sensitivity of exercise stress echocardiography ranges from 80 to 88%, with specificities ranging from 82 to 90%. For dobutamine stress echocardiography, the sensitivity ranges from 68 to 95% with a specificity of 77 to 100%. The sensitivity of vasodilator-based stress echocardiography ranges from 40 to 91% but with a good specificity. Although the sensitivity of vasodilator stress echocardiography is lower than for exercise or dobutamine stress echocardiography, its specificity is good and comparable to both modalities. Atropine is frequently used during dobutamine stress echocardiography when the peak heart rate is suboptimal, to improve the sensitivity.

   The sensitivity of stress echocardiography is proportionally related to the number of vessels involved, being the greatest for triple-vessel disease. Significant aortic regurgitation can produce regional wall motion abnormalities, thus reducing the specificity of stress echocardiography.

3. a. The sensitivity of stress myocardial perfusion imaging for single-vessel disease is better than stress echocardiography, while stress echocardiography has a greater specificity than stress myocardial perfusion imaging. Technically, stress echocardiography is a more challenging test compared to myocardial perfusion imaging, but has the advantage of being less costly and time-consuming for the patient, without the concern of radiation exposure. Interpretation of wall motion by stress echocardiography is subjective and requires some expertise.

4. e. It is important to recognize that not all wall motion abnormalities on stress are due to ischemia. Noncoronary causes of a false-positive study include the presence of a pacemaker, left bundle branch block, or prior cardiac surgery that can produce paradoxical septal motion. Hypertensive response, cardiomyopathy, dynamic right ventricular pressure overload, and aortic regurgitation can cause nonischemic wall motion abnormalities on stress. Inadequate workload with suboptimal peak heart rate, use of beta-blockers, delay on image acquisition, and concentric left ventricular hypertrophy decrease the sensitivity of the stress echo but not its specificity.
5. d. Symptoms not associated with objective evidence of ischemia (wall motion abnormalities) are not an indication to stop the test. Thus, chest pain or up-sloping ST-segment changes and T-wave inversions do not mandate termination of the test. Supraventricular or ventricular arrhythmias, such as atrial fibrillation or nonsustained ventricular tachycardia, are indications to stop the infusion of dobutamine, but not bigeminy.
6. c. The normal response of wall motion to stress is a hyperkinetic state with increase in myocardial thickening and endocardial excursion (greater than 5 mm). A normal or a hypokinetic segment that worsens on stress is considered abnormal and consistent with inducible ischemia. A hypokinetic segment that remains unchanged represents scar tissue. A hypokinetic segment that improves on stress represents viable myocardium (monophasic response). A hypokinetic segment that improves on low-dose dobutamine and deteriorates at peak dose represents viable myocardium and ischemia in this segment (biphasic response). Dyskinesis is the extreme degree of wall motion abnormality characterized by myocardial thinning and outward movement during systole.
7. a. The sensitivity of stress echocardiography to detect flow-limiting lesions depends not only on the degree of coronary stenosis, but also on the number of vessels involved or jeopardized myocardium. The sensitivity is superior for multivessel than for single-vessel disease. Likewise, the sensitivity to detect stenosis in the left anterior descending artery and right coronary artery territory is superior to the sensitivity for the left circumflex. The highest sensitivity is for left anterior descending artery stenosis.
8. d. Echocardiography is a complementary part of stress testing, and as such should be considered in conjunction with clinical and electrocardiographic variables for risk-stratifying patients. Stress echocardiography provides incremental value over clinical electrocardiography and resting echocardiographic parameters. The classification of stress echocardiography as normal and abnormal can effectively risk-stratify patients, but echocardiographic findings of ischemia, such as peak wall motion score index, are more important in the determination of risk. The event rate of a negative stress echo varies with the population studied, but overall in an intermediate risk population is <1%/year. The event rate and mortality are significantly increased (twofold), in diabetics versus nondiabetics with a negative stress echo (2.2% vs. 1%/year). Left ventricular ejection fraction is a strong independent prognosticator. A wall motion abnormality at lower heart rates is consistent with multivessel disease and a worse prognosis. Viability has incremental prognostic value over clinical and resting echocardiographic variables.
9. c. The negative predictive value of a normal stress echo is very good (93–100%). This high negative predictive value allows the identification of patients with a very low likelihood of experiencing perioperative events and thus can undergo noncardiac surgery without further testing. The positive predictive value of stress echocardiography (7–33%) and myocardial perfusion imaging is low. Patients who can exercise generally have a better prognosis than those undergoing a dobutamine stress echo. The area of ischemia identified by stress echocardiography or myocardial perfusion imaging does not predict the perioperative region of infarction.

10. d. The use of echo contrast is currently approved by the Food and Drug Administration only for left ventricular opacification and endocardial border delineation. Echo contrast decreases intra- and interobserver variability in wall motion interpretation, thus increasing the accuracy of stress echocardiography. Myocardial perfusion imaging is another application of echo contrast in stress testing. Vasodilator agents are the preferred method of perfusion stress testing with echo contrast. The use of echo contrast agents has been shown to be a safe practice in multiple studies. In October 2007, the Food and Drug Administration issued new warnings and contraindications for the use of ultrasound contrast agents, based on reports of four deaths occurring within 30 minutes of contrast injection. Although these deaths were temporally related, there is little evidence for causation; and it has been suggested that they may have been due to progression of underlying disease. In July 2008, these warnings were relaxed by the Food and Drug Administration. The use of contrast is contraindicated in the presence of known right-to-left, bidirectional, or transient right-to-left cardiac shunts (other than patent foramen ovale). This is based on the fact that in the presence of a significant cardiac shunt the microbubbles can bypass the pulmonary particle filtering mechanism and directly enter the arterial circulation causing microvascular occlusion and ischemia. Also, their use is contraindicated in patients with hypersensitivity to perflutren; and hypersensitivity to blood products (Optison only). Additional monitoring of vital signs, oxygen saturation, and electrocardiography is recommended for 30 minutes after contrast administration, in patients with unstable cardiopulmonary conditions. Although the Food and Drug Administration has not approved the use of echo contrast agents for stress echocardiography, it is used in most laboratories and recommended by the American Society of Echocardiography.
11. c. The predictive value of low-level exercise stress echocardiography for left ventricular function improvement is lower than dobutamine stress echocardiography. The use of dobutamine is based on the concept of inotropic contractile reserve in which a viable myocardium will improve its contractility, while nonviable myocardium will remain unchanged. Biphasic response has the highest predictive value of functional recovery. Sustained improvement or no change response can predict functional recovery, but with a lower positive predictive value than biphasic response. Dobutamine stress echocardiography unlike magnetic resonance cannot differentiate scar in the endocardium versus the epicardium.
12. d. Transient ischemic cavity dilatation of the left ventricle is defined as transient increase in the end-systolic dimensions from rest to peak stress. It is a marker of severe and extensive coronary artery disease and is associated with a high risk of cardiac events (19.7%/y event rate). Transient ischemic cavity dilatation occurs in patients with absent or limited collateral circulation. Peak left and right ventricular wall motion abnormalities, low ischemic threshold, and peak wall motion score index >1.7 are poor prognosticators associated with an increased cardiac event rate. Wall motion score index is derived from the cumulative sum score of all left ventricular wall segments, divided by the number of visualized segments. Hypotension occurring during exercise testing has been associated with an increased prevalence of multivessel coronary artery disease and a poor prognosis. Mild hypotension (a drop in systolic blood pressure < 50 mm Hg) occurs in 14%–38% of dobutamine stress echo. Unlike hypotension occurring with exercise stress echocardiography, mild hypotension during dobutamine infusion carries a good prognosis in the absence of new wall motion abnormalities.
13. e. The potential clinical utility of myocardial contrast echocardiography in conjunction with stress testing to diagnose hemodynamically significant coronary artery disease has been shown in numerous studies. The most commonly used stress agents for myocardial perfusion are adenosine, dipyridamole, and dobutamine. The accuracy of myocardial perfusion stress echocardiography to detect flow-limiting coronary artery stenosis is comparable to nuclear scintigraphy and dobutamine stress echocardiography, with a sensitivity of about 85% and a specificity of 74%. Myocardial perfusion stress echocardiography also provides prognostic

information in patients with stable coronary artery disease. Patients with normal perfusion have a better prognosis than patients with normal wall motion. Xie et al. showed how in patients with significant left anterior descending artery disease, myocardial perfusion during dobutamine stress echocardiography was able to detect subendocardial ischemia even when transmural wall thickening appeared normal. Tsutsui et al. evaluated the safety of myocardial perfusion during dobutamine stress echocardiography in 1,486 patients and found no difference in adverse events, including cardiac arrhythmias, when compared to conventional dobutamine stress echocardiography. The image interpretation during myocardial perfusion stress echocardiography is affected by the lateral resolution of the ultrasound beam, which affects mainly the lateral wall; and also by attenuation, affecting the basal segments. Myocardial perfusion can be accomplished by using high-power (high mechanical index) or low-power (mechanical index < 0.2) modalities. Since high power destroys the microbubbles, high frame rates and continuous imaging cannot be performed without destroying most of the microbubbles, making impossible the simultaneous analysis of wall motion. On the other hand, low-power imaging causes minimal microbubble destruction, allowing continuous imaging and wall motion analysis.

14. e. Diastole is an active process. Myocardial contraction is initiated by cytosolic calcium binding troponin C, causing disinhibition of troponin I and actin–myosin cross-bridge formation. During relaxation, the interaction of adenosine triphosphate with myosin causing actin–myosin dissociation and the removal of cytosolic calcium by sarcoplasmic reticulum calcium adenosine triphosphatase, are energy-dependent processes. As illustrated previously on the ischemic cascade, relaxation abnormalities occur earlier than systolic abnormalities making the assessment of stress-induced diastolic abnormalities a more sensitive technique than systolic abnormalities. Furthermore, diastolic abnormalities last longer than systolic abnormalities during ischemia. A recent study by Ishii et al. showed that at 10 minutes post exercise no systolic abnormalities were identified while delayed relaxation was seen in 85% of the territories supplied by stenotic coronary arteries. The accuracy of diastolic function assessment during stress echocardiography can be affected by conditions causing dyssynchrony, including cardiomyopathy and hypertensive heart disease. Regional diastolic abnormalities can be seen even if the global diastolic and systolic functions are normal. Patients whose left ventricle filling parameters worsen on stress have a lower exercise tolerance than those without diastolic abnormalities.

15. d. This case illustrates the hemodynamic pulmonary response to exercise in a patient with primary pulmonary hypertension who had only mild pulmonary hypertension at rest, with a pulmonary artery systolic pressure of 39 mm Hg that rose to 90 mm Hg during exercise. Post stress, there is right ventricular enlargement and hypokinesis due to a dynamic rise in right-side pressures.

16. d. An exercise stress echo is a useful tool to elicit a left ventricular outflow tract gradient in patients with latent hypertrophic cardiomyopathy. Patients without obstruction at rest or with provocation maneuvers may develop obstruction during exercise as evidenced in this patient, causing symptoms. The continuous-wave Doppler signal through the left ventricular outflow tract is a dagger-shaped, late peaking envelope characteristic of dynamic obstruction as opposed to aortic stenosis where the gradient usually peaks in early to midsystole.

17. e. Dobutamine stress echocardiography plays an important role in risk stratification of patients after myocardial infarction and for the assessment of myocardial viability. On baseline images, there is hypokinesis of the inferior, posterior, and lateral walls with marked inotropic contractile reserve at low-dose dobutamine stress echocardiography, without evidence of ischemia (monophasic response). The hypokinetic myocardium represents stunned myocardium without evidence of ischemia (biphasic response), indicating the absence of flow-limiting stenosis that may require revascularization. This phenomenon can be

caused by spontaneous coronary recanalization. The presence of marked viability carries a good prognosis with a lower cardiac event rate, and predicts improvement in wall motion after restoration of coronary blood flow. The absence of ischemia confers a more favorable prognosis.

18. a. The echocardiographic images in Figure 29.4 show wall motion abnormalities at peak heart rate, in the mid to apical anterior and septal wall, as well as the apex. There is also evidence of transient ischemic cavity dilatation. This is typical of a left anterior descending artery flow-limiting stenosis. Transient ischemic cavity dilatation predicts severe and extensive coronary artery disease; and is most commonly seen in the absence of distal collateral circulation.
19. d. The echocardiographic images in Figure 29.5 show new wall motion abnormalities in the anterior, lateral, septal, inferior, and posterior walls, as well as evidence of transient ischemic cavity dilatation, consistent with extensive and severe ischemia. This distribution is consistent with multivessel disease.
20. b. The echocardiographic images in Figure 29.6 reveal mild apical ischemia. Note on the apical long-axis view, the difference in cavity size between the stages of low dose and peak dose of dobutamine, at the level of the apex. During the low-dose stage, there is a normal hypercontractile response with complete cavity obliteration; while during the peak dose, there is apical hypokinesis without complete cavity obliteration that indicates ischemia in this region. The absence of symptoms and mild degree of ischemia (<four segments) are factors that portend a low risk for perioperative cardiovascular events and further workup and delay in the surgical procedure is not warranted.
21. b. The dobutamine stress echo in this patient with severe left ventricular dysfunction was performed for diagnostic and prognostic purposes: It illustrates a case of nonischemic cardiomyopathy with marked inotropic contractile reserve. Gradual decrease in left ventricular cavity size can be appreciated from baseline to low and peak dose, consistent with a hypercontractile response. All left ventricular segments improve at low and peak dose, with normalization of the left ventricular ejection fraction at peak dose. Deterioration in wall motion contractility at peak dose is not seen, indicating the absence of ischemia (biphasic response). Inotropic contractile reserve, as determined by the change in wall motion score index from baseline to low or peak dose dobutamine, as well as the number of recruiting segments. It portends a favorable prognosis in this patient, with a high probability of left ventricular function recovery, good response to beta-blockers, cardiac resynchronization therapy, and a lower cardiac event rate.
22. a. This patient presents with symptoms not explained by the degree of mitral regurgitation seen on the resting echo. The exercise stress echo shows an increase in the severity of mitral regurgitation and a further increase in the pulmonary artery systolic pressure, both consistent with hemodynamically significant mitral regurgitation. Mitral valve repair is the treatment of choice due to the lower risk of thrombosis and endocarditis compared to a prosthetic valve.
23. e. The echocardiographic images in Figure 29.9 reveal new wall motion abnormalities consistent with ischemia in the inferior and posterior walls.
24. d. The echocardiographic images in Figure 29.10 reveal new wall motion abnormalities consistent with mild ischemia in the anteroseptum.

30

Perioperative Transesophageal Echocardiography

1. Air embolization to a coronary artery is associated with wall motion abnormalities in which coronary territory?
   a. Right coronary artery
   b. Left anterior descending
   c. Left circumflex
   d. Global
   e. No coronary territory

2. In a patient who previously required dilation of an esophageal stricture, what should be done regarding intraoperative echocardiography?
   a. Passage of the transesophageal echocardiogram (TEE) probe can proceed as usual, because the stricture has been dilated
   b. Use of a pediatric probe is the only way to do a TEE
   c. The transesophageal probe should not be inserted. Epicardial echo is an alternative imaging modality
   d. A standard TEE probe can be used, but it should not be passed beyond the gastroesophageal junction
   e. Intraoperative echocardiography is not recommended

3. In patients with aortic and mitral stenosis, the prepump TEE is less reliable than aortic and mitral valve continuous-wave Doppler gradients by preoperative transthoracic echo because:
   a. Mitral and aortic valve velocity cannot reliably be recorded by TEE
   b. Mitral valve velocity cannot reliably be recorded by TEE
   c. Aortic valve velocity cannot be reliably recorded by TEE
   d. Changes in loading conditions make recordings of the valvular velocities in the operating room unreliable
   e. Continuous-wave Doppler cannot be reliably recorded by TEE during electrocautery

1. a 2. c 3. c

4. Intraoperative TEE during implantation of a left ventricular assist device (LVAD) is useful for:
   a. Exclusion of mitral regurgitation, which makes the LVAD ineffective
   b. Deciding on location of the inflow cannula into the left ventricle
   c. Exclusion of aortic regurgitation that causes a shunt to return back to the left ventricular (LV) cannula
   d. Quantitation of tricuspid regurgitation (TR) that affects the amount of right atrial (RA) hypertension
   e. Diagnosis of LV enlargement, which is necessary for allowing a large-enough outflow cannula size

5. The midesophageal long-axis view subtends which walls of the left ventricle?
   a. Anterior and posterior
   b. Lateral and anteroseptal
   c. Inferior and anterior
   d. Septal and inferior
   e. Posterior and anteroseptal

6. The midesophageal intercommissural view cuts through which portions of the mitral valve?
   a. The middle scallop of the posterior leaflet and the medial portion of the anterior leaflet
   b. The middle scallop of the posterior leaflet and the lateral portion of the anterior leaflet
   c. The lateral portion of the anterior leaflet and the medial portion of the posterior leaflet
   d. The medial commissure and the lateral commissure
   e. The lateral commissure and the medial portion of the anterior leaflet

7. When the left ventricle is underfilled, what happens to end-systolic volume (ESV) and ejection fraction (EF)?
   a. Increased ESV, increased EF
   b. Decreased ESV, increased EF
   c. Increased ESV, decreased EF
   d. Decreased ESV, decreased EF
   e. No change in ESV, increased EF

8. Immediately after implantation of a stented bioprosthesis, the most common transient abnormality is:
   a. Small amounts of periprosthetic regurgitation
   b. Immobility of valve prosthetic leaflets
   c. Significant central prosthetic regurgitation
   d. LV outflow tract obstruction by prosthetic stents
   e. Dehiscence of the prosthesis

9. If resistance is felt when trying to remove the TEE probe, the following measures should be taken:
   a. Pull firmly with increasing pressure in a cranial direction
   b. Obtain gastroscopic assistance for removal
   c. Push the probe in further before attempting to remove it again
   d. Retroflex the probe tip and pull steadily and firmly
   e. Reopen the chest to remove suture material

10. A 47-year-old woman in the intensive care unit, having just undergone aortic valve replacement (AVR) or mitral repair, develops decreased cardiac output, increased pulmonary artery wedge pressure, decreased oxygenation, and increased ventricular ectopy in the presence of hyperdynamic LV function. What can this be caused by?
    a. Hypovolemia
    b. Massive myocardial infarction
    c. Systolic anterior motion of the mitral valve
    d. Protamine reaction
    e. Blood loss

4. c 5. e 6. d 7. b 8. a 9. c 10. c

11. The physician taking care of a 66-year-old female patient did TEE imaging while the patient was still on cardiopulmonary bypass (CPB) and claimed that, as long as the aortic cross clamp was off, the assessment of LV EF would be the same as it would be in the postoperative period. Which statement is correct?
    a. EF postoperatively will be higher than it looks while on CPB
    b. EF postoperatively will be lower than it looks while on CPB
    c. EF postoperatively may be higher or lower than it looks while on CPB

12. A 66-year-old man has a history of infarction from distal left anterior descending coronary artery (LAD) occlusion with some apical hypokinetic segments. What is the most useful TEE imaging plane to see the LV apex?
    a. Midesophageal long axis
    b. Transgastric short axis of the left ventricle
    c. Midesophageal four chamber
    d. Transgastric long axis of the left ventricle

13. A 70-year-old man presents with chest and back pain and computerized tomographic imaging (CT) discovers a localized dissection of the ascending aorta. On arrival for the intraoperative TEE, you find aortic dilation but no dissection. What is the cause of the "blind spot" for TEE imaging?
    a. The esophagus is between the aorta and the right mainstem bronchus
    b. The esophagus is between the aorta and the trachea
    c. The trachea is between the aorta and the esophagus
    d. The right mainstem bronchus is between the aorta and the esophagus

14. Which imaging plane is most useful for determining whether posterior leaflet prolapse involves the medial, middle, or lateral scallop?
    a. The midesophageal long axis
    b. The midesophageal two chamber
    c. The midesophageal four chamber
    d. The transgastric long axis

15. Which is not a criterion for severe mitral regurgitation?
    a. A vena contracta of greater than or equal to 5 mm diameter
    b. A regurgitant orifice area (ROA) of greater than or equal to 0.4 cm^2
    c. Systolic reversal of pulmonary vein flow velocity
    d. A density of the continuous-wave Doppler recording in systole equal to the antegrade signal

A 62-year-old man develops new heart failure 8 weeks after AVR for endocarditis with aortic valve vegetations (Fig. 30.1A).

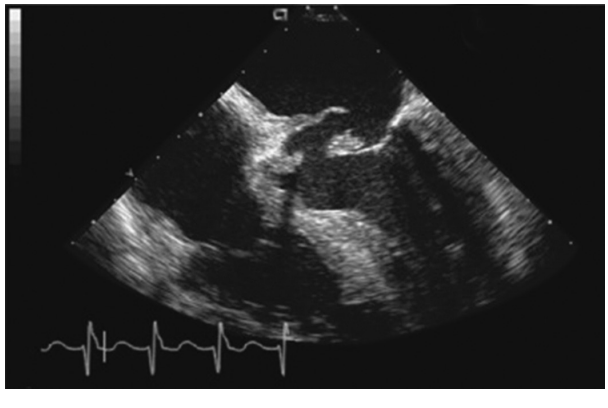


Fig. 30.1A

11. c 12. d 13. c 14. b 15. a

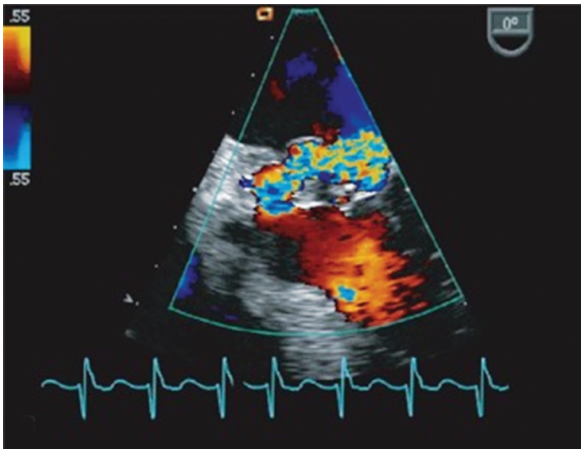


Fig. 30.1B

16. What is the hemodynamic problem causing this patient's recurrent heart failure?
    a. Mitral regurgitation
    b. Aortic regurgitation
    c. Aortic prosthesis dehiscence
    d. Aortic and mitral regurgitation
    e. A coronary fistula to the LV outflow tract

17. In the same patient, what is the mechanism of the valve process (Fig. 30.1B)?
    a. Leaflet flail
    b. Perforation of the leaflet
    c. Disruption of sutures
    d. Aortic dissection
    e. LV dilation

A 70-year-old woman with previous aortic and tricuspid valve replacements presents with leg edema and ascites, with clear lung fields. The frames in Figures 30.2A and B are recorded from a midesophageal transverse four-chamber view at a multiplane angle of 0 degree, rotated to the right to view the right atrium and right ventricle.

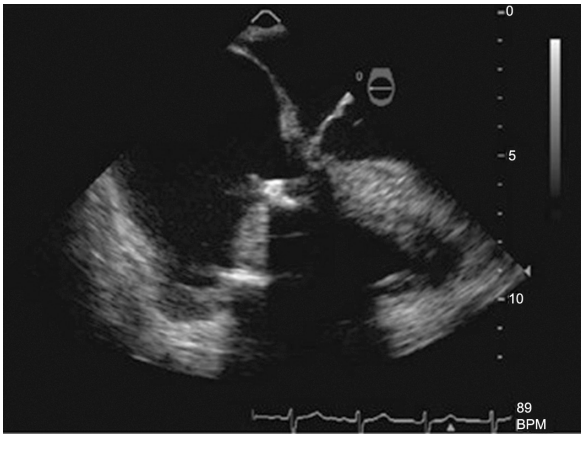


Fig. 30.2A

16. a 17. b

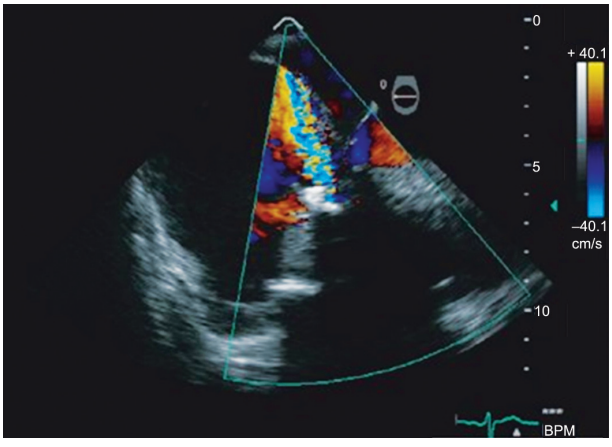


Fig. 30.2B

18. From where is the high velocity flow originating?
    a. Left ventricle
    b. Aorta
    c. Medial to the tricuspid prosthesis
    d. Anterior to the tricuspid prosthesis
    e. Right atrium

19. What are the expected findings on abdominal examination?
    a. Normal liver and spleen
    b. Hepatomegaly with nodularity
    c. Hepatomegaly with pulsations
    d. Small liver with splenomegaly
    e. Normal liver with splenomegaly

20. A patient undergoes aortic valve surgery and has the diastolic color image in Figure 30.3 recorded from the midesophageal long-axis view at 102 degrees, zoomed in to show the flow around the aortic valve. The two calipers marked (+) measure an aliasing radius of 0.63 cm.

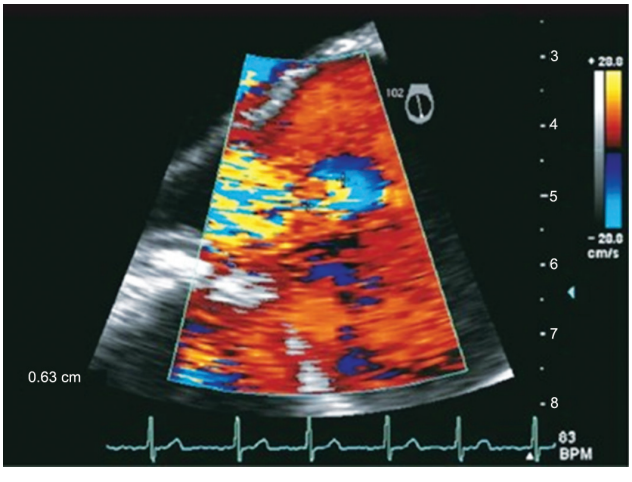


Fig. 30.3

18. c 19. c

Presuming the continuous-wave Doppler recording through this aortic regurgitation signal would have shown a maximum velocity of 4.0 m/sec, what is the maximum instantaneous ROA?

a. 0.18 cm^2
b. 0.28 cm^2
c. 17.9 mm
d. 0.46 cm^2

21. A 55-year-old woman was studied with a prepump TEE just prior to tricuspid and mitral valve surgery. Figures 30.4A and B was recorded from a long-axis view of the atrial septum after intravenous injection of agitated saline.

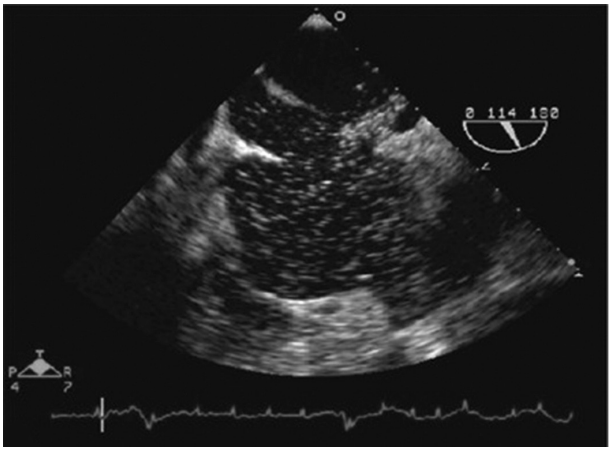


Fig. 30.4A

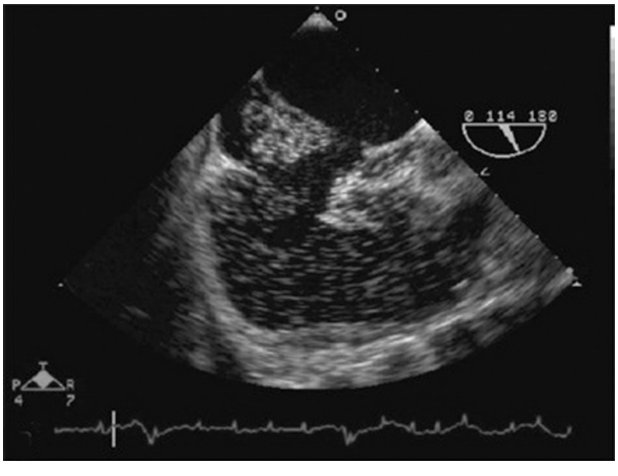


Fig. 30.4B

What can be said about the presence of shunting?

a. There is a right-to-left shunt
b. There is a left-to-right shunt
c. There is no shunt
d. There is a bidirectional shunt

20. a 21. d

22. A 60-year-old man with mitral regurgitation had the continuous-wave Doppler recording in Figure 30.5 made in the operating room prior to his surgery, using a deep transgastric imaging window.

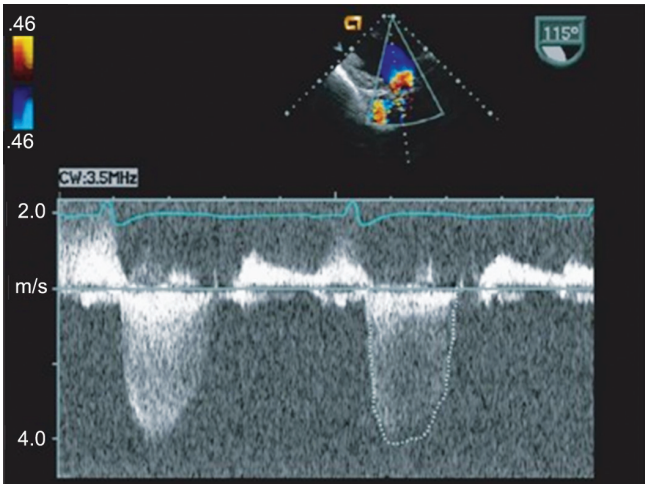


Fig. 30.5

What does the maximum velocity of the systolic signal inform us about this patient's hemodynamics?

a. A 64 mm Hg difference between LV systolic pressure and left atrial (LA) pressure
b. A 64 mm Hg difference between LV systolic pressure and aortic pressure
c. A 64 mm Hg difference between right ventricular (RV) systolic pressure and RA pressure
d. A 64 mm Hg difference between LV systolic pressure and RV pressure

23. This 32-year-old male patient is undergoing valve surgery, and has a TEE with this midesophageal long-axis view of the aortic valve (Fig. 30.6).

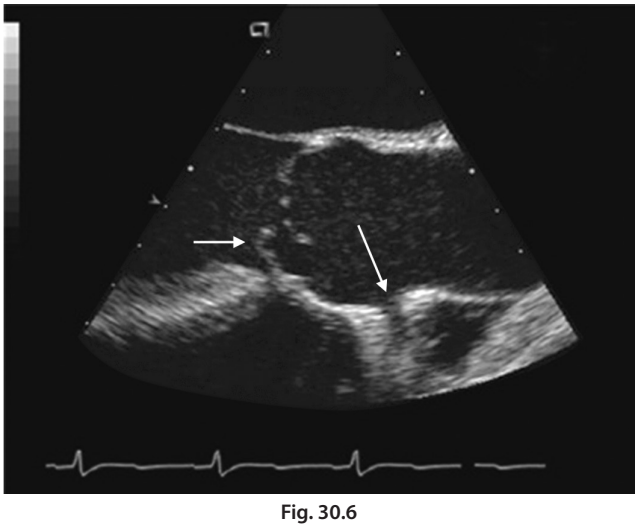


Fig. 30.6

22. b

What is the structure to which the small arrow points in Figure 30.6?

a. An aortic valve vegetation
b. A prolapsing noncoronary cusp
c. A fibroelastoma
d. A portion of the patient's bicuspid aortic valve

24. What is the structure to which the large arrow points in Figure 30.6?

a. An aortic dissection
b. An aortic pseudoaneurysm
c. A normal right coronary artery
d. A normal left coronary artery
e. An artifact in the anterior wall of the aorta

25. The surgeon noticed some discoloration of the external surface of the ascending aorta, after the patient had undergone quadruple coronary bypass (Fig. 30.7).

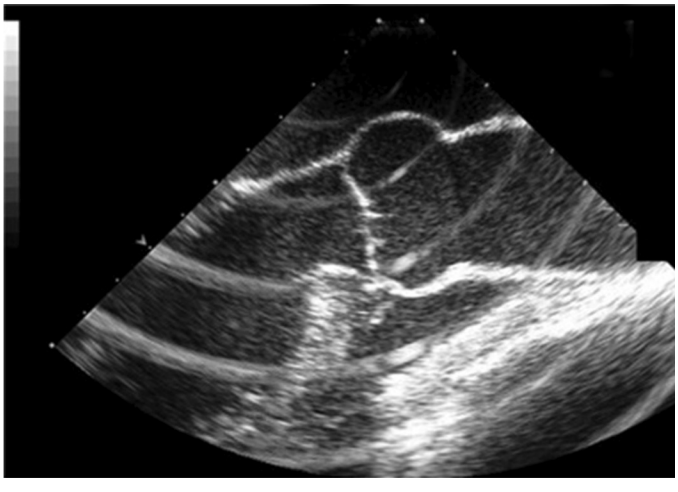


Fig. 30.7

What is the importance of the linear echo densities in the ascending aorta?

a. Possible iatrogenic aortic dissection from the aortotomy or the cross clamp
b. Atheromatous plaques
c. Artifacts from the electrocautery

23 d 24. c 25. c

Answers

1. a. The right coronary artery is located anteriorly within the sinuses of Valsalva, which is the highest portion of the aorta (farthest off the ground) with the patient in the supine position for a midsternal thoracotomy. Therefore, air which enters the heart during open-heart surgery is pushed by pressure into this coronary preferentially. This occurs more commonly in mitral repair than other types of heart surgery, because of insufflation of the left ventricle (filling it with fluid under pressure) done to examine leaflet coaptation. Most cases of coronary air embolization can be treated conservatively. Sometimes, it is necessary to put the patient back on cardiopulmonary bypass (CPB), or to treat ventricular arrhythmias with medicines.
2. c. Epicardial echo is an alternative imaging modality. The need for intraoperative echo still exists for those who have a contraindication to blind transesophageal echo (TEE) passage, and these can readily be accomplished by epicardial echo. A standard transthoracic echo transducer is placed within a sterile sleeve with ultrasound gel inside the sleeve for elimination of air.
3. c. Continuous-wave Doppler recordings of mitral flow using TEE can accurately be recorded and relied upon for calculation of mitral gradients. Recording aortic valve gradients is less reliable. Sometimes, they can be recorded from the deep transgastric views, but the results are often underestimates of the true values. All gradients are affected by loading conditions, but such changes can be corrected for, by understanding hemodynamics, especially altered cardiac output and preload. Electrocautery does interfere with ultrasound recordings, but most transesophageal imaging can be obtained in between those interruptions.
4. c. Intraoperative TEE is an important monitoring tool in patients undergoing implantation of an left ventricular assist device (LVAD). The presence of aortic regurgitation makes an LVAD ineffective by creating a loop of ineffective flow. The presence of left ventricle (LV) enlargement and mitral regurgitation (MR) are irrelevant to the placement of the device. Placement of the inflow LVAD cannula into the left ventricle does not require TEE guidance. The presence and severity of tricuspid regurgitation (TR) are not important objectives of TEE imaging.
5. e. Like the apical transthoracic view of the same name, the midesophageal long-axis view usually cuts through the posterior and anteroseptal walls. This imaging plane is usually obtained at a multiplane angle of about 130 degrees (range 110–150 degrees).
6. d. The medial commissure and the lateral commissure. This view is usually obtained at a multiplane angle of about 60 degrees (range 35–75 degrees).
7. b. The hypovolemic patient usually has a small LV end-systolic size with increased ejection fraction (EF). The increased EF probably results from sympathetic stimulation, an attempt to maintain stroke volume despite the reduced end-diastolic volume. The small end-systolic LV size is probably the most reliable visual guide to the presence of underfilling.
8. a. It is common to see one or more small color jets of periprosthetic regurgitation early after cessation of CPB. When small, most of these resolve progressively after protamine administration, within a few hours.
9. c. A TEE probe may occasionally become looped, with its tip turned superiorly within the esophagus, up toward the patient's head. Traction of the probe to pull it out may cause the esophageal wall to tear. However, if the probe is advanced further, the loop comes out after it gains more room within the stomach, and the entire probe can then be extracted.
10. c. Hypovolemia, blood loss, and a protamine reaction would have lower wedge pressure. Massive myocardial infarction would not have hyperdynamic LV function. Systolic anterior motion (SAM) is a common (a few percent) complication of mitral valve repair, particularly when the LV cavity is small and hyperdynamic, catecholamine medications are being administered, and the posterior leaflet is redundant. Mitral SAM has also been reported after aortic valve replacement (AVR), probably because of the LV hypertrophy and the reduction in LV cavity size from relief of increased afterload. Initial treatment should consist of intravascular volume replacement, cessation of catecholamines (beta1-agonists), appropriate diagnosis by TEE, and sometimes blood pressure support with phenylephrine.

11. c. Often the heart is underfilled on the pump, with lower cavity size in systole and diastole than in the ambulatory state, and therefore a higher EF. However, on the pump, the patient may have metabolic abnormalities, or may have transient ischemia making the EF lower than it will be later when the patient has been weaned from CPB.
12. d. The transgastric short axis of the left ventricle does not cut through the apex. The midesophageal four-chamber view often foreshortens the left ventricle, and passes anterior and superior to the apex; what is seen is a pseudoapex which is really the anterior wall near but not at the apex. The midesophageal long axis view is not as likely to be foreshortened; but it is difficult to get a view of the true LV apex in many patients. Therefore, the transgastric long axis of the left ventricle is the preferred view.
13. c. The trachea is between the aorta and the esophagus. Because air provides a relatively poor propagation of ultrasound, the trachea does not transmit the reflecting images from the probe in the esophagus through the trachea to the mid ascending aorta.
14. b. Sometimes called the "intercommissural view," this plane is parallel to a line connecting the medial and lateral commissures of the mitral valve. Structural imaging or color flow information can be obtained using this view to make a determination of which portion of the anterior or posterior leaflet is abnormal. Arranged in the normal way with the inferior LV wall to the left of the screen, the medial scallop (P3) is located to the left on the upper portion of the screen, the middle scallop (P2) in the midupper part of the screen, and the lateral scallop (P1) to the upper right (Figs 30.8A and B).

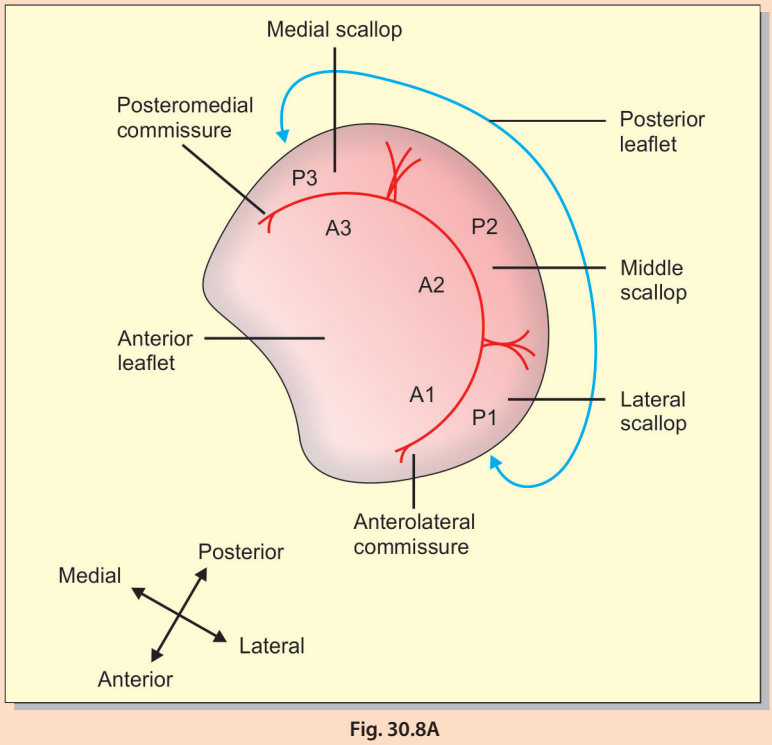


Fig. 30.8A

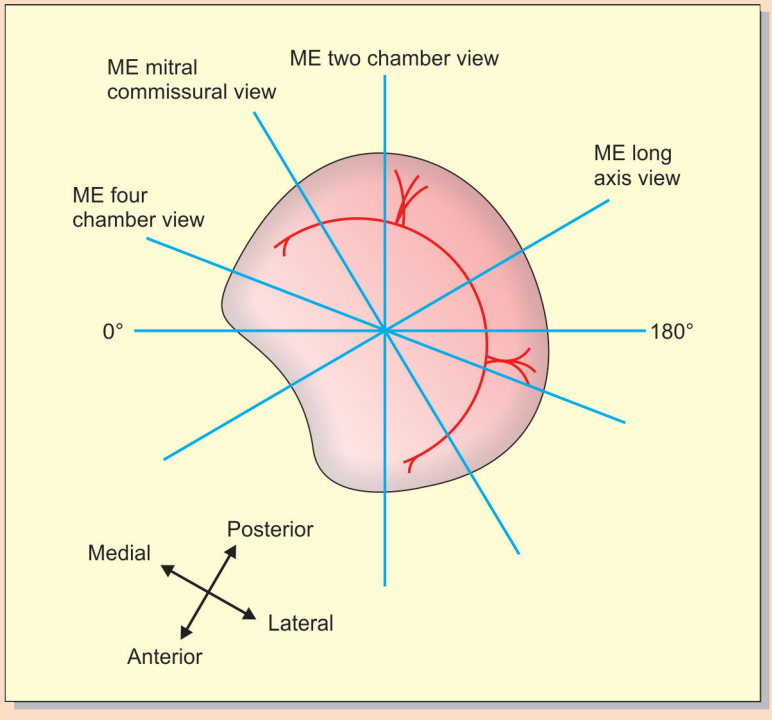


Fig. 30.8B

15. a. The valid criterion for severe MR is a vena contracta of greater than or equal to 7 mm diameter. The other criteria listed are correct ones for the threshold of severe MR.
16. a. Explanation for 16 and 17 is the same.
17. b. The midesophageal transverse images in Figures 30.1A and B show that this patient has a perforation in the anterior mitral leaflet. This was likely caused by the jet of aortic regurgitation that was presumedly present prior to the AVR. Such a "jet lesion" causes endocardial abrasion of the LV surface of the base of the anterior mitral leaflet, allowing infection to set up locally, which may cause a perforation, leading to the MR, which is seen in the color flow image.
18. c. Explanation for 18 and 19 is the same.
19. c. The patient has a partially dehisced tricuspid prosthesis, with a periprosthetic leak of TR, located medial to the valve. For this reason, his exam would show pulsatile hepatomegaly. The key in this case is to understand the imaging plane, which is stated in the question given. Note that the right atrium is very large and that the interatrial septum bows toward the left atrium due to right atrial hypertension. The anterior mitral leaflet is shown in the image, while the aortic prosthesis is not shown.
20. a. The correct answer to the question is 0.18 cm^2. The formula is two times π, times the radius squared, times the aliasing velocity (Nyquist limit), divided by the maximum velocity. In this case, the regurgitant orifice area (ROA) calculates to 0.18 cm^2.
    This is moderate aortic regurgitation because it is between 0.1 and 0.2 cm^2. Note that the size of the aliased flow convergence is larger because the Nyquist has purposely been decreased to 28.8 cm/sec (from the nominal 50–60 cm/sec level used for spatial mapping); this was done in order to make the measurement of the aliasing radius more feasible and accurate.
21. d. There is a bidirectional shunt. Figure 30.4A shows a positive contrast effect with bubbles in the left atrium that have passed from the right atrium. Figure 30.4B shows a negative contrast

effect with a streak of blood without bubbles that has passed into the right atrium from the left atrium.

22. b. There is a 64 mm Hg difference between LV systolic pressure and aortic pressure. This is a patient with aortic valve stenosis in addition to MR. The deep transgastric views are the usual and best ones with which to record LV outflow velocities using TEE. Figure 30.5 shows that the cursor extends through the left ventricle to the LV outflow tract. In addition, the continuous-wave recording itself shows a key factor there is a blank period lasting about 80 milliseconds, during isovolumic relaxation. This blank period on the tracing starts immediately at the cessation of the AS signal, occurring at the time of aortic valve closure. It ends at the beginning of the mitral valve antegrade flow signal. The separation of these two events in time, separated by isovolumic relaxation, confirms the systolic jet to be AS, not MR or TR.
23. d. Explanation for 23 and 24 is the same.
24. c. This is a patient without fever or any signs of infection. He has a congenital bicuspid aortic valve of the horizontal type, with fusion of what would have been the right and left coronary cusps. In patients like this, the conjoined cusp has a longer length of its free edge, causing it to prolapse back into the outflow tract, causing aortic regurgitation. His right coronary artery is normal, and well-visualized on Figure 30.6.
25. c. Figure 30.7 shows artifacts from the electrocautery. Note that these artifacts extend across tissue planes, appearing as a stripe through the aorta and left ventricle. The discoloration of the external surface of the ascending aorta was not related to this image.

31

Echocardiography for Rhythm Disturbances

1. What is the estimated prevalence of left atrial (LA) thrombus in nonrheumatic atrial fibrillation (AF)?
   a. 0–10%
   b. 10–20%
   c. 20–30%
   d. 40–50%
   e. >50%

2. A 75-year-old man with a history of hypertension is admitted after a transient ischemic attack and is found to be in AF. He is referred for a transesophageal echocardiogram (TEE). Which echo findings are associated with an increased likelihood of LA thrombus?
   a. Patent foramen ovale
   b. LA appendage (LAA) velocities greater than 50 cm/sec
   c. LA volume index of 25 mL/m^2
   d. Spontaneous echo contrast (SEC)
   e. Anomalous pulmonary veins

3. Which LA measurements best correlate with the maintenance of sinus rhythm after cardioversion?
   a. LA volume index of 30 mL/m^2 and LA appendage velocity 40 cm/sec
   b. LA volume index of 30 mL/m^2 and LA appendage velocity 50 cm/sec
   c. LA volume index of 40 mL/m^2 and LA appendage velocity 40 cm/sec
   d. LA volume index of 40 mL/m^2 and LA appendage velocity 30 cm/sec

4. E/e' best estimates pulmonary capillary wedge pressure (PCWP) in a patient with which cardiac pathology?
   a. Mitral annuloplasty ring
   b. Severe mitral annular calcification (MAC)
   c. AF
   d. Mechanical mitral valve

5. What is the estimated prevalence of right atrial appendage (RAA) thrombus in patients with AF?
   a. <1%
   b. 1–6%
   c. 7–10%
   d. 11–15%
   e. 16–20%

1. b 2. d 3. b 4. c 5. b

6. What is the prevalence of cardioversion-related thromboembolism in patients with nonvalvular AF of less than 48 hours without screening TEE?
   a. <1%
   b. 1–5%
   c. 6–10%
   d. 11–15%
   e. 16–20%
7. Approximately what percent of patients with recent nonrheumatic AF and prior LA thrombus on TEE will have thrombus resolution after 4 weeks of therapeutic anticoagulation?
   a. 25%
   b. 50%
   c. 75%
   d. 100%
8. What is the reported sensitivity of transthoracic echocardiography (TTE) in identifying LA or LAA thrombi?
   a. 0–20%
   b. 40–60%
   c. 70–90%.
   d. >90%
9. What is hypothesized to be the reason for a lower prevalence of RAA thrombus in patients with AF?
   a. RAA velocities are usually higher than those in the LAA
   b. LAA neck is larger and "traps" thrombi
   c. RAA width is larger and lacks anatomic remodeling during AF
   d. RAA is resistant to clot formation
   e. RAA does not fibrillate
10. In which patient would the development of AF be most hemodynamically compromising?
   a. Hypertrophic cardiomyopathy (HCM) with a resting left ventricular outflow tract (LVOT) outflow velocity of 4 m/sec
   b. Bicuspid aortic valve with a peak velocity of 3 m/sec
   c. Ventricular septal defect with a peak velocity of 5 m/sec across the defect
   d. Mitral annular calcification with a mean gradient of 5 mm Hg across the mitral valve
   e. Mild to moderate mitral regurgitation with a peak velocity of 6 m/sec
11. Which statement regarding AF postcardiac surgery is true?
   a. It is more frequent after coronary artery bypass surgery (CABG) than after mitral valve surgery
   b. CABG combined with valvular surgery decreases the incidence of AF
   c. It occurs in less than 5% of cardiac transplantation
   d. Prophylaxis with beta blockade significantly decreases the risk of stroke postoperatively
   e. Warfarin should be initiated if AF lasts more than 24 hours for a total of 4 weeks
12. A 63-year-old woman with a history of chronic AF is referred for an echocardiogram prior to cardioversion. However, the patient refuses to undergo a TEE. What alternative may be offered to this patient to evaluate for LAA thrombi?
   a. Color M-mode through the left and right atrium
   b. Pulse wave Doppler through the LAA
   c. Cardiac magnetic resonance (CMR) imaging without gadolinium
   d. TTE with harmonic imaging with intravenous (IV) contrast
   e. Electron beam computed tomography (EBCT)

6. a 7. c 8. b 9. c 10. a 11. e 12. d

13. A 55-year-old woman with a history of hypertension and new onset AF is hospitalized after 3 days of worsening palpitations. She is started on a heparin drip and beta blockade for rate control and referred for a TEE prior to cardioversion. TEE reveals a mildly dilated LA and is free of thrombi. Upon removal of the TEE probe, she spontaneously converts to sinus rhythm. What should be recommended to this patient upon discharge?
    a. Discontinue heparin and discharge with low-dose aspirin
    b. Repeat TEE and discontinue anticoagulation if there are no thrombi
    c. Anticoagulate with warfarin with a goal International Normalized Ratio (INR) of 2–3 for 4 weeks
    d. Refer for LAA ligation
    e. Pulmonary vein isolation

14. A 67-year-old woman with chronic AF is admitted for acute shortness of breath and transient hypoxemia. Her INR is subtherapeutic at 1.3. A TEE is performed for possible electrical cardioversion. A thrombus is noted in the right atrium (RA) during TEE and the tricuspid regurgitation (TR) velocity is noted to be 4 m/sec. What would you recommend at this time?
    a. Immediate electrical cardioversion
    b. Bolus amiodarone intravenously and follow with a continuous infusion
    c. Surgical removal of the RA thrombus
    d. Add aspirin and plavix and perform electric cardioversion
    e. Start heparin drip, defer cardioversion, and evaluate for pulmonary embolus

15. Which is a true statement with regard to spontaneous echo contrast (SEC)?
    a. It is only found in patients with AF
    b. If not seen on initial TEE, there is a low likelihood it will be seen on a subsequent TEE
    c. It is thought to be due to platelet aggregation similar to what occurs in ruptured plaques
    d. Warfarin therapy does not affect the presence of SEC
    e. It is only seen in the left atrium

16. A 68-year-old woman with AF is referred for TEE due to a transient ischemic attack. Which of the following is true about her TEE finding in Figure 31.1?

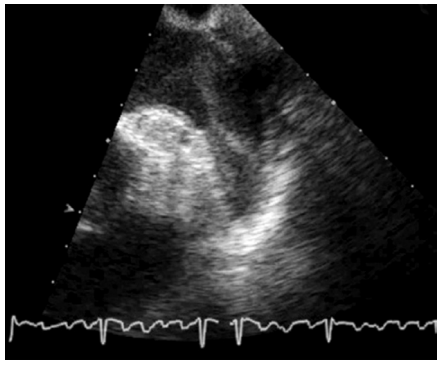


Fig. 31.1

    a. Its prevalence is the same for both AF and atrial flutter
    b. Mitral regurgitation worsens this finding
    c. There is an association with LA myxoma
    d. It is an independent predictor of thromboembolic risk
    e. Its prevalence declines with warfarin

13. c 14. e 15. d 16. d

17. What can be inferred from these Doppler findings (Fig. 31.2)?
    a. There is a high probability of maintaining sinus rhythm after cardioversion
    b. This is associated with an increased risk of thromboembolism
    c. There is severe pulmonary hypertension
    d. The patient should be referred for pulmonary vein isolation (PVI)
    e. It is associated with minimal to no spontaneous echo contrast

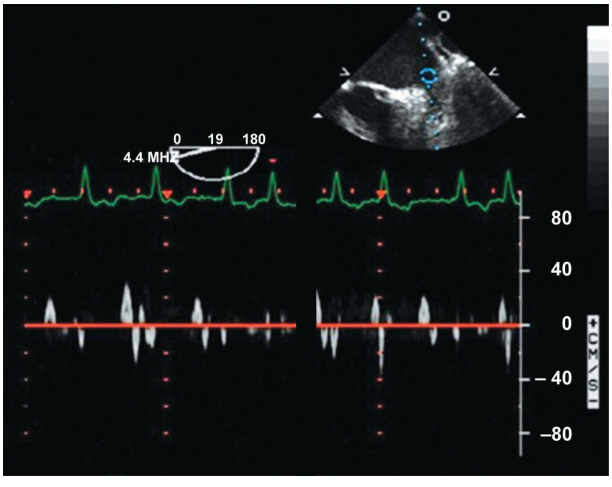


Fig. 31.2

18. A 22-year-old man presents with increasing dyspnea and decreased exercise tolerance that has limited his ability to participate in his basketball league. A TTE is performed (Fig. 31.3). What would confirm the diagnosis?

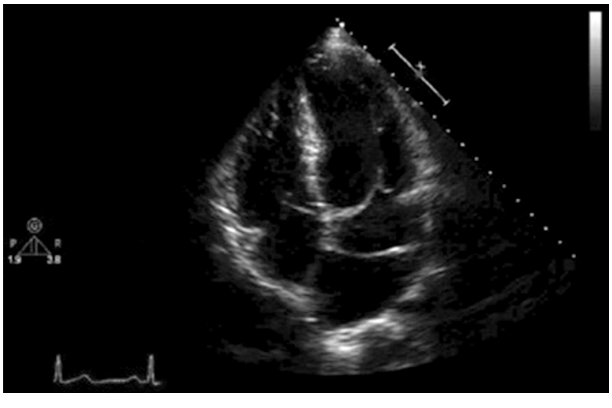


Fig. 31.3

    a. Increased gradient across the mitral valve
    b. LAA contiguous with the basal (proximal) chamber
    c. LAA contiguous with the apical (distal) chamber
    d. Increased pulmonary vein velocity
    e. Normal apical two-chamber view (e.g. this is an artifact).

17. b 18. c

19. An 83-year-old man with a history of AF presents with a transient ischemia attack. The patient was therapeutic on warfarin at the time of hospitalization (INR = 2.5). The patient was referred for a TEE for further work-up. During TEE inspection of the left atrium, a small patent foramen ovale was observed but no LA or LAA thrombi were seen. A view of his aortic arch is shown in Figure 31.4. Based on these echo findings, what should be recommended?

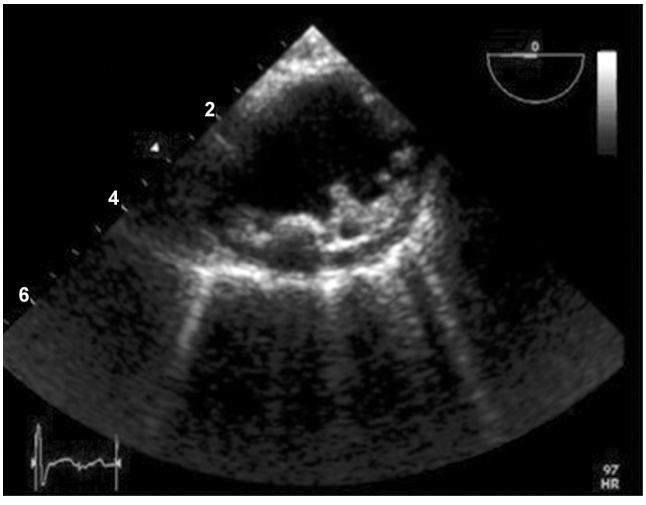


Fig. 31.4

a. Percutaneous closure of the patent foramen ovale
b. Increase the target INR to 3–4
c. Add statin therapy
d. Emergent cardiac surgery
e. Confirmation with contrast chest computed tomography (CT)

20. A 64-year-old man with a sternotomy scar is admitted to the hospital with atypical chest pain and new onset AF. The patient denies neurologic symptoms and is without focal neurologic findings on physical exam. INR on admission is 2.5. The patient's TEE is without evidence of LA or LAA thrombi or valvular thrombus. Coronary angiography was performed the following day. Although there was no significant coronary disease, fluoroscopy as in Figure 31.5 was observed. Based on these findings, what would you recommend?
    a. Warfarin therapy with goal INR 1.5–2.5 and full-dose aspirin
    b. Warfarin therapy with goal INR 2–3 for only 3 months, followed by low-dose aspirin
    c. Warfarin therapy with goal INR 2.5–3.5 and no aspirin
    d. Warfarin therapy with goal INR 2.5–3.5 and low-dose aspirin
    e. Warfarin therapy with goal INR 3.5–4.5 and full-dose aspirin

21. A 78-year-old man without prior medical history is admitted with a 1 day history of palpitations and shortness of breath. Based on the M-mode finding in Figure 31.6, what would you recommend?
    a. Emergent cardiac surgery
    b. Thrombolytics
    c. Check TSH
    d. Cardiac CT
    e. Alcohol septal ablation

19. c 20. d 21. c

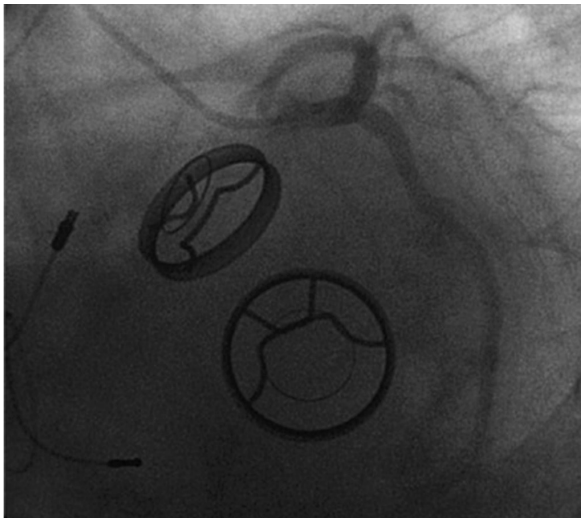


Fig. 31.5

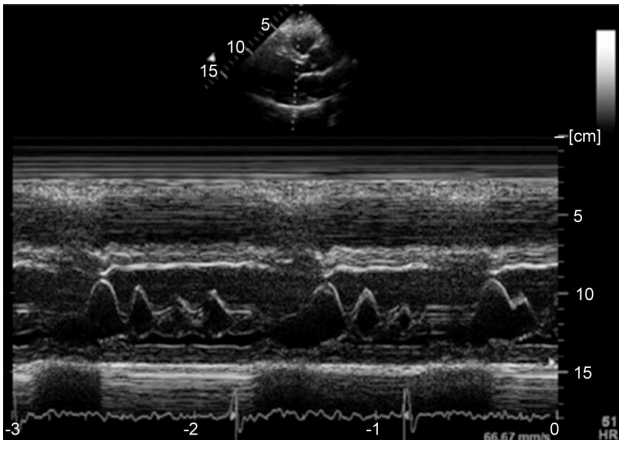


Fig. 31.6

22. A 43-year-old woman with a history of paroxysmal AF is referred for an echocardiogram. Based on Figure 31.7, which statement is true?
    a. Direct current cardioversion is contraindicated
    b. Emergent cardiac surgery is warranted
    c. Risk for sudden cardiac death is increased
    d. Antibiotics should be started immediately
    e. This is a normal variant

22. e

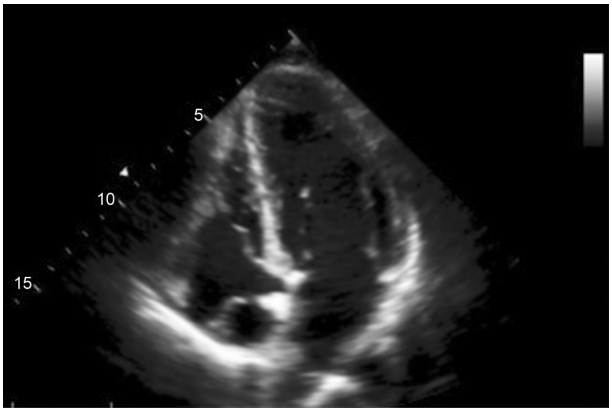


Fig. 31.7

23. An 81-year-old man is admitted to the hospital for chest pain and shortness of breath and found to have an acute myocardial infarction. The patient is referred for TEE for a questionable transient ischemic attack on hospital day 2. Based on the Doppler findings in Figure 31.8, which of the following statements is correct?

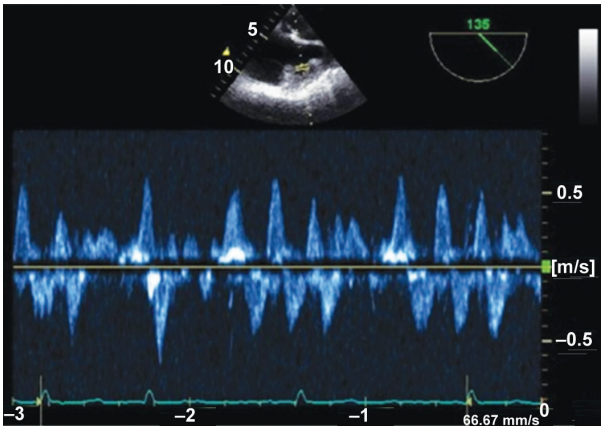


Fig. 31.8

a. The patient's prognosis is worse than if this finding were not seen on Doppler
b. This finding occurs in approximately 50% of acute myocardial infarctions
c. The patient should be referred for percutaneous closure
d. There is evidence of anomalous pulmonary venous return
e. The estimated PCWP is 30 mm Hg

23. a

24. A 58-year-old man with a history of AF is referred for a TEE prior to cardioversion. Although there was no evidence of LAA thrombus, this image (Fig. 31.9) was seen. What is a true statement regarding this finding?

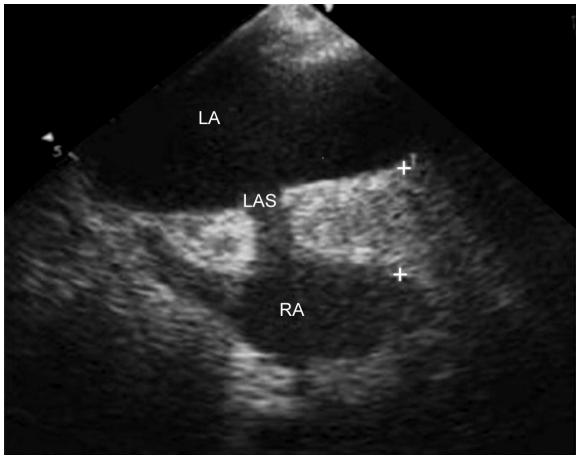


Fig. 31.9

a. Electrical cardioversion is contraindicated
b. It is due to encapsulated adipose tissue in the interatrial septum
c. Emergent surgery is warranted
d. It is a normal variant
e. A malignancy work-up is needed

25. A 55-year-old man is referred for electrical cardioversion for symptomatic AF/atrial flutter. Based on the Doppler findings in Figure 31.10, what would be expected immediately postcardioversion?

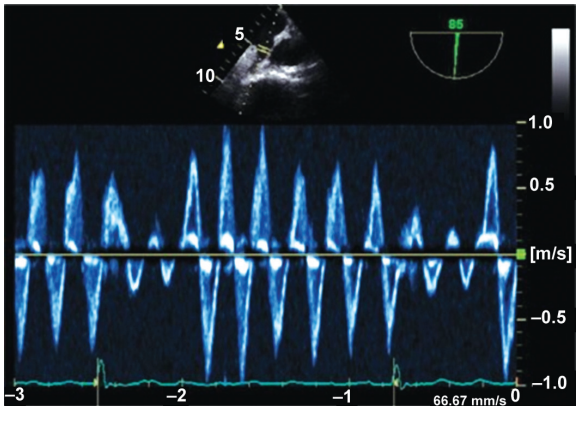


Fig. 31.10

a. Resolution of SEC
b. Decreased risk of thromboembolism
c. Recurrence of AF
d. Improvement of LA function
e. Decreased velocities in the LAA

24. d 25. e

26. Based on the M-mode in Figure 31.11, what is her estimated annual thromboembolic risk?
    a. 1%
    b. 5%
    c. 10%
    d. 20%
    e. 30%.

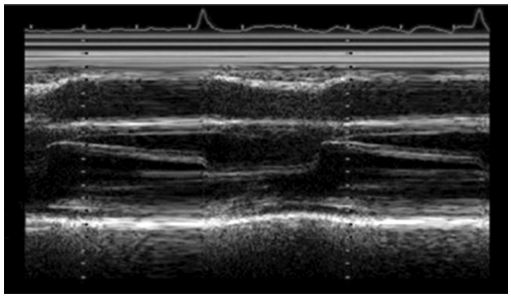


Fig. 31.11

27. Increasing age and what other risk factors are independent predictors of AF in multivariate analysis of patients with this pathology?
    a. LA dimension
    b. Ejection fraction
    c. Mitral regurgitation
    d. Tricuspid stenosis
    e. Tricuspid regurgitation

28. What is the preferred imaging modality to evaluate for LA thrombi?
    a. TTE
    b. TTE with IV-administered contrast agent and harmonic imaging
    c. Three-dimensional (3D) TTE
    d. TEE
    e. Pulsed wave Doppler through the LAA

29. What is the specificity of TEE for LA thrombus?
    a. <75%
    b. 75–80%
    c. 80–85%
    d. 85–90%
    e. >90%

30. The patient undergoes a successful PVI procedure.
    Three months postprocedure, he develops progressive shortness of breath with exertion. He is referred for TEE which demonstrates the findings in Figure 31.12.
    Based on these Doppler findings, what is the likely etiology of his shortness of breath?
    a. Mitral stenosis
    b. AF
    c. Severe mitral regurgitation
    d. Pulmonary vein stenosis

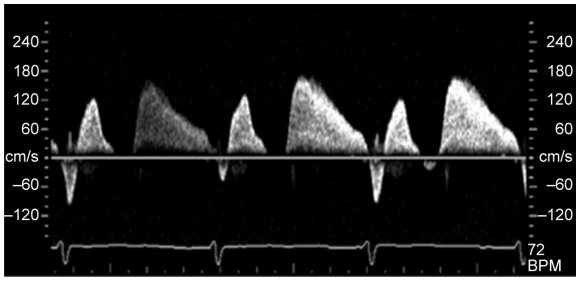


Fig. 31.12

26. c 27. a 28. d 29. e 30. d

Answers

1. b. Transesophageal echocardiographic evidence of left atrial (LA) thrombi is seen in approximately 13% of patients presenting with nonrheumatic atrial fibrillation (AF) of more than 3 days duration.
2. d. Spontaneous echo contrast (SEC) is present in over 50% of all patients with AF and in over 80% of those with left atrial appendage (LAA) thrombi or a recent thromboembolic event.
3. b. Left atrial size is important prognostically in AF. Progressive enlargement is associated with a decreased probability of maintaining sinus rhythm. Left atrial appendage velocity is also thought to be a predictor of the likelihood of maintaining sinus rhythm after cardioversion. Choice B has the smallest LA size and highest LAA velocity and is therefore the best option.
4. c. Atrial fibrillation is the best choice among these options. E/e' should not be used to determine pulmonary capillary wedge pressure (PCWP) in patients with a mitral valve prosthesis or severe mitral annular calcification, as e' velocities may be inaccurate.
5. b. Although much less common than left atrial (LA) thrombi in patients with AF, right atrial (RA) or right atrial appendage (RAA) thrombi occur in 3–6% of cases (versus 11–15% for LA thrombi). The majority of patients with RA thrombi also have LA thrombi. Cardioversion should be deferred even if patients have isolated RA thrombi due to the theoretical risk of thromboembolism to the pulmonary artery.
6. a. In a consecutive series of more than 350 hospitalized patients with nonvalvular AF, the incidence of cardioversion-related thromboembolism was 0.8% in patients without screening TEE and AF of less than 48 hours. Of note, these patients were not on anticoagulation at the time of their thromboembolic event (anticoagulation was not initiated or was stopped shortly after admission). All thromboembolic events occurred in patients who had spontaneously converted to sinus rhythm.
7. c. In a study looking at patients with nonrheumatic AF, resolution of thrombi occurred in approximately 75% after 4 weeks of anticoagulation therapy.
8. b. The ability of TTE to identify or exclude LA or LAA thrombi is limited, with a reported sensitivity of 39–63%. This is largely due to poor visualization of the LAA.
9. c. The larger RAA width and lack of anatomic remodeling may partially explain the substantially lower prevalence of RAA thrombus found among patients with AF. All the other choices are false statements.
10. a. The patient in choice A has a resting gradient of 64 mm Hg across the left ventricular outflow tract (LVOT), which is significantly elevated. Patients with hypertrophic cardiomyopathy (HCM) and LVOT obstruction often have compromised left ventricular (LV) filling due to abnormal relaxation secondary to myofibril disarray. Additionally, systolic anterior motion of the anterior leaflet of the mitral valve, which results in outflow tract obstruction and mitral regurgitation, can severely compromise cardiac output. The development of AF in such a patient would compromise LV filling significantly. Choices B–D are essentially mild forms of their respective pathologies.
11. e. The ACC/AHA recommends that warfarin should be initiated if AF lasts more than 24 hours for a total of 4 weeks postcardiac surgery. Atrial fibrillation and atrial flutter occur frequently after cardiac surgery. The prevalence of AF is more frequent in valvular surgery than in CABG and greatest when combined (CABG plus valve surgery). Atrial fibrillation is reported to be between 15% and 40% after CABG, 37–50% after valve surgery, and up to 60% in CABG plus valve replacement. Atrial fibrillation is reported to occur in 11–24% after cardiac transplantation. Despite the reduction of AF with prophylactic medical therapy, the reduction in stroke has been found to be statistically nonsignificant.
12. d. The CLOTS Multicenter Pilot Trial found that the combination of harmonic imaging with IV contrast was useful in the detection of the thrombus by TTE. Although cardiac-computed tomography with iodinated contrast and delayed imaging could be used to evaluate LAA

thrombi, EBCT would not, as it is not used with IV contrast and primarily used for calcium scoring. Cardiac magnetic resonance (CMR) without gadolinium has poor visualization of the LAA and would be suboptimal in the evaluation for LAA thrombi in patients with AF.

13. c. Although this patient spontaneously converted into sinus rhythm, she remains at risk for thromboembolism in the immediate postcardioversion period and should remain anticoagulated. The ACC/AHA/ESC guidelines recommend that warfarin therapy be continued for at least 4 weeks after cardioversion with a target INR of 2.5 (range 2.0–3.0) after being in AF for 48 hours.
14. e. This patient's history and TEE findings are suggestive of a pulmonary embolus (PE). Cardioversion should be deferred, especially with a known RA thrombus, and treatment with a work-up for a PE should be instituted immediately.
15. d. Warfarin leads to thrombus resolution and a lower incidence of thromboembolism, but does not affect the presence of SEC. Serial TEE studies have shown that SEC subsequently develops in many patients with AF (44% in one report) who do not have SEC on initial TEE. SEC is thought to reflect increased erythrocyte aggregation caused by low shear rate due to altered atrial flow dynamics and uncoordinated atrial systole. Erythrocyte aggregation is mediated by plasma proteins, especially fibrinogen, which promotes red cell rouleaux formation by moderating the normal electrostatic forces (due to negatively charged membranes) which keep erythrocytes from aggregating. Thrombi can be seen in both the left and right atrium.
16. d. Figure 31.1 shows prominent spontaneous echo contrast (SEC) in the LAA. It is an independent predictor of thromboembolic risk and associated with an increase in embolic rate in patients with AF. Mitral regurgitation appears to lessen the frequency of SEC. Warfarin does not impact the prevalence of SEC. There is a strong association between LA SEC and LA thrombi. The prevalence of SEC occurs more frequently in AF than in atrial flutter. There is no known association between SEC and LA myxoma.
17. b. The risk of stroke is increased with marked reductions in blood flow velocity, particularly in the LAA or posterior LA. A low-appendage ejection flow velocity is associated with the presence of appendage thrombus and with dense SEC. Left atrial blood flow velocity (>40 cm/sec) is thought to be a predictor of the likelihood of maintaining sinus rhythm after cardioversion. There are no definitive findings that suggest that this patient has severe pulmonary hypertension or should be referred for PVI based on atrial appendage velocities.
18. c. Cor-triatriatum sinister is differentiated from a supravalvular mitral ring by the position of the LAA (Fig. 31.13, white arrow). In cor-triatriatum sinister, the left appendage is part of the distal (mitral valve) atrial chamber, while the LAA is part of the proximal (pulmonary vein) atrial chamber in patients with a supravavlular ring.

    Cor-triatriatum may be associated with other congenital abnormalities (atrial septal defect, persistence of left superior vena cava), but is commonly seen in isolation when found in an adult. It may be associated with increased gradients across the membrane, leading to this patient's symptoms. However, this finding lacks specificity and does not confirm a diagnosis. Pulmonary vein stenosis is not commonly associated with cor-triatriatum and would not confirm a diagnosis.

    Such a finding should be further investigated with multiple views, with and without Doppler. If TTE findings are ambiguous, a TEE may be warranted.
19. c. Figure 31.4 reveals a complex aortic plaque (pedunculated with mobile components). Patients who experience a cerebral event should be aggressively treated for secondary prevention with aspirin, statins, blood pressure control, smoking cessation, and glycemic control (if diabetic). Patent foramen ovale closure is not warranted given this patient's age and complex aortic atheroma. Although there is controversy with regards to warfarin therapy and aortic arch plaque, this patient is already therapeutic on antithrombotic agents for his AF. There is no data to demonstrate that a goal INR of 3–4 will improve the outcome of patients with aortic

atheroma. Confirmation by chest CT is not warranted as Figure 31.4 represents atheroma and not aortic dissection.

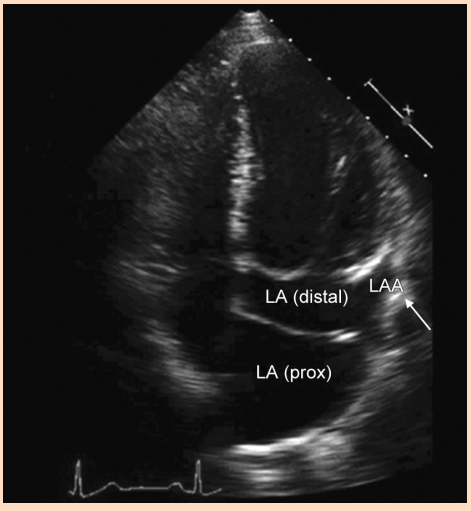


Fig. 31.13

20. d. Fluoroscopy reveals that the patient has mechanical valves (Bjork Shiley) in both the aortic and mitral positions. Due to the mitral position of his mechanical valve, anticoagulation with warfarin with a goal INR 2.5–3.5 is recommended. Additionally, low-dose aspirin (75–100 mg), concomitantly with warfarin, is recommended as per the 2008 ACC/AHA guidelines (Class I).
21. c. This M-mode reveals that this patient is in coarse AF. In a patient with new-onset AF, reversible causes of AF (e.g. hyperthyroidism) should be investigated and treated, if possible. There are no findings on this M-mode that would suggest that cardiac surgery, thrombolytics, cardiac CT, or alcohol septal ablation would be appropriate in this patient.
22. e. This four-chamber TTE demonstrates a prominent Eustachian valve and is a normal variant. The Eustachian valve is a remnant of the embryologic valve responsible for directing inferior vena caval blood across the atrial septum to the LA. It is a rigid and protuberant structure that arises along the posterior margin of the inferior vena cava to the border of the fossa ovalis. Although usually immobile, it may occasionally demonstrate independent motion within the RA and can be confused with tumors, vegetations, or thrombi. This should be differentiated from a Chiari network, which is a delicate-appearing, highly mobile, membranous structure arising near the orifice of the inferior vena cava. A Chiari network serves as the valve of the coronary sinus and is usually fenestrated. Like the Eustachian valve, the Chiari network has little clinical significance but may be confused with pathologic structures, such as vegetations or thrombi.
23. a. This is a pulsed wave Doppler of the LAA revealing AF/flutter. AF occurs transiently in 6–10% of patients with an acute myocardial infarction, presumably due to atrial ischemia or atrial stretching secondary to heart failure. These patients have a worse prognosis than those who have acute myocardial infarctions without AF.
24. d. This finding on TEE represents lipomatous hypertrophy of the interatrial septum. In this condition, there is an unencapsulated accumulation of mature adipose tissue in the interatrial septum with sparing of the fossa ovale, which gives it the classic "dumb-bell" appearance on both TTE and TEE. It is thought to be a normal variant and is generally considered benign. This finding alone would not be a contraindication for cardioversion.

25. e. Immediately postcardioversion, there is an initial increase in SEC and thus an increased risk of thrombus formation/thromboembolism. This has been described with spontaneous conversion as well as following electrical and pharmacologic cardioversion. These findings are thought to be due to the reduction of LA function ("atrial stunning"), which can last for several weeks after successful cardioversion. Relatively high atrial appendage ejection velocity suggests shorter duration AF, and thus a higher likelihood of long-term maintenance of sinus rhythm. Additionally, there is a reduction in LAA function, demonstrated by decreased velocities through the LAA.
26. c. This M-mode demonstrates mitral stenosis and AF. Patients with mitral stenosis and AF have a stroke risk between 7% and 15% per year.
27. a. In a multivariate analysis of patients with mitral stenosis, only two independent risk factors for AF were found: LA dimension and increasing age.
28. d. The vast majority of atrial thrombi among patients with AF are located in the LAA. TTE has a reported sensitivity of 39–63% in identifying or excluding LAA. Although there is improvement of visualization of the LA and the LAA with IV contrast and harmonic imaging with TTE, TEE still remains the gold standard to evaluate the LA and especially the LAA for thrombi.
    - Recognize mitral stenosis by M-mode and know there is an increase in stroke risk in patients with AF associated with rheumatic valvular disease.
    - Only LA dimension and increasing age are independent predictors for AF in patients with mitral stenosis based on multivariate analysis.
    - TEE remains the gold standard in the evaluation for LA thrombi.
29. e. The specificity of TEE for LA thrombi is reported to be between 90% and 100%.
30. d. Pulsed wave Doppler at the ostium of the pulmonary vein shows elevated velocities and spectral broadening both in systole and diastole, consistent with pulmonary vein stenosis. On TEE, normal right upper pulmonary vein S and D wave velocities are ~50–70 cm/s. The mean onset of pulmonary vein stenosis occurs between 2 and 5 months postprocedure. Pulmonary vein stenosis is one of the potential complications of PVI. Early experience with PVI reported PV stenosis rates of up to 38%. More recent studies report the incidence to be only 1–3%. The decline is likely related to a modification of the procedure with ablation now occurring in the body of the LA rather than within the pulmonary vein. A "retrograde" A wave is present confirming sinus rhythm.

32

Echocardiography for Intracardiac Tumors

1. A structure found in the left atrium that can be misinterpreted as a pathologic mass is:
   a. Eustachian valve
   b. Crista terminalis
   c. Moderator band
   d. Chiari network
   e. Suture line following transplant

2. The following is a Class IIb indication for performing echocardiography in patients with cardiac masses or tumors:
   a. Evaluation of patients with clinical syndromes and events suggesting an underlying cardiac mass
   b. Follow-up or surveillance studies after surgical removal of masses known to have a high likelihood of recurrence
   c. Screening persons with disease states likely to result in mass formation but for whom no clinical evidence for the mass exists
   d. Evaluation of patients with underlying cardiac disease known to predispose to mass formation for whom a therapeutic decision regarding surgery or anticoagulation will depend on the results of echocardiography
   e. Patients with known primary malignancies when echocardiographic surveillance for cardiac involvement is part of the disease staging process

3. This tumor is a benign cardiac tumor:
   a. Angiosarcoma
   b. Rhabdomyoma
   c. Lymphoma
   d. Mesothelioma
   e. Prominent ventricular trabeculations

4. It is uncommon for this tumor to metastasize to the heart:
   a. Renal cell carcinoma
   b. Breast
   c. Thyroid
   d. Lung
   e. Melanoma

1. e. 2. c. 3. b. 4. c.

5. The most common mechanism by which cardiac papillary fibroelastomas cause symptoms is:
   a. Direct invasion of the myocardium, resulting in impaired contractility or arrhythmias
   b. Embolization
   c. Obstruction of blood across heart valves
   d. Pericardial effusion leading to cardiac tamponade

6. Lipomatous hypertrophy of the atrial septum:
   a. Does not commonly cause symptoms
   b. Is caused by fibrosis
   c. Has the same histologic pattern as lipomas
   d. Can be seen on transthoracic echocardiography and is an indication for the performance of transesophageal echocardiography

7. Which statement appropriately describes fibromas?
   a. Fibromas are typically small tumors
   b. Fibromas are benign connective tissue tumors derived from fibroblasts that occur predominantly in children
   c. Fibromas are typically found in one of the atria
   d. Fibromas are usually asymptomatic
   e. No treatment is recommended for asymtomatic patients with cardiac fibromas

8. Which mass is the most common benign cardiac tumor in infants and children?
   a. Atrial myxoma
   b. Angiosarcoma
   c. Teratoma
   d. Hemangioma
   e. Rhabdomyoma

9. The clinical manifestations of the Carney complex include:
   a. Papillary fibroelastoma
   b. Hemangioma
   c. Epilepsy
   d. Cardiac myxoma
   e. Nevoid basal cell carcinoma

10. The following are symptoms associated with cardiac myxoma:
    a. Palpitations and diarrhea
    b. Syncope and diarrhea
    c. Dyspnea and fever
    d. Dyspnea and dysphagia

11. Which of the following statements about tuberous sclerosis is true?
    a. Tuberous sclerosis is a syndrome characterized by hamartomas in several organs, epilepsy, cognitive impairment, and adenoma sebaceum
    b. The genetic defect for tuberous sclerosis has not been identified
    c. Only a minority of patients with cardiac rhabdomyomas have tuberous sclerosis
    d. Surgical resection of the cardiac tumors is recommended in asymptomatic patients with tuberous sclerosis

12. Papillary fibroelastomas:
    a. Cannot occur on the pulmonic valve
    b. Are usually single rather than multiple
    c. Exclusively occur on cardiac valves
    d. Commonly result in valvular regurgitation

13. The most common malignant tumor of the heart is:
    a. Angiosarcoma
    b. Lymphoma
    c. Metastatic disease
    d. Leiomyosarcoma
    e. Myxoma

5. b. 6. a. 7. b. 8. e. 9. d. 10. c. 11. a. 12. b. 13. c.

14. A characteristic feature of a cardiac myxoma on two-dimensional echocardiography is:
    a. An associated pericardial effusion
    b. A narrow stalk connected to the fossa ovalis
    c. An intramural hyperechoic mass
    d. A mobile mass with a short pedicle attached to a cardiac valve

15. In patients with human immunodeficiency virus (HIV) infection and acquired immunodeficiency syndrome (AIDS), this tumor has been described to affect the heart:
    a. Lipoma
    b. Kaposi sarcoma
    c. Rhabdomyosarcoma
    d. Angiosarcoma
    e. Hemangioma

16. A 36-year-old woman was diagnosed with leiomyosarcoma (Fig. 32.1 of a zoomed view of the left atrium on parasternal long axis). Which of the following statements about leiomyosarcoma is correct?

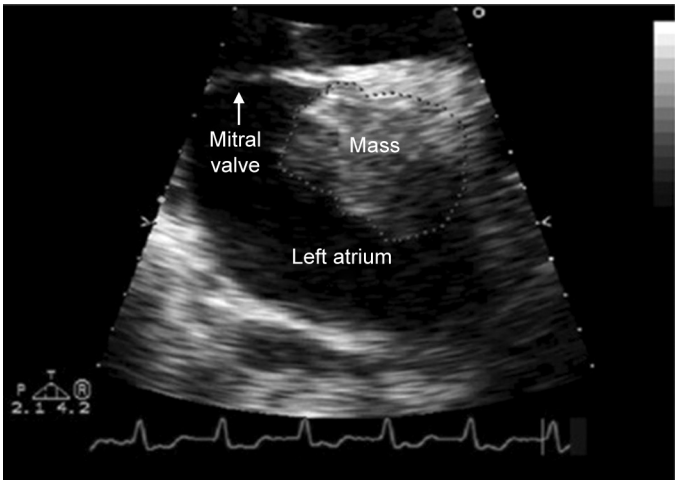


Fig. 32.1

    a. Treatment of cardiac leiomyosarcomas consists solely of chemotherapy and radiation
    b. Leiomyosarcomas, like other malignant cardiac tumors, occur preferentially in the right heart
    c. Leiomyosarcomas typically present in their seventh decade
    d. Leiomyosarcomas are derived from smooth muscle cells

17. A 40-year-old man with dyspnea is found to have a mass on transthoracic echocardiography (Fig. 32.2 of the right ventricular outflow tract in the pulmonic valve tilt view from parasternal long axis). Pathology at the time of surgery revealed an angiosarcoma. Which of the following accurately describes angiosarcomas?
    a. Angiosarcomas usually are discovered late and typically have grown to be large or metastasized at the time of diagnosis
    b. Like other cardiac sarcomas, the gender distribution is equal (1:1)
    c. Angiosarcomas most often occur in the left ventricle
    d. Patients usually present with tachyarrhythmias

14. b. 15. b. 16. d. 17. a.

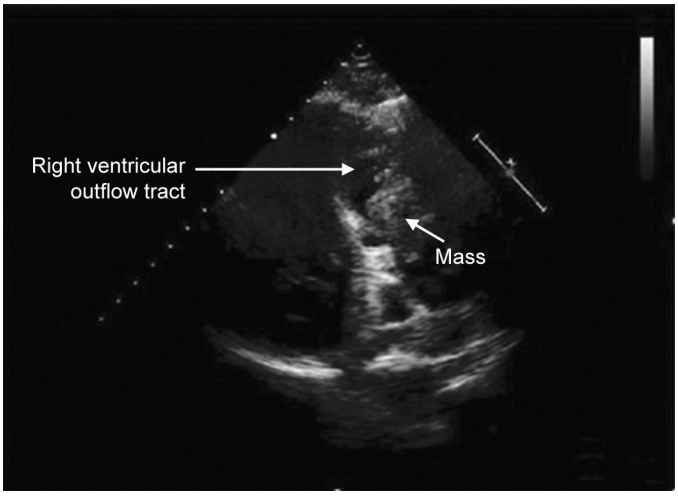


Fig. 32.2

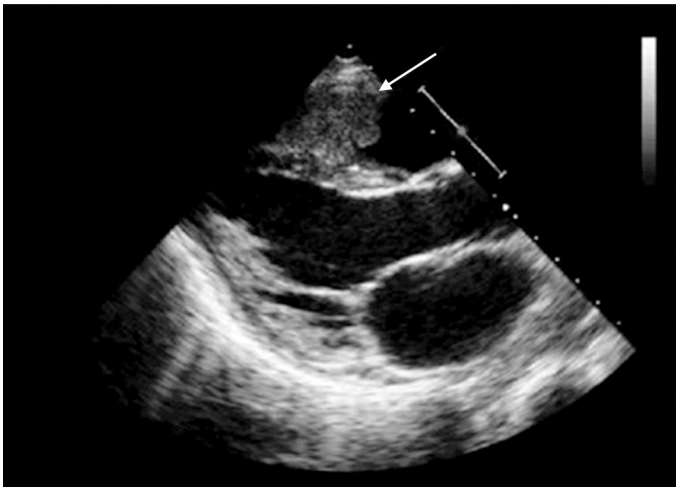


Fig. 32.3

18. A 52-year-old woman presented with right flank pain and weight loss. Renal cell carcinoma was diagnosed. A transthoracic echocardiogram was performed (Fig. 32.3 of the parasternal long axis). Arrow points to a mass in the right ventricle. Which of the following statements about renal cell carcinoma is correct?
    a. Intravascular extension of the tumor is not a common manifestation of renal cell carcinoma
    b. Pulmonary embolization is not seen with metastatic renal cell carcinoma
    c. Metastatic renal cell carcinoma is rarely confused with thrombus on echocardiography
    d. The initial diagnosis of renal cell carcinoma can be made by detection of an intracardiac mass on echocardiography in some cases

18. d.

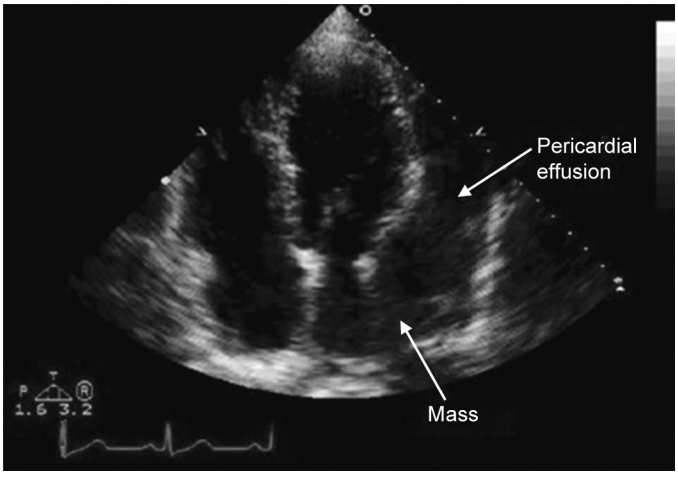


Fig. 32.4

19. A 24-year-old man with synovial sarcoma had a transthoracic echocardiogram performed (Fig. 32.4 of the apical four-chamber view demonstrating a large pericardial effusion and mass abutting the lateral left atrial wall). Which of the following accurately characterizes synovial sarcomas?
    a. Synovial sarcoma is caused by a translocation between chromosome 18 and the X chromosome
    b. Synovial sarcoma is not a malignant primary cardiac tumor
    c. Synovial sarcoma is a common type of cardiac tumor
    d. Synovial sarcoma has an excellent prognosis

20. A 0.2 ml bolus of perflutren lipid microspheres was injected intravenously followed by a saline flush. A two-chamber view at 80 degrees on a transesophageal echocardiogram is show in Figure 32.5. Based on these images, which of the following conclusions is true about this patient's condition?
    a. The structure seen in the left atrium near the mitral annulus is likely to be an angiosarcoma
    b. The structure seen in the left atrium near the mitral annulus is likely to be a cystic structure
    c. The structure seen in the left atrium near the mitral annulus is likely to be a myxoma
    d. The structure seen in the left atrium near the mitral annulus is likely to be a papillary fibroelastoma

21. An apical view from a transthoracic echocardiogram is shown in Figure 32.6. A prominent Chiari network is seen in the right atrium. Based on these images, which of the following statements is correct?
    a. A Chiari network is present in 20–30% of normal hearts
    b. A Chiari network is associated with an increased risk of sudden cardiac death
    c. A Chiari network is a congenital remnant of the right valve of the sinus venosus
    d. A Chiari network is another name for crista terminalis

19. a. 20. b. 21. c.

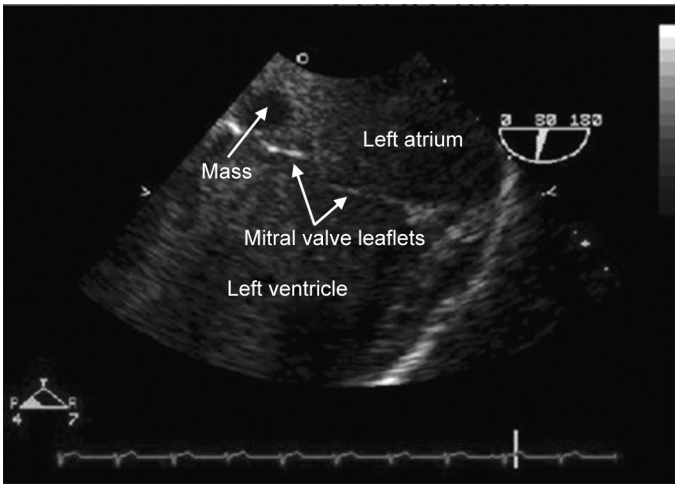


Fig. 32.5

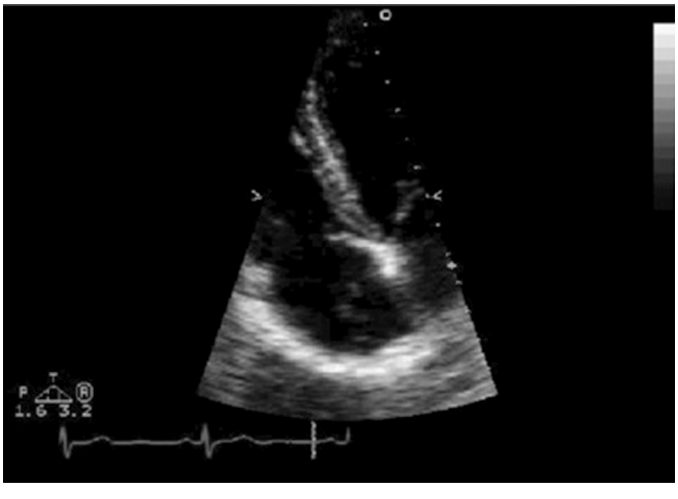


Fig. 32.6

22. A 62-year-old woman presented with worsening dyspnea on exertion and chest pain that began 4 months earlier. A transthoracic echocardiogram revealed a very large partially echodense fluid collection compressing the right atrium and right ventricle (Fig. 32.7). This structure was surgically removed and histology revealed a fibrovascular cyst with chronic inflammation consistent with a pericardial cyst. Which of the following statements about pericardial cysts is correct?
    a. The diagnosis of pericardial cyst can sometimes be suggested on chest radiograph by the identification of a rounded mass along the right heart border
    b. Pericardial cysts are the most common anterior mediastinal mass lesion
    c. Cysts are considered to be true neoplasms
    d. It is common for pericardial cysts to become large enough to cause compressive symptoms

22. a.

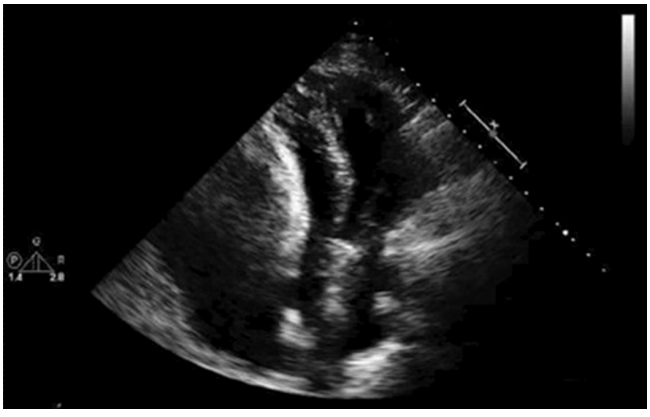


Fig. 32.7

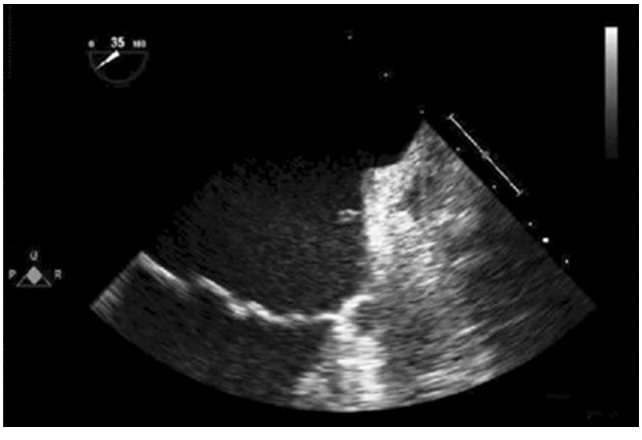


Fig. 32.8

23. A 56-year-old man with persistent atrial fibrillation underwent a minimally invasive modified surgical Maze procedure with suture closure of the left atrial appendage. A transthoracic echocardiogram was performed 1 month later. Figure 32.8; show the left atrium at 30 degrees with a small mobile echodensity that appears to be attached to the left atrial wall. Color Doppler showed contiguous flow between the left atrium and left atrial appendage and the pulsed Doppler tracing was consistent with a left atrial appendage flow pattern (not shown). Which of the following statements is correct?
    a. The interpretation of masses found on echocardiography is not dependent on the clinical context in which it occurs
    b. There is a high occurrence of unsuccessful surgical left atrial appendage closure reported in the literature
    c. Transesophageal echocardiography is not helpful in assessing the results of a surgical left atrial appendage closure procedure
    d. Residual communication between an incompletely closed left atrial appendage and the body of the left atrium is not a potential mechanism for thrombus formation and embolic events

23. b.

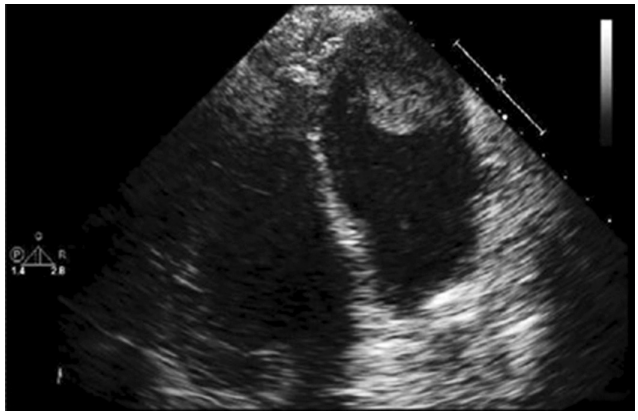


Fig. 32.9

24. An 82-year-old man with a past history of an anterior wall ST segment elevation myocardial infarction had a transthoracic echocardiogram performed. A large left ventricular apical mass was seen (Fig. 32.9 of the apical four-chamber view) and the anterior wall and apex were akinetic. This mass most likely represents a:
    a. Myxoma
    b. Rhabdomyosarcoma
    c. Thrombus
    d. Vegetation

25. A 16-year-old boy was diagnosed with a single rhabdomyoma during his first year of life. He is asymptomatic. Figure 32.10, parasternal short axis, is from his most recent transthoracic echocardiogram. Which of the following conclusions is true about this patient's condition?
    a. The presence of a rhabdomyoma cannot be diagnosed before birth with fetal echocardiography
    b. The ventricular wall is a typical location for rhabdomyomas
    c. This patient should be referred to a cardiothoracic surgeon for removal of the rhabdomyoma
    d. This patient meets diagnostic criteria for tuberous sclerosis

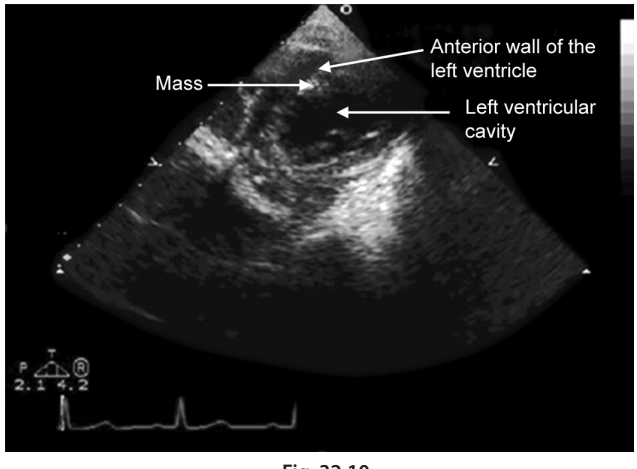


Fig. 32.10

24. c. 25. b

Answers

1. e. There are many normal variants and benign conditions that can be misinterpreted on two-dimensional echocardiography as pathologic entities. A suture line following transplant is an example of a structure found in the left atrium that can be misinterpreted as a mass. The Eustachian valve, crista terminalis, and Chiari network are all normal structures found in the right atrium. The moderator band is a normal structure present in the right ventricle.
2. c. Screening persons with disease states likely to result in mass formation but for whom no clinical evidence for the mass exists is a Class IIb indication for performing echocardiography. Class I indications for echocardiography include evaluating patients with clinical syndromes suggesting an underlying cardiac mass, follow-up studies after surgical removal of masses known to recur, evaluating patients where treatment plans depend on the results of echocardiography, and assessing patients with known primary malignancies where surveillance for cardiac involvement is part of the disease staging process.
3. b. Rhabdomyoma is a benign cardiac tumor. Rhabdomyomas are usually small and lobulated, with diameters in the range of 2 mm to 2 cm. Rhabdomyomas are most often multiple and are strongly associated with tuberous sclerosis. Angiosarcoma, lymphoma, and mesothelioma are all malignant cardiac tumors. Prominent ventricular trabeculations can also be seen on echocardiography and represent either a normal variant, or, if severe enough, may indicate noncompaction.
4. c. It is uncommon for thyroid cancer to metastasize to the heart. Renal cell carcinoma, breast cancer, lung cancer, and melanoma all are known to metastasize to the heart. Renal cell carcinoma spreads hematogenously to the inferior vena cava and right side of the heart. Breast cancer spreads to the heart by either hematogenous or lymphatic means. Lung cancer usually metastasizes to the heart via direct extension. Lymphoma spreads through the lymphatic system. Metastatic melanoma can result in intracavitary or myocardial involvement. Carcinoid typically results in tricuspid and pulmonic valve thickening.
5. b. The most common mechanism by which papillary fibroelastomas cause symptoms is embolization. Other cardiac tumors may cause symptoms through several mechanisms, including direct invasion of the myocardium leading to impaired contractility or arrhythmias, obstruction, and pericardial effusions resulting in cardiac tamponade.
6. a. Lipomatous hypertrophy of the atrial septum does not commonly cause symptoms. This condition is thought to be benign although there is a reported association with atrial arrhythmias and superior vena cava obstruction if there is massive lipomatous hypertrophy. The atrial septum is infiltrated by lipomatous material that results in thickening of the inferior and superior portions. The fossa ovalis is spared and results in a "dumb-bell-shaped" appearance on two-dimensional echocardiography. Lipomatous hypertrophy of the atrial septum is usually distinguishable by the highly refractile echogenic quality of fat. Although no absolute diagnostic criteria have been established, a septal thickness of 20 mm is often quoted. Lipomatous hypertrophy of the atrial septum represents a hamartoma. Pathologically, in contrast to true lipomas, lipomatous hypertrophy consists of a nonencapsulated accumulation of mature and fetal adipose tissue and atypical cardiac myocytes within the interatrial septum. The term hypertrophy is a misnomer since the condition is due to an increased number rather than an increased size of adipocytes. This condition can be seen on transthoracic echocardiography and its presence alone is not an indication for transesophageal echocardiography.
7. b. Fibromas are benign connective tissue tumors derived from fibroblasts that occur predominantly in children. Fibromas are the second most common type of primary cardiac tumors occurring in the pediatric population. Most are detected in children younger than 10 years, and about one-third are diagnosed in infants younger than 1 year. Cardiac fibromas are typically large tumors, ranging from 3 to 10 cm in diameter. Cardiac fibromas usually

occur within the ventricular myocardium, most commonly in the anterior wall of the left ventricle or interventricular septum. About 70% of patients with fibromas are symptomatic. Symptoms result from either obstruction, systolic dysfunction, or conduction abnormalities. The most common clinical manifestations are congestive heart failure and ventricular tachyarrhythmias. Given the risk of fatal arrhythmias, resection is usually recommended in asymptomatic patients. Sudden death has been reported to occur in approximately 15% of patients, typically in infants.

8. e. Rhabdomyomas are the most common benign cardiac tumor in infants and children, accounting for approximately half of the cardiac tumors in these age groups.
9. d. The diagnostic criteria for the Carney complex include having two of 12 recognized clinical manifestations or one clinical manifestation plus one of the two genetic criteria. Cardiac myxoma is a diagnostic clinical criterion for the Carney complex. The other clinical manifestations relate to either pigmented skin lesions or endocrine neoplasia. Familial myxomas, such as those seen in the Carney complex, account for a small percentage of all myxomas. Patients with familial myxomas tend to present earlier, are more likely to have myxomas in atypical locations, may have multiple myxomas, and are more likely to develop recurrent tumors. Epilepsy is associated with tuberous sclerosis. Nevoid basal cell carcinoma is associated with cardiac fibroma in the Gorlin syndrome.
10. c. Myxomas present with symptoms resulting from intracardiac obstruction, systemic embolization, or constitutional symptoms. Dyspnea is the most common symptom. Syncope and palpitations are also seen. Constitutional symptoms, such as fever and weight loss, are also seen in approximately 15–20% of patients. The association of constitutional symptoms with cardiac myxoma is likely due to the tumor's synthesis and secretion of interleukin (IL)-6. IL-6 is a proinflammatory cytokine that induces the acute phase response. Increased levels of IL-6 have been found in myxoma tissue and the constitutional symptoms resolve after removal of the myxoma. Diarrhea is seen in the carcinoid syndrome.
11. a. Histologic evidence suggests that cardiac rhabdomyomas are actually myocardial hamartomas or malformations that are composed of myocytes rather than true neoplasms. The microscopic hallmark is a large (<80 micrometer diameter) cell containing a central cytoplasmic mass that is suspended by myofibrillar processes, termed the Spider cell. Tuberous sclerosis is an autosomal-dominant hamartoma syndrome whose causative genes (TSC-1 and TSC-2) are tumor suppressor genes that encode a protein complex that regulates cell size. At least 80% of patients with cardiac rhabdomyomas have tuberous sclerosis. Fifty percent or more of cardiac rhabdomyomas regress spontaneously after infancy. Therefore, in the absence of symptoms, surgery is not indicated.
12. b. More than 90% of the time papillary fibroelastomas are single. Papillary fibroelastomas can occur on any valve. The aortic and mitral valve are most commonly involved in adults. Despite their valvular attachment, valve dysfunction is rare. Much less commonly, papillary fibroelastomas can occur on papillary muscle, chordae tendineae, or in the atria. The median diameter of papillary fibroelastomas is 8 mm and the largest reported is 40 mm. A short pedicle is seen approximately 50% of the time, and is more typical in tumors arising from the endocardium of a cardiac chamber.
13. c. Primary malignant tumors of the heart are much less common than metastatic tumors to the heart. In autopsy series, the incidence of primary tumors of the heart was only 0.02%.
14. b. Cardiac myxomas typically have a narrow stalk connected to the fossa ovalis. Approximately 75% of cardiac myxomas occur in the left atrium, where the site of attachment is almost always in the region of the fossa ovalis of the interatrial septum. Cardiac myxomas may occasionally be found on the posterior wall of the left atrium. However, this location within the left atrium should raise the suspicion for a malignant cardiac tumor. Approximately 15–20% of cardiac myxomas occur in the right atrium, and less often they can be seen in the right or left ventricle.

There are case reports of myxomas originating from the atrioventricular valves. Pericardial effusions are usually found in the setting of malignant cardiac tumors. Lipomas appear as an intramural hyperechoic mass. A mobile mass with a short pedicle attached to a cardiac valve is a papillary fibroelastoma.

15. b. Kaposi sarcoma, as well as malignant lymphoma, is recognized to occur in the setting of acquired immunodeficiency syndrome (AIDS). Cardiac involvement with Kaposi sarcoma usually occurs as part of a disseminated Kaposi sarcoma. The incidence of Kaposi sarcoma involving the heart has been estimated to be 12–28% by autopsy studies.
16. d. Leiomyosarcomas are derived from smooth muscle cells and may originate from the smooth muscle cells lining the pulmonary veins. Although chemotherapy and radiation are part of the treatment plan, they are adjuncts to radical surgical resection. However, cardiac leiomyosarcomas have a poor prognosis, with a mean survival after surgery of less than 7 months. The majority of malignant tumors occur preferentially in the right side of the heart, with the exception of leiomyosarcoma, which often occurs in the left atrium. The preferential left atrial location and the frequently myxoid appearance of leiomyosarcomas makes them difficult to differentiate preoperatively from atrial myxomas. Unlike myxomas, leiomyosarcomas may originate from the posterior wall of the left atrium and involve the pulmonary veins. Patients with leiomyosarcoma typically present in their 30s, a decade younger than with other types of sarcomas.
17. a. Angiosarcomas usually are large or have metastasized at the time of diagnosis. Angiosarcomas often are not amenable to complete resection and have a very poor prognosis, even compared to the other cardiac sarcomas. Unlike other sarcomas, which have a 1:1, gender ratio, there appears to be a 3:1 male-to-female ratio among patients with angiosarcoma. Angiosarcomas have a strong predilection for the right heart, particularly the right atrium. They can be either intracavitary or diffuse and infiltrative. The common presentation is right-sided heart failure or cardiac tamponade as well as constitutional symptoms.
18. d. Some patients with renal cell carcinoma may present with symptoms related to cardiac metastases. The diagnosis of renal cell carcinoma may be first introduced by the echocardiogram. Intravascular extension of tumor is a common manifestation of renal cell carcinoma. Since vena caval and right heart involvement is known to occur with metastatic renal cell carcinoma, pulmonary embolism, either from tumor or thrombus, can be seen. The appearance of metastatic renal cell carcinoma itself can be confused with thrombus on echocardiography and sometimes cardiac magnetic resonance imaging is helpful to distinguish these entities.
19. a. Synovial sarcoma is caused by a translocation between chromosome 18 and the X chromosome. Synovial sarcoma is one of the malignant primary cardiac sarcomas. Synovial sarcoma is an extremely rare cardiac tumor. Like most cardiac sarcomas, the prognosis of synovial sarcoma is poor.
20. b. The use of myocardial contrast echocardiography to identify intracardiac tumors based on masses with vascularization has been described for both transthoracic echocardiography and transesophageal echocardiography. The mass shown in Figure 32.5 does not opacify with the administration of perflutren lipid microspheres. This lack of uptake indicates a lack of vascularity. Given its echocardiographic appearance, this structure was considered to be consistent with a cyst rather than a thrombus or vegetation.
21. c. The Chiari network is a congenital remnant of the right valve of the sinus venosus. It consists of a network of fibers in the right atrium that originate from a region of the Eustachian valve at the orifice of the inferior vena cava with attachments to the upper wall of the right atrium or atrial septum. Chiari networks are present in 2–3% of normal hearts. Chiari networks are usually not clinically significant although their role in cryptogenic stroke, in association with a patent foramen ovale or atrial septum aneurysm, is controversial.

22. a. The diagnosis of pericardial cyst can sometimes be suggested on chest radiograph by the identification of a rounded mass along the right heart border. Echocardiography or chest computed tomography is recommended to follow-up this finding to better establish the diagnosis. Primary cysts of the mediastinum account for approximately 20% of all mediastinal lesions. This group includes pericardial cysts, bronchogenic cysts, enteric cysts, thymic cysts, and thoracic duct cysts. Cysts are not considered to be true neoplasms. Cysts lack malignant potential, although the examination of tissue either by open, thoracoscopic, or percutaneous means is necessary to definitively exclude a neoplasm. However, conservative management of asymptomatic patients in whom noninvasive imaging is strongly suggestive of a pericardial cyst is also a reported approach. It is rare for pericardial cysts to become large enough to cause compressive symptoms and hemodynamic alterations.
23. b. In a series from the Cleveland Clinic, only 55 of 137 (40%) surgical left atrial appendage closures were successful. Successful left atrial appendage closure occurred more often with excision than suture exclusion and stapler exclusion. This clinical vignette highlights the importance of clinical correlation when interpreting echocardiographic images. In this case, the echodensity most likely represents suture material given the patient's history. Transesophageal echocardiography is an excellent method for assessing the success of left atrial appendage closure procedures. Evidence suggests that the residual communication between an incompletely closed left atrial appendage and the body of the left atrium is a potential mechanism for thrombus formation and embolic events.
24. c. The development of a left ventricular thrombus is one of the more common complications of myocardial infarction. Thrombi are important clinically because they can lead to embolic complications. The likelihood of developing a left ventricular thrombus after an acute myocardial infarction varies with infarct location and size. Left ventricular thrombus is most often seen in patients with large anterior ST elevation infarctions with aneurysm formation and akinesis or dyskinesis. Transthoracic echocardiography has been the standard procedure for the diagnosis of left ventricular thrombus after acute myocardial infarction. Echocardiography can help identify those patients at high risk of thromboembolism. The two major echocardiographic risk factors for clinical thromboembolism are mobile thrombi and protruding thrombi. Echocardiography can also be used to monitor resolution of thrombus with anticoagulation. In patients with suboptimal acoustic windows or prominent trabeculations, the use of an intravenous contrast agent to opacify the left ventricular apex can sometimes be used to improve the sensitivity and specificity of thrombus detection. Alternatively, cardiac magnetic resonance imaging could be performed.
25. b. Rhabdomyomas are usually found in the ventricular walls or on the atrioventricular valves. The presence of a rhabdomyoma can be diagnosed before birth with fetal echocardiography. There is no evidence that these tumors undergo malignant transformation and no treatment is required for asymptomatic tumors. Although 80–90% of rhabdomyomas are associated with tuberous sclerosis, cardiac rhabdomyomas can occur as an isolated finding as it has in this case.

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Echocardiography for Hypertrophic and Dilated Cardiomyopathy

1. Which statement regarding idiopathic dilated cardiomyopathy is correct?
   a. Segmental wall motion abnormalities are predictors of worse outcome in idiopathic dilated cardiomyopathy
   b. Atrial dilatation is uncommon; biventricular dilatation is common
   c. Improvement in sphericity index in response to dobutamine is a predictor of late recovery of left ventricular (LV) systolic function
   d. The finding of significant coronary artery disease is common
   e. Routine endomyocardial biopsy is recommended for adequate diagnosis

2. A 48-year-old woman presents to the emergency department complaining of shortness of breath and recurrent palpitations. Initial electrocardiography (ECG) showed atrial flutter at a rate of 150 bpm with 2:1 atrioventricular conduction. A transthoracic echocardiogram is obtained and it revealed four-chamber dilatation and moderate to severe biventricular systolic dysfunction. Which of the following statements is correct regarding this patient's cardiomyopathy?
   a. This cardiomyopathy is most likely irreversible
   b. The ventricular systolic dysfunction may be improved by radiofrequency ablation of the atrial flutter
   c. Idiopathic dilated cardiomyopathy is not in the differential diagnosis in this patient
   d. Electrical cardioversion is not helpful in these types of patients

3. Which of the following statements is true about peripartum cardiomyopathy?
   a. If the patient's ejection fraction (EF) normalizes after the initial cardiomyopathy episode, there is no recurrence of LV systolic dysfunction in subsequent pregnancies
   b. Up to 25% of patients have marked improvement in LV systolic function and clinical symptoms after the initial episode
   c. Most women initially present with symptoms and echocardiographic abnormalities between 3 and 6 months postpartum
   d. An elevated E/e' ratio is uncommon in these patients
   e. Marked inotropic contractile reserve measured during dobutamine stress echocardiography may serve as a predictor of the likelihood of recurrence of cardiomyopathy with subsequent pregnancy

1. c 2. b 3. e

4. A 49-year-old man comes in for an evaluation of syncopal episodes. As part of the initial evaluation, he had a 12-lead ECG that revealed complete atrioventricular block. A transthoracic echocardiogram showed an overall EF of 55% with thinning of the basal septum and moderate to severe mitral regurgitation (MR). Which of the following statements is true regarding this patient's condition?
   a. The initial presentation is expected to be a dilated cardiomyopathy
   b. This patient's MR is likely to improve after a course of high-dose steroids
   c. The correct diagnosis is usually made by endomyocardial biopsy
   d. Other areas of the left ventricle (besides the basal septum) and right ventricle are rarely involved in this disorder

5. A 52-year-old man presents for evaluation of dyspnea on exertion and lower extremity edema. He has a history of lymphoma and has completed chemotherapy treatment 5 months ago. He received a total cumulative lifetime dose of doxorubicin of 450 mg/m^2. Transthoracic echocardiogram reveals four-chamber dilatation and reduced LV systolic function. Which of the following statements regarding doxorubicin-induced cardiomyopathy is true?
   a. The probability of developing doxorubicin-induced cardiomyopathy only increases after total cumulative doses of 600 mg/m^2 or more
   b. Inflammatory infiltrates are commonly seen in histological examination
   c. Doppler-derived diastolic parameters are sensitive measures to detect early onset doxorubicin-induced cardiomyopathy
   d. Patients with doxorubicin-induced cardiomyopathy have a better 4-year survival compared with patients with idiopathic dilated cardiomyopathy
   e. Echocardiographic-derived LV systolic parameters demonstrate abnormalities before LV diastolic parameters

6. When differentiating athlete's heart from hypertensive LV hypertrophy (LVH), which echocardiographic parameter is most consistent with athlete's heart?
   a. Reduced peak annular early diastolic filling velocity (e')
   b. Increased E/e' ratio
   c. Normal longitudinal strain and peak systolic strain rates
   d. LV systolic dysfunction

7. Which of the following echocardiographic parameters has been demonstrated to be the best independent predictor of development of future congestive heart failure (CHF) symptoms?
   a. Myocardial performance index (Tei Index)
   b. Left ventricular ejection fraction (LVEF)
   c. LV wall motion score
   d. E/A ratio
   e. Pulmonary artery pressure

8. Which of the following statements best describes the cardiac findings in patients with Friedreich's ataxia?

4. b 5. c 6. c 7. a

a. In patients with the asymmetric septal hypertrophy form, provocable LV outflow obstruction is consistently seen, similar to classical hypertrophic obstructive cardiomyopathy (HOCM)
b. Patients with the concentric hypertrophy form have a worse prognosis than patients with HOCM
c. There is a direct relationship between the degree of neurologic involvement and the degree of cardiac abnormalities
d. Prolonged isovolumic relaxation period, decreased E/A ratio, increased LV mass index, and normal LV cavity dimensions are initial echocardiographic findings in these patients
e. Patients with global hypokinesis and the dilated cardiomyopathy form usually have the best prognosis of the three types of cardiac involvement

9. Which of the following statements is correct regarding cardiac involvement in primary hemochromatosis?
   a. Cardiac chamber dilatation is uncommon in this disease
   b. Iron deposition is consistent with an infiltrative cardiomyopathy
   c. Cardiac involvement leads to a restrictive filling pattern with severe increase in wall thickness and overall preserved LV systolic function
   d. With treatment, the cardiomyopathy may be reversible

10. Based on echocardiographic criteria, which asymptomatic athlete should be allowed to participate in competitive sports without further testing?
   a. A 20-year-old American football player with an LVEF of 65%, left ventricular end-diastolic diameter (LVEDD) of 5.3 cm, septal wall thickness of 1.9 cm, posterior wall thickness of 1.3 cm, lateral e' (by tissue Doppler imaging) of 6 cm/sec
   b. A 21-year-old basketball player with an LVEDD of 5.9 cm, left ventricular end-systolic diameter of 3.6 cm, septal wall thickness of 1.3 cm, posterior wall thickness of 1.3 cm, left atrial area of 22 cm^2, lateral e' (by tissue Doppler) of 18 cm/sec
   c. A 26-year-old soccer player with an LVEF of 55%, LVEDD of 5.2 cm, right ventricular (RV) outflow tract measurement in diastole of 3.2 cm, RV apical hypokinesis
   d. A 24-year-old basketball player with an LVEF of 60%, LVEDD of 5.3 cm, mitral valve prolapse with mild to moderate MR, aortic diameter at the sinuses of 4.2 cm, and at the ST junction of 4.1 cm

11. Which of the following descriptions helps differentiate cardiomyopathy related to Duchenne muscular dystrophy from cardiomyopathy related to Becker muscular dystrophy?
   a. Four-chamber dilatation and LV systolic dysfunction
   b. Mitral valve prolapse and MR
   c. Predilection for involvement of the posterobasal and posterolateral LV walls
   d. The severity of cardiac involvement does not correlate with the extent of skeletal muscle weakness

12. A 32-year-old man presents to the emergency department with angina. Pertinent findings on the physical examination include an audible S4. As part of his cardiac evaluation, a transthoracic echocardiogram is obtained. It shows an apical thickness of 19 mm, interventricular septal thickness of 11 mm, and posterior wall thickness of 10 mm. Which of the following is most likely found in this patient?

8. d 9. d 10. b 11. c

a. A normal 12-lead electrocardiogram
b. LV outflow tract (LVOT) peak velocity by continuous-wave Doppler of 1 m/sec after amyl nitrite administration
c. Systolic anterior motion of the mitral valve
d. A malignant clinical course

13. Which of the following echocardiographic findings are consistent with noncompaction cardiomyopathy?
    a. Three layers should be identifiable: epicardial, myocardial, and endocardial layers with the endocardial layer representing the noncompacted region
    b. The ratio of the noncompacted to compacted layers should be >1.5:1
    c. The most commonly affected regions are the midventricular lateral, inferior, and anterior walls
    d. Deep recesses filled with blood from the ventricular cavity should be seen by contrast echocardiography or color Doppler

14. Which of the following measures of diastolic function is most likely found in a patient with restrictive cardiomyopathy?
    a. Propagation velocity Vp of 60 cm/sec
    b. Peak early diastolic filling velocity of 115 cm/sec; tissue Doppler e' lateral velocity of 6 cm/sec
    c. Mitral E deceleration time of 165 milliseconds
    d. Mitral filling velocity ratio (E/A ratio) of 1.1
    e. Pulmonary vein Doppler pattern: systolic velocity > diastolic velocity

15. Which of the following serves as a predictor of mortality in patients with primary amyloidosis (AL) amyloidosis with cardiac involvement?
    a. LV end-diastolic dimension
    b. LV wall thickness
    c. Pericardial effusion
    d. Increased myocardial echogenicity

12. b 13. d 14. b 15. b

Answers

1. c. Improvement in left ventricular (LV) geometry as expressed by the sphericity index and improvement in LV contractile response in response to dobutamine predicted late recovery of LV function in idiopathic dilated cardiomyopathy, as demonstrated by several studies. The left ventricular sphericity index is the ratio of the LV long axis (apex to mitral annulus) to short axis dimension and represents the extent of chamber remodeling. Segmental wall motion abnormalities are present in up to 65% of patients with idiopathic dilated cardiomyopathy and actually predicted a more favorable prognosis than global hypokinesis. Four-chamber dilatation, including atrial and ventricular chamber dilatation, is present in idiopathic dilated cardiomyopathy. The coronary arteries are typically normal in autopsy studies. The routine use of ventricular endomyocardial biopsy is not recommended because of its low yield.
2. b. Tachycardia-induced cardiomyopathy is an often underrecognized, reversible dilated cardiomyopathy that occurs secondary to prolonged periods of supraventricular and ventricular tachycardia. The most important treatment goal is heart rate control. In this patient with atrial flutter, radiofrequency ablation could be potentially curative. Electrical cardioversion is the initial treatment option for heart rate/arrhythmia control in these patients. There are primary and secondary forms of tachycardia-induced cardiomyopathy, with the primary form occurring in otherwise normal subjects. The secondary form occurs in patients with underlying cardiac disease. An arrhythmia could be the initial presentation of any cardiomyopathy.
3. e. Peripartum cardiomyopathy is a disorder of uncertain etiology characterized by the development of heart failure symptoms during the last trimester of pregnancy or during the first 5 months postpartum in the absence of any other identifiable cause of heart failure, and an ejection fraction (EF) of <40%. Up to 50% of patients fully recover with normalization of EF and resolution of congestive heart failure (CHF) symptoms. There is a significant rate of recurrence during subsequent pregnancies, most commonly in patients with persistent LV dysfunction, but there is also a chance of recurrence in patients with normalization of the left ventricular ejection fraction (LVEF). For those women having a recurrent pregnancy despite persistent cardiomyopathy, the risks of mortality and heart failure are high. Most women present with symptoms during the first month of the postpartum period. It is very common to have markedly elevated LV filling pressures, which would be demonstrated as an abnormally elevated E/e' ratio by echocardiography. It has been demonstrated in small series of patients who have recovered from peripartum cardiomyopathy that dobutamine stress echocardiography is a useful tool to predict the safety of a recurrent pregnancy. Those women who have recovery of function to normal and normal contractile reserve with dobutamine have a lower risk of recurrence.
4. b. This is a description of a patient with cardiac sarcoidosis. Although only approximately 5% of patients with sarcoidosis have apparent cardiac manifestations, nearly 50% of patients have confirmed disease at autopsy. The presence of conduction disease and a regional cardiomyopathy with preserved LV function suggests this disorder. With sarcoidosis, there is granulomatous infiltration of the myocardium and subsequent healing and scar formation in various areas that may manifest as segmental wall thinning, regional wall motion abnormalities, dilation of the left ventricle, and apical LV aneurysm formation in some cases. In addition, patients may have findings consistent with cor pulmonale. The mechanism for mitral regurgitation (MR) in this patient is likely due to granulomatous infiltration of the papillary muscles resulting in restriction of leaflet motion and may improve after a course of high-dose steroids. The systolic function may remain normal initially, progressing to systolic dysfunction later in the disease. Many other areas of the left ventricle besides the basal septum and also the right ventricle have been involved with cardiac sarcoidosis. Endomyocardial biopsy has a low sensitivity in detecting sarcoid granulomas and is not routinely performed

to make the diagnosis. Gadolinium-enhanced cardiac magnetic resonance imaging is a useful tool for the diagnosis of cardiac sarcoidosis.

5. c. The incidence of doxorubicin-induced cardiomyopathy is closely related to the total lifetime cumulative dose that the patient receives. The probability of developing this cardiomyopathy greatly increases after cumulative doses above 400 to 500 mg/m^2. Characteristic changes in electron microscopy include vacuolar degeneration and then progressive myofibrillar loss; inflammatory infiltrates are not usually seen in this cardiomyopathy. Patients with doxorubicin-induced cardiomyopathy have a worse prognosis at 4 years compared with patients with idiopathic-dilated cardiomyopathy and ischemic cardiomyopathy.

   Echocardiography is a very important tool in the follow-up of these patients and usually LVEF is used to help guide possible future doses. However, abnormalities in diastolic echocardiographic parameters usually precede systolic abnormalities and serve as a sensitive tool to detect early cases when the systolic parameters still remain normal.

6. c. In athlete's heart, most diastolic parameters including those obtained via tissue Doppler imaging are very similar to normal controls. Athletes have normal diastolic e' velocities and normal E/e' ratio consistent with normal LV filling pressures. Athletes most commonly have normal LV systolic function and they also have normal or exaggerated values when measuring systolic and diastolic strain/strain rate parameters, which are usually abnormal in hypertensive patients with LV hypertrophy (LVH). These strain parameters help differentiate an athlete's heart from a patient with hypertensive LVH.

7. a. The myocardial performance index (MPI or Tei index) is a measurement that incorporates both systolic and diastolic parameters and it is defined as the sum of the isovolumic contraction time and isovolumic relaxation time divided by the ejection time. This Doppler-derived index has been shown to closely correlate to +dP/dt and –dP/dt measurements directly obtained via cardiac catheterization. Other echocardiographic parameters such as LVEF, LV wall motion score, E/A ratio, and E deceleration time, also serve as predictors of future heart failure morbidity. MPI is believed to have strong independent predictive value due to the fact that MPI reflects both systolic and diastolic function.

8. d. Up to 90% of patients with Friedreich's ataxia may demonstrate various cardiac abnormalities. There are two types of cardiac involvement: the most common, the hypertrophic form that is subdivided into asymmetric septal hypertrophy and the concentric LVH. The other type of cardiomyopathy is the dilated form with global hypokinesis. Abnormalities in diastolic parameters like isovolumic relaxation time (IVRT) and LV filling pattern may be the first signs of cardiac involvement in patients with this disease entity. Interestingly, in patients who develop the asymmetric septal hypertrophy form, a provocable significant left ventricular outflow tract (LVOT) gradient is rarely seen in contrast to patients with HOCM. Patients with the concentric hypertrophy form have a better prognosis than patients with HOCM. Patients who develop the dilated cardiomyopathy form have the worse prognosis. There is no relationship between the degree of neurologic and cardiac involvement.

9. d. Hemochromatosis is a form of iron-storage disease with deposition in various organs including the sarcoplasmic reticulum of myocardial cells in the heart. By the proposed American Heart Association (AHA) classification of cardiomyopathies, it is characterized as a secondary cardiomyopathy since it is part of a systemic disease. It is not an infiltrative disorder, and wall thickness is generally normal. The atrium, ventricles, and atrioventricular conduction system may be involved. Cardiac involvement in hemochromatosis leads to cavity enlargement in approximately one-third of patients with normal wall thickness. The earliest form may manifest as a restrictive cardiomyopathy, although subsequently mixed or dilated forms may occur. As the disease progresses, there may be a decrease in LV systolic function, significant cavity dilation, and biatrial enlargement. Identification of cardiac hemochromatosis is important since treatment with chelating agents or phlebotomies may improve cardiac function.

10. b. In athlete's heart, there is usually an increase in LV cavity size (rarely beyond 6.0 cm); and in a small group of athletes, there may be a symmetric increase in wall thickness (between 1.2 and 1.5 cm—"the gray zone"). There is normal LV systolic and diastolic function. Mild atrial enlargement can be seen. Choice A is suggestive of hypertrophic cardiomyopathy (HCM). In HCM, there is often an asymmetric increase in LV wall thickness, typically >15 mm, and LV cavity size remains normal.
11. c. In the cardiomyopathy related to Duchenne muscular dystrophy, there is usually predilection for involvement of the posterobasal and posterolateral walls. This is thought to be related to the increased stress that cardiac myocytes encounter in the posterior wall. In Becker muscular dystrophy, cardiomyopathy, perfusion defects have been observed in the anterior and septal walls. Four-chamber dilatation, LV dysfunction, and mitral valve prolapse, and MR are usually seen in both disease entities. The degree of cardiac involvement is not necessarily related to the degree of skeletal muscle weakness in both etiologies.
12. b. This patient presents with features consistent with apical HCM. Most commonly, these patients complain of angina or atypical chest pain between the ages of 20 and 59 years. Most patients have a characteristic pattern on their electrocardiography (ECG), showing "giant negative T waves" in the precordial leads. They typically do not present with systolic anterior motion (SAM) of the mitral valve or LV outflow obstruction either at rest or after provocative maneuvers. They usually have a more benign clinical course, especially when compared to the classic patients with HCM, although atrial fibrillation and stroke are not uncommon.
13. d. Noncompaction cardiomyopathy may occur as an isolated cardiomyopathy when no associated congenital abnormalities are present. It is classified as a primary genetic cardiomyopathy according to the AHA proposed classification scheme. Answer 9 shows this in the classification. It results from a failure of the normal embryologic process of compaction of myocardial fibers in the endocardial layer. Various echocardiographic and cardiac magnetic resonance imaging criteria have been proposed. The criteria by Oechslin et al. require that (1) the ratio of noncompacted to compacted layer is ≥2; (2) there are prominent and excessive trabeculations; and (3) deep recesses are present that fill with blood from the LV cavity as seen by color Doppler (or contrast echocardiography). The most commonly involved region of noncompaction is the apex followed by the midventricular lateral, inferior, and anterior walls.
14. b. In restrictive cardiomyopathy, the main abnormality is diastolic dysfunction that is usually advanced. The LV filling pressure is usually elevated. LV systolic function is usually preserved, and LV size is usually normal. Choice B describes a patient with rapid transmitral early filling, decreased mitral annular tissue Doppler velocities, and an E/e' ratio of >15 suggestive of elevated LV filling pressures. The other choices describe normal diastolic function parameters.
15. b. Amyloid cardiomyopathy is the most common infiltrative cardiomyopathy and it has been reported to account for 10% of all nonischemic cardiomyopathies. There is abnormal deposition of fibrils of various precursor proteins, which lead to this restrictive cardiomyopathy. A direct relationship between LV wall thickness and mortality has been established with worsening survival as LV thickness increases above 15 mm. There is also a correlation between increased LV wall thickness and the occurrence of heart failure symptoms. Diastolic parameters such as decreased deceleration time, increased transmitral inflow velocity ratio (E/A ratio), and an elevated Tei index are also strong predictors of survival. Other prognostic echocardiographic variables include LV dysfunction and RV enlargement. LV cavity size usually remains normal and does not give significant prognostic information. The finding of a pericardial effusion is common and is usually not clinically significant. One of the distinguishing features of cardiac amyloid infiltration is the increased echogenicity and "speckled" appearance of the LV wall on 2D echocardiography; however, this finding does not offer specific prognostic information.

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MCQs Video-based on Echocardiography and Transesophageal Echocardiogram

1. A 30-year-old woman presents for evaluation of shortness of breath. As part of that evaluation, a 2D echocardiogram is requested. A highly mobile echodensity was noted in the right atrium (Video 1). Based on this image, the most likely diagnosis is:
   a. The moderator band
   b. A mobile thrombus
   c. The Eustachian valve
   d. A pacing catheter
   e. A Chiari complex

2. A 60-year-old man presents to hospital with 2 weeks of fever and shortness of breath. As part of his diagnostic evaluation, a 2D echocardiogram is obtained. The image in Video 2 is representative of the findings on the complete echocardiogram. Based on this image, the following conclusions can be drawn:
   a. A vegetation involving the mitral valve is present
   b. A large pericardial effusion with evidence of tamponade is present
   c. A left pleural effusion and pericardial effusion are present
   d. A large left pleural effusion is present

3. A 75-year-old woman undergoes echocardiography for the evaluation of chest pain. Video 3 shows a parasternal long-axis view. The image shown demonstrates:
   a. Marked left atrial enlargement
   b. A large thoracic mass
   c. A dissection involving the descending aorta
   d. Both a pericardial and pleural effusion

4. A 73-year-old woman develops profound dyspnea and chest pressure after an emotional encounter with her Parish priest. She has a history of hypertension and depression but is otherwise well. The history is negative for prior symptoms of coronary artery disease and there is no history of any cardiovascular disease beyond the hypertension. The initial electrocardiogram, obtained within 1 hour of the development of symptoms, is interpreted as normal. Initial biomarkers determinations are likewise normal. See Videos 4 A, B, and C. Troponin I at 6 hours, however, is abnormal and continues to rise, whereas the peak creatine phosphokinase (CPK) remains within the normal range, with positive myocardial band (MB) determination.

1. e 2. b 3. b, a

Based on the data you have, the most likely diagnosis is:

a. An acute left anterior descending artery (LAD) territory infarction
b. Apical hypertrophic cardiomyopathy
c. Stress cardiomyopathy
d. None of the above

5. The patient continues to have symptoms and is taken to the catheterization suite, where the ventriculogram in Video 5 is obtained. Coronary arteriography shows nonobstructive disease, and the filling pressures are at the upper limits of normal. The patient remains symptomatic. The evening of admission, approximately 12 hours after presentation and 4 hours after the catheterization is completed, she is noted to be severely hypotensive, with systolic pressure in the 70 to 80 mm Hg range. See Video 5 and Figure 34.1.

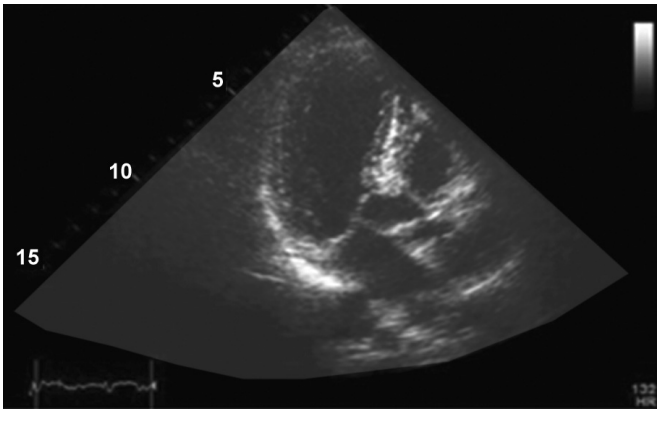


Fig. 34.1

Likely explanations for hypotension in this case include:

a. Myocardial rupture
b. Mitral regurgitation due to papillary muscle dysfunction
c. LV outflow tract obstruction
d. Ventriculoseptal rupture

6. A 46-year-old man is seen by you to evaluate dyspnea on exertion. He complains of being "winded" easily and notes that these symptoms have progressed over the past few months. Nevertheless, he belongs to a local gym and is able to exercise on various "cardio" machines, such as the treadmill and stationary bicycle, for 1 hour. He also lifts weights. He denies recreational drug use, drinks 2–5 beers per week, and takes no supplements. He has a history of hypertension and is being treated with amlodipine and hydrochlorothiazide; treatment with an angiotensin-converting enzyme inhibitor was unsuccessful, and he was unable to tolerate β-blocker therapy. His blood pressure is 150/100 mm Hg. His physical examination shows nonpitting edema of both ankles, the aforementioned hypertension, but is otherwise unremarkable. See Videos 6 A, B, and C. You interpret the echo as showing left ventricular hypertrophy (LVH), no significant valvular heart disease. Biplane method of disks shows an end-diastolic volume of 200 cm^3 and an end-diastolic volume of 120 cm^3.

a. Normal EF
b. Low normal EF
c. Reduced EF

4. c 5. c 6. c

7. Longitudinal strain is performed and is shown in Video 7. Do these data support your conclusion?
   a. Support
   b. Do not support

8. A 63-year-old gentleman with a history of a mitral valve replacement presented with chest discomfort. On physical examination, an audible click is heard with a diastolic murmur. He was evaluated with a cardiac catheterization and was found to have no significant coronary obstruction. On further investigation, he admits that he has not been taking Coumadin regularly over many months but has not noticed change in his physical activity. A TEE was performed revealing the 3D image in diastole from a left atrial perspective; please review Videos 8A and B (Ao = aorta; LAA = left atrial appendage):
   What are the findings seen in Video 4-2A?
   a. This is a normal bileaflet mechanical mitral valve
   b. This is a single tilting disc valve
   c. There is valve vegetation
   d. There is a valvular dehiscence and an immobile mitral valve disc
   e. There is thrombosed mitral valve leaflet

9. What is the mechanism of mitral seen in Video 9?
   a. P1 flail
   b. P2 flail
   c. P3 prolapse
   d. Severe prolapse of P2 and P3 flail
   e. Severe prolapse of P2–P3

10. A 45-year-old Hispanic woman has a history of rheumatic fever as a child and had balloon mitral valvuloplasty as young adult. She now feels fatigued doing housework such as vacuuming her living room and has been unable to walk up a hill to get to the market. She is currently on a beta-blocker with a heart rate of 55 bpm. On transthoracic echocardiogram, she has a mean mitral valve gradient of 5.4 mm Hg, moderate mitral regurgitation, and moderate aortic stenosis. On TEE, 3D imaging of the mitral valve, a 3D mitral valve area planimetry demonstrates an orifice area of 0.6 cm^2, as shown in VIDEO . The mitral valve anatomy is shown from a left atrial and LV perspective (see Video 10). (Ao = aorta; LC = left commissure; MC = medial commissure; LVOT = LV outflow tract.)
    What findings are seen in Video 10?
    a. There is symmetric fusion of the medial and lateral commissures, with more fibrosis/thickening of the subvalvular apparatus, and calcification of the A2 segment
    b. There is asymmetric fusion of the medial commissure with severe subvalvular fibrosis
    c. There is asymmetric fusion of the lateral commissure with severe subvalvular fibrosis
    d. There is asymmetric fusion of the medial commissure with mild subvalvular fibrosis
    e. There is mild mitral stenosis with equal fusion of medial and lateral commissures

11. As part of the cardiology consultation, a bedside 2D echocardiography was performed to assess the LV filling status and overall performance. The initial images were difficult to interpret and the overall LV systolic function was estimated at 10%–15% (see Video 11):
    What should be done following the unenhanced echocardiogram?
    a. TEE to assess LV function
    b. Contrast enhanced MRI to assess LV function
    c. Multigated acquisition scan to assess ejection fraction
    d. Contrast ultrasound injection to visualize the endocardial surfaces and assess the ejection fraction

7. a 8. d 9. d 10. a 11. d

12. A cardiology consultation was initiated; and following an initial history and physical examination, a 2D echocardiogram was ordered to identify regional wall motion abnormalities. The initial study revealed a relatively normal left ventricle without clear evidence for regional wall motion abnormalities (see Video 12).
Following the intravenous injection of an ultrasound contrast injection and based on the identification of the endocardial surfaces of the left ventricle, the following therapeutic approach was taken:
    a. Transfer to the cardiac catheterization laboratory for percutaneous intervention (PCI)
    b. Observe in the ED and monitor
    c. The patient was discharged after monitoring in the ED
    d. Conservative therapy that included oxygen, rest, and monitoring

13. A patient was scheduled for a pharmacologic echo stress examination. Prior to initiating the dobutamine agent, a baseline image of the heart was obtained with and without ultrasound contrast agents. As noted from the examination, the apical region of the left ventricle was dyskinetic, consistent with a prior myocardial infarction (see Video 13).
Based on the baseline, unenhanced images of the left ventricle, what clinical approach should be followed:
    a. Proceed with the study despite the lack of clear endocardial definition of the apex
    b. Stop the test, and proceed with a nuclear imaging test (single photon emission computed tomography [SPECT])
    c. Proceed but consider the test to be technically difficult and will likely require an additional imaging test (contrast-enhanced MRI or CT scan)
    d. Inject an ultrasound contrast agent to allow visualization of the LV endocardial surfaces

14. A 56-year-old male patient presents with atypical chest pain. He is hypertensive and hyperlipidemic on medication. The patient underwent rest and dipyridamole stress echo. Both rest and stress wall motions were normal (see Video 14).
What abnormalities are seen?
    a. Perfusion defect at rest
    b. Transmural perfusion defect at stress
    c. Subendocardial perfusion at stress
    d. LV cavity dilatation at stress

15. A 45-year-old woman with no other coronary risk factors presented with acute onset of chest pain. ECG showed significant ST depression in V1–V4. Troponin level was mildly raised at 12 hours. Real-time myocardial contrast echo was performed at rest and at 24 hours (see Video 15).
What is the likely diagnosis?
    a. Acute anteroseptal myocardial infarction
    b. Noncardiac chest pain
    c. Acute myocarditis
    d. Takotsubo cardiomyopathy

16. A 62-year-old man with coronary risk factors presented with acute anteroseptal MI. The patient underwent primary PCI. Myocardial contrast echocardiography (MCE) was performed 48 hours after PCI. Apical four-chamber view is shown in Video 16.
What are the abnormalities seen?
    a. Normal perfusion
    b. Mild apical-septal perfusion defect
    c. Severe apical-septal perfusion defect
    d. Severe lateral perfusion defect

12. a 13. d 14. c 15. d 16. c

17. The resting wall motion abnormalities in Video 17 suggest infarctions in:
    a. No discrete territory (nonischemic cardiomyopathy)
    b. Left anterior descending
    c. Right coronary
    d. Left circumflex
    e. Multiple vessels

18. The baseline echocardiogram in Videos 18A, B, C demonstrates severe, posteriorly directed MR due to:
    a. Papillary muscle rupture
    b. Anterior prolapse
    c. Severe LV dysfunction
    d. Annular enlargement
    e. Posterior leaflet restriction

19. A 61-year-old woman presents with fatigue and edema. The right heart border is prominent on CXR but PA pressure and pulmonary vascular resistance are normal. The echocardiogram is shown in Videos 19A, and B.
    The RV findings are consistent with:
    a. RV infarction
    b. Pulmonary embolism (McConnell's sign)
    c. Arrhythmogenic RV dysplasia
    d. Pulmonary hypertension and cor pulmonale
    e. Ebstein's anomaly

20. The images in Video 20 demonstrate a follow-up scan.
    What procedure has been undertaken?
    a. Tricuspid valve replacement
    b. Heart transplant
    c. Tricuspid valve repair
    d. Heart-lung transplant
    e. None of the above

21. The LV echocardiographic findings in Videos 21A, B, C, D are consistent with:
    a. Apical HCM
    b. Laminated apical thrombus
    c. LV noncompaction
    d. Hemangioma of the LV
    e. None of the above

22. A 55-year-old man with a history of hypertension presented to the emergency department with left-sided chest discomfort lasting for 15 minutes. He started taking a diuretic and a calcium channel blocker 2 years ago. His BP was 155/90 mm Hg and the ECG revealed left ventricular hypertrophy without repolarization abnormalities. He was admitted and ruled out for myocardial infarction. A stress echocardiogram was ordered. He exercised on the treadmill for 6 minutes reaching a peak heart rate of 150 bpm and workload of 7 METS. The test was ended due to shortness of breath. His ECG at peak heart rate revealed 3 mm downsloping ST depressions in leads II, III, AVF, V5, and V6. He did not experience chest pain during the test. (Video 22A, B, C).
    Which of the following statements about the stress echo on this patient is correct?
    a. The ECG and echocardiographic findings are consistent with ischemia
    b. The stress ECG is more specific for ischemia
    c. The stress ECG changes make the results of this test equivocal
    d. The ECG changes represent a false-positive result
    e. The event rate in this patient approaches 5% per year

17. b 18. e 19. e 20. c 21. c 22. d

23. A 50-year-old man with a history of a previous myocardial infarction, diabetes, and dyslipidemia status post permanent pacemaker, presents to the emergency department complaining of shortness of breath and is found to be in pulmonary edema. He is admitted to the cardiac care unit. A transthoracic echocardiogram reveals moderate mitral regurgitation, dilated and severely hypokinetic left ventricle with an ejection fraction of 10%. A coronary angiogram reveals severe triple-vessel disease. A dobutamine stress echo is requested. (Video 23A, B, C, D, E, F).
Which of the following statements best describes the stress echo?
    a. Right ventricular ischemia
    b. Septal wall ischemia
    c. Marked viability in the inferior wall
    d. Mild ischemia in the apex
    e. Mild viability in the posterior wall

24. On color Doppler images, the patient showed severe functional mitral regurgitation (Video 24A). Two-dimensional speckle tracking echocardiography was used to evaluate mechanical dyssynchrony between the LV segments underlying the papillary muscles (panel B) (Video 24-B).
Which of the following statements regarding the assessment of mitral regurgitation in this patient is correct?
    a. The ischemic etiology can be excluded because the most frequent cause of functional mitral regurgitation in patients with heart failure is isolated mitral annulus dilatation
    b. A significant reduction in mitral regurgitation can be observed by resynchronizing the LV segments underlying the papillary muscles
    c. Two-dimensional speckle tracking echocardiography cannot distinguish between segments with active contraction and segments that are tethered and, therefore, ischemic etiology cannot be excluded
    d. The evaluation of LV dyssynchrony should be performed at the level of the mitral valve (basal short-axis view)

25. A CRT device was implanted in a 67-year-old woman with dilated cardiomyopathy, New York heart Association heart failure functional class III, LV ejection fraction of 30% (see Video 25), and QRS duration on surface electrocardiogram of 120 milliseconds. The key issues to evaluate cardiac dyssynchrony.
Which of the following sentences about cardiac dyssynchrony is correct?
    a. There is no AV, interventricular, or LV dyssynchrony
    b. There is only AV dyssynchrony with a diastolic LVFT of <40%
    c. There is substantial LV dyssynchrony as assessed with real-time 3D echocardiography with the inferoposterior segments as the most delayed activated segments
    d. Pulsed-wave TDI does not indicate the presence of LV dyssynchrony because the ultrasound beam was not properly aligned

26. What is the most likely cause of his murmur? (See Video 26).
    a. Mitral regurgitation secondary to myxomatous disease
    b. Mitral regurgitation secondary to papillary muscle rupture
    c. Mitral regurgitation secondary to papillary muscle migration due to LV dilatation and wall motion abnormalities
    d. Mitral regurgitation secondary to endocarditis

23 e 24. d 25. c 26. c

27. A 70-year-old man presents to a rural hospital with inferior ST elevation. He is treated with thrombolytics. Three days later, he is transferred to a university hospital ICU because of pulmonary edema and hypotension. A bedside two-dimensional echocardiogram is ordered by the medicine team (See Videos 27A and B). The consulting cardiologist hears a harsh, systolic murmur.
The most likely cause of his symptoms is:
    a. Extensive inferoposterior infarction with a ventricular septal rupture
    b. Papillary muscle rupture with severe mitral regurgitation
    c. A new anterior infarction
    d. Free wall rupture with pericardial tamponade

28. A 61-year-old man presents to the clinic for evaluation of severe ischemic cardiomyopathy and triple vessel disease. His ejection fraction is 18%. He reports dyspnea on moderate exertion with occasional chest pain relieved by nitroglycerin. Prior to considering potential revascularization, the consulting cardiothoracic surgeon asks for a dobutamine viability study (See Videos 28A and B).
This shows:
    a. No improvement in wall motion
    b. Improvement at low dose with sustained, additional improvement at peak dose
    c. Mostly biphasic response—improvement at low dose, worse at peak dose
    d. Not interpretable

29. A 30-year-old woman presents with right-sided heart failure but without clubbing or cyanosis. She has had a murmur since childhood but has only recently complained of fatigue and ankle edema. On admission, she developed a wide complex tachycardia at a fast rate and required immediate cardioversion. An apical four-chamber view of her heart is shown in Video 29.
What is the most likely cause of her heart failure symptoms?
    a. Tachycardia-mediated cardiomyopathy
    b. Severe TR
    c. Severe pulmonary hypertension
    d. Recent endocarditis
    e. Right-to-left shunt at the atrial level

30. A 65-year-old man is readmitted 8 weeks following tricuspid and mitral valve repair for myxomatous disease of both valves. He has been feeling unwell and is anemic but has had no significant febrile illness. He has a white blood cell count of 12,000, with a leftward shift. A transesophageal echocardiogram is performed, an image of which is shown in Video 30. He has no significant mitral regurgitation or TR.
The most likely cause of this scenario is:
    a. Staphylococcal infection
    b. Thrombus formation at the valve ring
    c. Ring dehiscence
    d. Embolus in transit
    e. Fungal infection

31. A color Doppler image of the RV outflow tract in an asymptomatic young man found to have a murmur on routine physical examination is shown in Video 31. He has a right parasternal heave, an ejection click, and a loud ejection systolic murmur with a soft P2 heard on auscultation.
Based on these findings, select the correct statement from the following.
    a. He has a patent ductus arteriosus with Eisenmenger physiology
    b. He has an ASD with Eisenmenger physiology
    c. He has pulmonic stenosis, possibly severe, with mild pulmonic insufficiency
    d. He has a high outflow state with a flow murmur
    e. He has infundibular pulmonic stenosis

27. a 28. b 29. b 30. a 31. c

32. A 50-year-old man presents with heart failure. His physical examination is remarkable for jugular venous distention and abdominal distention. A soft systolic murmur is heard over the precordium but is soft and hard to elicit. Apical images of his heart are shown in Video 32.
The most likely cause of his presentation is:
    a. Flail anterior leaflet of the tricuspid valve with severe TR
    b. Cor triatriatum dexter
    c. Ebstein's anomaly
    d. Perforation of the tricuspid valve with severe regurgitation and a vegetation
    e. Carcinoid syndrome

33. A 65-year-old man presents for evaluation of chest pain. An echocardiogram is obtained (Video 33).
The echocardiographic images shown are suggestive of:
    a. Mitral regurgitation due to posterior leaflet prolapse
    b. Mitral regurgitation due to ischemic tethering
    c. Mitral regurgitation due to annular enlargement
    d. Mitral regurgitation due to rheumatic valve disease
    e. Mitral regurgitation due to ruptured posterior chord

34. A 52-year-old man is referred for evaluation of a systolic murmur. He has no history of coronary or valvular disease. He is a nonsmoker and exercises regularly. Over the last few months, he noticed dizziness when lifting heavy weights but is otherwise completely asymptomatic. His only brother died at a young age of an unknown cause. An outside echocardiogram is available for review in Video 34.
The images shown are suggestive of:
    a. Mitral regurgitation due to posterior leaflet prolapse
    b. Mitral regurgitation due to ischemic tethering
    c. Mitral regurgitation due to annular enlargement
    d. Mitral regurgitation due to rheumatic valve disease
    e. Mitral regurgitation due to LVOT obstruction

35. A 60-year-old gentleman is referred for a cardiac consultation. He has had a known murmur for a long time; but during the most recent evaluation, his primary care physician noted that the murmur is more intense. The patient exercises regularly, alternating 20-mile bicycle rides with 3-mile walks. He has noted no change in his exercise ability. Physical examination shows presence of mild pectus excavatum, a 3/6 holosystolic murmur at the apex, but no systolic clicks and no peripheral edema. Lung examination is unremarkable. An echocardiogram is obtained (Video 35).
Which of the following statements is correct?
    a. There is evidence of bileaflet mitral valve prolapse
    b. Afterload reduction is recommended even when normotensive
    c. Screening of other family members is suggested
    d. The calculated EF is 57%; reassure the patient
    e. There are no restrictions on physical activity in this type of disease

36. A 72-year-old gentleman is being evaluated for a murmur detected by the primary care physician. He denies any shortness of breath or chest discomfort. On clinical examination, he has a harsh systolic murmur over the aorta and a musical murmur best heard at the apex. Peripheral pulsations are of low volume. Echocardiographic study is shown in (Video 36).

32. a 33. b 34. e 35. c

Which of the following statements is correct?

a. Patient has a clear indication for surgical intervention; recommend preoperative coronary angiography
b. If surgery is performed, patient will need aortic and mitral valve replacement
c. If the aortic valve peak velocity is >4 m/sec, an exercise test is formally contraindicated
d. If the LVOT TVI is 15 cm and the aortic valve TVI is 75 cm, left heart catheterization is recommended to confirm the status of the aortic valve
e. If the aortic peak velocity is >4 m/sec, the chance of remaining asymptomatic at 5 years is <30%

37. The echocardiographic study in Video 37 was performed at routine follow-up 6 months after septal myectomy.
The images show:

a. A double-inlet ventricle
b. A ventricular septal defect as a complication after surgery
c. Cleft mitral valve
d. Repaired mitral valve
e. None of the above

38. A 65-year-old man presents with fever and transient loss of right eye vision. He has had a previous valve replacement. Four weeks ago, he had a dental extraction and received prophylactic antibiotic therapy. An echocardiogram is performed and shows vegetations on the aortic valve (Video 38).
What is the type of prosthesis that the patient has?

a. Aortic homograft
b. Aortic bioprosthesis
c. Aortic stentless prosthesis
d. Aortic mechanical prosthesis

39. A patient presented with mitral valve endocarditis. He had been treated with antibiotics for 4 weeks. (Video 39) shows parasternal long- and short-axis views of the mitral valve.
What is the site of the attachment of the vegetation on the mitral valve?

a. A1
b. A2
c. A3
d. P3

40. A patient with a previous mitral valve replacement is admitted for jaundice and shortness of breath. A zoomed apical four-chamber view is shown in Video 40.
What is abnormal about the mitral prosthesis?

a. Large left atrial mass
b. Dehiscence of the prosthesis
c. Fistula between LA and aorta
d. There is no abnormality

41. A 55-year-old man with diabetes mellitus and hypertension is undergoing an evaluation for exertional dyspnea. An exercise echocardiogram is ordered. The baseline transthoracic echocardiogram is reported to reveal an intracardiac mass. The exercise portion of the exam is not completed and the patient is referred for a transesophogeal echocardiogram. Video 41 shows a zoomed-in view of the left atrium at zero degree. Video demonstrates the mass using real-time three-dimensional imaging.
Which of the following statements about Video 41 is correct?

a. The size of the mass makes it most likely to be a metastatic tumor to the heart rather than a primary cardiac tumor
b. The left atrial location of this tumor and its attachment to the midportion of the atrial septum make it most likely a myxoma
c. This tumor may be found as part of a multisystem disease called tuberous sclerosis complex
d. This tumor type accounts for approximately 10% of all primary cardiac tumors
e. This tumor is characterized by infiltration of the atrial septum by lipomatous material

36. e 37. d 38. b 39. c 40. b 41. b

42. A 71-year-old woman presented with fatigue and dyspnea in the setting of diarrhea and flushing for 5 months. Video 42A shows the tricuspid valve in the right ventricular inflow view. Video 42B is the same view with the addition of color flow imaging.
Which of the following statements about carcinoid heart disease is correct?
    a. Carcinoid affecting the tricuspid valve frequently results in tricuspid stenosis as the dominant lesion
    b. Involvement of the left-sided valves usually occurs without a patent foramen ovale or high tumor activity
    c. The valve pathology of carcinoid involves fibrosis, smooth muscle proliferation, and endocardial thickening which give the echocardiographic appearance of a thickened, retracted, and immobile valve
    d. Treatment of carcinoid heart disease usually achieves cure with modern antitumor therapy and surgical intervention
    e. Carcinoid heart disease typically causes severe symptoms shortly after the onset of the disease

43. Videos 43A and 43B show two views from a prepump intraoperative TEE in the midesophageal four-chamber view. What is the severity of the TR at the time of this study?
    a. No TR
    b. Mild TR
    c. Moderate TR
    d. Moderately severe TR
    e. Severe TR

44. Videos 44A and 44B show a problem with the atrial septum. What is this?
    a. Lipomatous hypertrophy of the atrial septum
    b. A fistula from the left ventricle to the right atrium—Gerbode ventricular septal defect (VSD)
    c. Abscess of the atrial septum near the aortic prosthesis
    d. A simple cystadenoma, a primary cardiac neoplasm
    e. Congenital coronary arterio-venous (A-V) fistula

45. Three-dimensional echocardiographic structural imaging in Video 45 shows that the echolucent space is posterior to the aortic prosthesis. Where and what is this space?
    a. Periprosthetic pseudoaneurysm within the posterior mitral annulus
    b. Periprosthetic abscess within the intervalvular fibrosa
    c. Periprosthetic abscess within the posterior mitral annulus
    d. Periprosthetic abscess within the coronary sinus
    e. An aneurysm of the coronary artery

46. Three-dimensional echocardiography with color imaging in video 46A shows that there is a perivalvular fistula from the aorta to the LV out-flow tract.
Video 46B shows two-dimensional images of the structure and Video 46C shows two-dimensional images of flow, which includes severe periprosthetic regurgitations along the posterior side of the aortic annulus. Notice how the abscess expands as ventricular contraction causes flow to pass into it (and out into the aorta), and it partially collapses during the diastolic interval of regurgitation through the same channel. What is the intervalvular fibrosa?
    a. The mitral annulus and the aortic annulus
    b. The mitral annulus but not the aortic annulus
    c. The aortic annulus but not the mitral annulus
    d. The tricuspid annulus but not the aortic annulus
    e. Neither the mitral annulus nor the aortic annulus

42. c 43. b 44. c 45. b 46. a

47. The patient underwent AVR with a homograft (a cryopreserved human cadaver valve), tricuspid valve repair with an annuloplasty, and mitral valve repair (Video 47A and video 47B). The anterior mitral annulus, consisting of the donor homograft tissue, was reinforced by suturing to it a new mitral annuloplasty band. Besides providing tissue for the intervalvular fibrosa for the mitral valve attachments, what other advantages, compared to a stented bioprosthesis, does the AVR homograft have in this case?
    a. Reduction in postoperative infection
    b. Higher gradient
    c. Less regurgitation
    d. Easier implantation
    e. More available

48. Video 48A and 48B show her intraoperative transesophageal echocardiographic images in a transverse midesophageal view at 0 degree multiplane angle, before CPB (prepump). Video 48C shows her prepump intraoperative midesophageal imaging TEE images at a multiplane angle of 122 degrees.
    Video 48D shows her prepump midesophageal intraoperative images at a multiplane angle of 63 degrees. What is the primary mechanism of mitral regurgitation?
    a. Prolapse of the medial scallop of the mitral posterior leaflet
    b. Flail of the middle scallop of the posterior leaflet
    c. Restricted leaflet motion of the anterior leaflet
    d. Flail of the A2 portion of the anterior leaflet
    e. Bileaflet prolapse

49. Video 49 shows a color Doppler image of the mitral regurgitation recorded in a transverse midesophageal imaging plane, from which the maximum aliasing radius was measured at 1.1 cm. The wall constraint was measured to be 90 degrees, meaning that exactly half of the hemispheric velocity isopleth converging into the regurgitant orifice was constrained by the adjacent ventricular wall. The maximum mitral regurgitation (MR) systolic velocity recorded by continuous-wave Doppler (not shown) was 5.5 m/sec.
    What is the regurgitant orifice area (ROA)?
    a. 0.38 cm^2
    b. 0.76 cm^2
    c. 0.31 cm^2
    d. 415 cm^2
    e. 75.5 cm^2

50. In addition to the mechanism of mitral regurgitation shown in this patient, the same jet direction might be caused by what type of MR (Video 50)?
    a. Posterior leaflet restriction
    b. Ischemic (functional MR)
    c. Anterior leaflet prolapse
    d. Anterior leaflet flail
    e. Posterior leaflet perforation

51. Video 51 shows a transgastric short-axis view of the left ventricle. What is the approximate EF?
    a. 80%
    b. 60%
    c. 40%
    d. 30%
    e. 20%

52. Videos 52A, 52B and 52C show the aortic valve. What would you conclude from these data?
    a. The aortic valve is normal
    b. There is severe aortic stenosis and mild aortic regurgitation
    c. There is mild aortic stenosis with mild to moderate aortic regurgitation
    d. There is severe aortic stenosis and no aortic regurgitation
    e. There is mild aortic stenosis and severe aortic regurgitation

47. a 48. b 49. a 50. e 51. b 52. c

53. Video 53 shows the proximal aortic arch. What is the abnormality shown?
    a. A large aortic atheroma
    b. A large dissection flap
    c. An intramural hematoma
    d. A small dissection flap
    e. A small aortic atheroma

54. Video 54 show the ascending aorta on the prepump intraoperative TEE. As indicated, the diameter of the tubular ascending aorta is 4.0 cm. What is the echo-free space posterior to the ascending aorta highlighted by the arrow?
    a. A double lumen consistent with a small localized aortic dissection
    b. A pericardial cyst
    c. A reflection of pericardium with small amount of normal fluid
    d. Part of the right upper pulmonary vein
    e. The transverse portion of the hemiazygous vein

55. A 37-year-old man has dyspnea and exertional presyncope. His TTE shows congenital aortic stenosis with a mean maximum gradient 52 mm Hg, mean gradient 28 mm Hg, and calculated valve area 0.77 cm^2. Angiography showed normal coronaries, although the aortic valve gradient was not re-evaluated at catheterization. As he undergoes TEE in the operating room, after the chest incision but before cannulation for CPB, the aortic valve gradient and short-axis planimetry suggest that the stenosis is not as bad as had been depicted on the preoperative studies. Video 55A shows a midesophageal long-axis view at 128 degrees, of the aortic valve, showing the doming in systole. Video 55B shows a similar view at 158 degrees with color Doppler, showing no significant aortic regurgitation. Video 55B shows a continuous-wave Doppler recording through the aortic valve showing a mean gradient of only 14 mm Hg and a maximum gradient of 35 mm Hg. Video shows a short-axis view at 74 degrees with planimetry of the valve, calculating a valve area of 3.6 cm^2. Video 55C shows a short-axis view of the aortic valve at 49 degrees with the valve in motion. Video 55C shows a short-axis view at 74 degrees with planimetry of the valve, calculating a valve area of 2.95 cm^2.
    How severe is the aortic stenosis?
    a. Mild
    b. Moderate
    c. Moderately severe
    d. Severe

56. This patient is a 50-year-old female being evaluated for right ventricular dilatation (see Videos 56A and 56B).
    The finding shown in video 56 is frequently associated with:
    a. Cleft anterior mitral valve
    b. A normal variant
    c. Anomalous pulmonary drainage
    d. Continuous murmur

57. This is a 65-year-old patient with atrial fibrillation. A TEE is performed prior to cardioversion.
    The structure incidentally found and marked with the arrow represents in Video 57:
    a. Descending aorta
    b. Aneurysm of the circumflex artery
    c. Left lower pulmonary vein
    d. Dilated coronary sinus

58. The apical views in Videos 58A and 58B were obtained from a 36-year-old man with complaints of recurrent focal weakness of the right upper extremity, and reduced arterial O_2 saturation with exertion.
    Which of the following is true?
    a. RV size is enlarged
    b. LV EF appears reduced
    c. A short-axis view would show a D-shaped septum in systole
    d. RA "v" wave pressure is increased

53. e 54. c 55. c 56. b 57. b 58. d

59. The transesophageal view in Video 59 is obtained from a 51-year-old woman in NYHA class IV. Which of the following is true?
    a. The right atrium appears enlarged
    b. There is predominant left-to-right shunting
    c. LA pressure is higher than RA pressure
    d. The lesion is not amenable to percutaneous closure

60. The parasternal views (see Videos 60A and 60B) were obtained from a patient with a systolic murmur since birth.
    Which is true?
    a. PA systolic pressure is normal
    b. RV free wall thickness is likely 4 mm
    c. LV EF is 50%–54%
    d. Color Doppler shows severe PR

61. A 4-week-old male infant was referred to a pediatric cardiology clinic for an ejection systolic murmur found during a routine clinic visit at the primary pediatrician's office. His echocardiography is shown in Video 61A (apical) and Video 61B (parasternal short-axis).
    Based on his clinical presentation and echocardiography, the most likely diagnosis is:
    a. Truncus arteriosus
    b. TOF
    c. D-Transposition of great arteries with a VSD
    d. VSD
    e. Pulmonary stenosis

62. At 3 months of age, his parents noticed frequent episodes of bluish discoloration when the child was crying. According to the parents, there is no history suggestive of any lethargy, tiredness, or respiratory distress. He was brought to the pediatrician's office where his saturation is now 75% as compared to 86% at 4 weeks of life. Other than that, he was playful and active in the doctor's office. Echocardiography is shown in Video 62. Which of the following will be the most likely finding in his echocardiography?
    a. Decreased blood flow across the pulmonary valve
    b. Dynamic right ventricular outflow tract obstruction suggestive of tetralogy spells
    c. Decreased right-to-left shunting across the VSD
    d. Decreased left ventricular function
    e. Increased blood flow across the pulmonary valve

63. A 2-day-old baby boy was transferred to a tertiary care center and was found to have a decreased oxygen saturation before discharge. His oxygen saturation was 80% and did not improve with 100% O_2. Echocardiography is as shown in Video 63A (parasternal view) and Video 63B (apical view).
    What is the diagnosis?
    a. Double outlet right ventricle
    b. Anomalous origin of coronary arteries
    c. Congenitally corrected transposition
    d. D-Transposition of great arteries
    e. Truncus arteriosus

64. A 12-year-old boy was sent to the cardiology clinic for shortness of breath with exertion. In the clinic, his saturation was 79%. Echocardiography was done and is shown in Videos 64A and 64B.
    What is the cause of desaturation?
    a. Pulmonary arteriovenous malformation
    b. Right-to-left shunting at the atrial septal level
    c. Pulmonary hypertension
    d. Right ventricular dysfunction

59. a 60. a 61. b 62. a 63. d 64. b

65. Echocardiography was performed on a 48-hour-old newborn because of persistent cyanosis. Videos 65A (apical view), 65B, and 65C (parasternal short axis) are shown.
Based on these findings, which one of the following best describes this patient's problem?
    a. About 75% of the cases are associated with D-transposition of great arteries
    b. Coarctation of aorta is usually not present in this condition
    c. An obligatory left-to-right shunt is seen at the ASD level
    d. The size of the VSD is extremely important in this lesion
    e. Coronary artery anomalies are frequently seen

66. What is a true statement about the type of TAPVR shown in the suprasternal view in Video 66A, 66B and 66C?
    a. Obstruction is never present in this type of TAPVR
    b. It is almost always associated with pulmonary venous obstruction
    c. It is associated with an intact atrial septum
    d. This is the most common form of TAPVR
    e. This form of TAPVR produces profound cyanosis of the newborn

67. A 66-year-old man presented with a transient ischemic attack. A transthoracic echocardiogram was performed. Video 67A shows the parasternal long-axis view. Video 67B shows the long-axis view at 129 degrees on the transesophageal echocardiogram. A diagnosis of papillary fibroelastoma is made.
Which of the following statements about papillary fibroelastomas is correct?
    a. Papillary fibroelastomas are usually easily distinguishable from vegetations
    b. Papillary fibroelastomas are typically associated with significant valvular regurgitation
    c. Papillary fibroelastomas usually attach to the upstream side of the valve
    d. Papillary fibroelastomas account for the majority of valve-associated tumors
    e. The major risk associated with papillary fibroelastomas is cardiac tamponade

68. A 71-year-old woman presented with fatigue and dyspnea in the setting of diarrhea and flushing for 5 months. Video 68A shows the tricuspid valve in the right ventricular inflow view. Video 68B is the same view with the addition of color flow imaging.
Which of the following statements about carcinoid heart disease is correct?
    a. Carcinoid affecting the tricuspid valve frequently results in tricuspid stenosis as the dominant lesion
    b. Involvement of the left-sided valves usually occurs without a patent foramen ovale or high tumor activity
    c. The valve pathology of carcinoid involves fibrosis, smooth muscle proliferation, and endocardial thickening which give the echocardiographic appearance of a thickened, retracted, and immobile valve
    d. Treatment of carcinoid heart disease usually achieves cure with modern antitumor therapy and surgical intervention
    e. Carcinoid heart disease typically causes severe symptoms shortly after the onset of the disease

69. A patient with a previous aortic valve replacement is admitted for increased dyspnea. A TEE is performed and the long-axis view of the LVOT is shown in diastole and systole Video 19-7).
The primary abnormality seen in this image is?
    a. Dehiscence of the aortic prosthesis
    b. Severe mitral regurgitation
    c. Flail prosthetic leaflet
    d. Severe aortic stenosis

65. d 66. d 67. d 68. c 69. a

70. A 78-year-old woman is admitted for endocarditis. A TEE is performed and confirms a vegetation, measuring 2.5 cm × 0.5 cm (see Video 70).
What is the site of attachment of the vegetation?
    a. Left atrial aspect of the posterior mitral valve leaflet
    b. Left atrial aspect of the AMVL
    c. Left atrial aspect of A1 of mitral valve
    d. Left atrial aspect of P1 of mitral valve
    e. Left atrial aspect of A2 of mitral valve

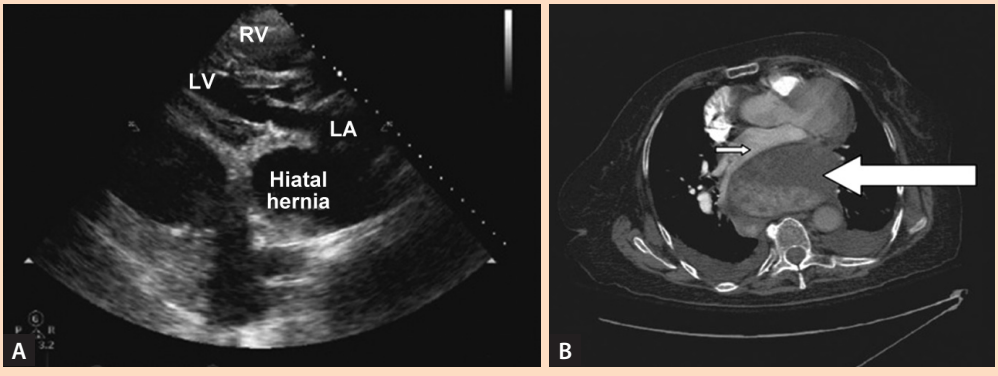
70. a

Answers

1. e. This ultrasound exhibits normal biventricular size and function. The structure in question is a filamentous thin mobile structure in the right atrium extending from the area of the Eustachian valve toward the interatrial septum. This finding is most consistent with the presence of a Chiari complex, a remnant of the right venous valve. The appearance here is quite typical in that this filamentous structure has an undulating appearance when viewed in real time. The moderator band is a structure noted within the right ventricle. The Eustachian valve would appear as a more solid, protuberant, and nonmobile structure arising along the posterior margin of the IVC and coronary sinus. A pacing catheter would also present as a linear structure traversing the cavity of the right atrium. However, it would not be expected to appear as mobile nor be filamentous in nature as the structure demonstrated in this example. An intracavitary thrombus may appear as a mobile structure within the right atrium. Most often, however, right atrial thrombus has a multilobulated appearance and exhibits a worm-like shape often reflecting its origin from the deep veins. Some authors have described such a thrombus as having "popcorn" appearance. The thin, filamentous, and mobile nature of this structure and its typical anatomical location make a thrombus very unlikely in this situation.
2. b. This patient with fever and shortness of breath has both a large left pleural effusion and a small-to-moderate sized pericardial effusion. No evidence of right ventricular diastolic collapse or left atrial collapse is noted to suggest the diagnosis of a pericardial effusion under significant pressure. The limited images of the mitral valve do not show a mobile or oscillating echodensity that would be diagnostic of vegetation involving the mitral valve. While a large left pleural effusion is present, the most precise answer also should describe the presence of the pericardial effusion. In Panel A, the pericardial effusion (Pericard Eff) and pleural effusion (PL Eff) are illustrated. As shown in this still frame, the descending thoracic aorta serves as a useful marker to help differentiate left pleural effusions from pericardial effusions. Typically pleural effusions lie posterior to the descending thoracic aorta while pericardial effusions lie in a more anterior location. In this example the pericardial reflection is well visualized and helps to clearly differentiate the pleural from pericardial spaces. In panel B, pericardial effusion (Pericard Eff) adjacent to the lateral borders of the right atrium (RA) and left ventricle (LV) is visualized. No evidence for right heart compression is evident. RV, right ventricle.
3. b. & a. In, the echocardiogram shows that the patient has a large hiatal hernia.

   The accompanying CT scan in demonstrates a hiatal hernia (large white arrow) that is clearly encroaching on the left atrium (smaller white arrow). Hiatal hernias are commonly encountered in clinical echocardiography and are seen as cystic masses. These masses may be mistaken for an atrial space-occupying structure. With transthoracic echocardiography, the administration of a carbonated beverage can produce a contrast effect within the hiatus hernia and can be used as a diagnostic maneuver to demonstrate its true nature as a pseudomass (Fig. 34.2A).

   Although perflutren contrast would certainly demonstrate whether this structure is cardiac or vascular, Fig. 34.2B it would not be as likely to unambiguously make the diagnosis. Agitated saline injected through the left antecubital vein is useful for many indications, including helping to diagnosis an anomalous left superior vena cava draining into the coronary sinus. In general, the structure shown is too large to be a dilated coronary sinus. Finally, a Valsalva maneuver might be helpful in the diagnosis of a hiatal hernia, in that it might provoke a "disparate degree of encroachment on the left atrium attributable to respiratory motion." However, ingestion of a carbonated beverage would likely make the diagnosis clearer.



Figs 34.2A and B

4. c. This patient's syndrome is consistent with the syndrome of stress cardiomyopathy, apical variety. Thanks to the widespread availability of echocardiography, this is a syndrome that is now widely recognized. The initial reports of this syndrome came from Japanese investigators, who have given it the name "Takotsubo" because the shape of the ventricle in systole is reminiscent of an octopus trap, with a narrow neck and wide bottom. Biomarker release is different than acute myocardial infarction (MI), with peak CPK determinations much lower, and it can even be normal. Resolution of the wall motion abnormality can be seen as early as 48 hours following symptom onset.

   At present, stress cardiomyopathy is a clinical diagnosis, even one of exclusion, in patients presenting with a chest pain syndrome. Criteria have been published by Tsuchihashi et al. These include chest symptoms or electrocardiographic changes suggestive of acute myocardial infarction, reversible apical dysfunction demonstrated by ventriculography, and absence of significant coronary artery narrowing on coronary arteriography performed within 48 hours of symptom onset.

   More recently, investigators in western countries, including the United States, have described an identical clinical syndrome. The typical patient is a woman in the seventh decade who experiences chest symptoms triggered by, or in association with, severe emotional distress or a medical procedure. At initial presentation, transient apical ballooning is difficult, if not impossible to distinguish from acute LAD territory MI. The extent of wall motion abnormality on echocardiography, in our experience, tends to exceed that seen in LAD territory infarction, in that the akinetic areas tend to involve more than one coronary perfusion territory; this has been confirmed by more recent series. However, the diagnosis is made by the return of function.

   The ubiquity of emotional stress or preceding medical illness (often a respiratory crisis) is suggestive of catecholamine toxicity. The distribution of wall motion abnormalities far exceeds the usual territory of the LAD coronary artery because it involves so much of the inferior wall. Nevertheless, a cardiac catheterization should still be strongly considered to exclude CAD.

   There is really no significant evidence for apical hypertrophic cardiomyopathy. In apical hypertrophic cardiomyopathy, there is significant hypertrophy confined to the apex of the LV.

5. c. This patient has developed LV outflow tract (LVOT) obstruction with significant mitral regurgitation as shown in Video 3-6. Highlights systolic anterior motion of the mitral valve in this systolic frame. Demonstrates turbulent LVOT flow as well as MR. It is likely that the hyperdynamic function at the base of the heart, along with unfavorable geometry in this

region, has led to conditions which promote obstruction. The mechanism is similar to what is observed in hypertrophic cardiomyopathy or even in individuals with large LAD territory MI.

6. c. The calculated EF would be 40%, (200–120)/200 × 100%. This would place this EF in the reduced or abnormal range.

7.a. The strain values are low, which implies systolic dysfunction in the longitudinal plane.

8. d. From this left atrial view of the mitral valve in diastole, only one leaflet appears to open. The opened leaflet (arrow) reveals a darker background since the ventricle is segmented during a zoom acquisition, whereas the thrombosed leaflet is the same appearance as the surrounding structure. This can be better appreciated in Video 4-2A. Two-dimensional TEE images in Video 4-2B (a four-chamber and long axis view) are shown. In the midesophageal four-chamber view, there is an immobile mitral valve leaflet also confirmed in a long-axis view. With color flow Doppler imaging, there is a laterally directed eccentric jet and color flow through the mitral valve leaflet that is not thrombosed. Three-dimensional color Doppler imaging reconfirms this finding demonstrating flow through the mobile leaflet and also the area of dehiscence (indicated by the double white arrows). Hence, there is a thrombosed leaflet and a paravalvular leak due to dehiscence. (Ao = aorta; LAA = left atrial appendage)

9. d. In this systolic phase, the mitral valve is seen from a left atrial orientation. Most of the P2 leaflet appears myxomatous prolapsing into the left atrium. The P3 scallop tip is flail since the tip of the leaflet is directed superiorly to the left atrium.

10. a. Shows a multiplanar reconstruction from a zoomed acquisition of the mitral valve. There are two orthogonal views on the top panels and in the bottom left panel, there is a short-axis plane that is placed at the tips of the mitral leaflets. This ability to place this plane at the tips of the mitral leaflets allows better accuracy and reproducibility of the mitral valve orifice area. From a left atrial perspective, the posterior leaflet appears smooth and short. There is a calcific nodule on the A2 scallop. The lateral and medial commissures are sometimes seen from this left atrial view. Typically the LV orientation demonstrates the nature of the commissures best. Here the medial commissure appears thickened with significant fusion compared with the lateral commissure which has less thickening.

11. d. The use of ultrasound contrast was clinically indicated for the detection of the LV endocardial surfaces to assist in the assessment of the ejection fraction.

12. a. Following the clinical use of ultrasound contrast, the anterior apical region of the left ventricle was noted to be akinetic; suggestive of an acute coronary occlusion and myocardial infarction. Subsequently, the patient was taken to the cardiac catheterization laboratory for an urgent percutaneous coronary intervention.

13. d. Injection of an ultrasound contrast agent was indicated because of the lack of clear endocardial definition.

14. c. This is a typical subendocardial perfusion defect. Wall motion abnormalities are less common after a vasodilator stress as oxygen demand is only mildly increased. However, capillary derecruitment occurs early in the ischemic cascade.

15. d. The left ventricle demonstrated akinetic apex and septum with normal perfusion. Absence of a perfusion defect suggests minimal necrosis. The combination of presentation characteristics, that is, female, with no significant risk factors and large wall motion abnormality with mild rise in cardiac enzyme and normal perfusion suggests Takotsubo cardiomyopathy.

16. c. Very patchy perfusion is noted in the septum and apex. For the assessment of perfusion after AMI, intravenous contrast is administered. After attainment of a steady state in the myocardium, destruction and replenishment contrast imaging is performed. Imaging is continued for 15 seconds after destruction phase to assess collateral circulation. Marked perfusion defect at 15 seconds indicates very poor collateral and antegrade flow, which suggests myocardial necrosis.

17. b. The shape of the LV apex is altered and thickening is reduced (see also the strain map). Function in the other territories appears preserved.
18. e. The findings are consistent with ischemic MR due to posterior leaflet restriction caused by inferoposterior infarction. The resulting anterior leaflet "over-ride" leads to posteriorly directed MR. Ischemic MR is a disease caused by changes of LV structure and function, and contrasts with acute MR, which is an infarct complication related to rupture or stretching of the papillary muscle. Ischemic MR is identified in 50% of post-MI patients, of whom 12% are moderate or severe. Moderate or severe ischemic MR is associated with a threefold increase in HF risk and a 1.6-fold increased risk of death at 5 years.
    There are two major mechanisms—displacement of the posterior papillary muscle (causing anterior leaflet "override" and posteriorly directed MR) and LV enlargement, tethering both leaflets and a more central jet.
19. e. Ebstein's anomaly involves "atrialization" of part of the RV, due to apical displacement of the tricuspid valve. This tricuspid abnormality distinguishes this entity from the alternative diagnoses.
20. c. Tricuspid valve surgery involves freeing the septal leaflet, which is adherent to the septum, and often an annuloplasty.
21. c. LV noncompaction is a developmental abnormality that shows a wide phenotypic spectrum—patients with the most extensive disturbances may develop HF, systemic thromboembolism, and arrhythmias. Although apical soft tissue thickening is seen with all of the above, the characteristic color flow mapping profile showing flow into sinusoids is typical of noncompaction.
22. d.
23. e.
24. d. Cardiac dyssynchrony evaluation includes the assessment of the following:
    LVFT: On pulsed-wave Doppler recordings of the transmitral flow.
    Interventricular dyssynchrony: By calculating the time delay between the onset of RV and LV ejections on the pulsed-wave Doppler recordings of the LV outflow tract and the pulmonic flow.
    LV dyssynchrony: Preferably by TDI techniques, as currently recommended by the American Society of Echocardiography.
    In the present case, there is substantial cardiac dyssynchrony at all three levels, indicated by a reduced LVFT (<40%), delayed LV ejection onset as compared to RV ejection onset (>40 milliseconds), and significant time delay between the septal and the lateral wall (>65 milliseconds).
25. c. Cardiac dyssynchrony may exist in patients with heart failure with narrow QRS. LV filling may be shortened by a long AV delay and LV mechanical dyssynchrony may be present, as previously demonstrated. The example illustrates the presence of AV dyssynchrony and substantial LV dyssynchrony as assessed with real-time 3D echocardiography. The left panel illustrates the pulsed-wave Doppler recordings of the transmitral flow and indicates the presence of AV dyssynchrony with a reduced LVFT (<40% of the R-R interval). The middle panel shows the pulsed-wave TDI tracings of the basal segments of the right ventricular free wall and the septal and lateral segments of the left ventricle. Time from the onset of the QRS to peak systolic velocity is calculated in each region. Interventricular dyssynchrony is measured as the peak systolic velocity time delay between the basal segment of right ventricular free wall and the most delayed basal LV segment. LV dyssynchrony is calculated as the time difference between peak systolic velocity of the septum and the lateral wall. In this example, a borderline interventricular dyssynchrony was observed (40 milliseconds), whereas no LV dyssynchrony with pulsed-wave TDI could be noted (septal-to-lateral wall delay of 10 milliseconds).

However, one of the limitations of pulsed-wave TDI is that the interrogation of opposing LV walls cannot be performed simultaneously. In contrast, real-time 3D echocardiography allows for the assessment of LV dyssynchrony in the entire left ventricle and in the same cardiac cycle. Time to minimum systolic volume is automatically calculated for 16 LV segments and the SDI is derived. In addition, time to minimum systolic volume is displayed in a polar map. The latest activated segments can be identified from this polar map. In this case, borderline LV dyssynchrony could be reported with an SDI of 6.4%. The latest activated segments were the mid and apical inferoposterior segments (coded in red).

26. c. Mitral regurgitation (MR) due to papillary muscle migration or displacement is referred to as "functional MR." Progressive LV remodeling and dilatation lead to both apical and medial/lateral displacement of the papillary muscles from their usual position relative to the mitral annulus. This results in tethering (restriction) of the mitral leaflets with the characteristic appearance of tenting of the valve. The coaptation point is displaced into the ventricle. Often restriction of the mitral leaflets is asymmetric (as in this case) with the posterior leaflet more tethered. This result in an asymmetric mitral regurgitation jet directed toward the lateral wall of the left atrium.

27. a. The four view two-dimensional cine loop confirms the presence of extensive inferior and posterior wall motion abnormality. The short-axis view suggests a ventricular septal rupture, which is confirmed by color Doppler. Ventricular septal rupture occurs as a complication of infarction in about 0.2% of cases in fibrinolytic trials. Septal rupture is more common in elderly women presenting with their first myocardial infarction. The size of the rupture dictates the magnitude of the left-to-right shunt and the subsequent hemodynamic consequence. Anterior infarctions tend to cause apical interventricular septal rupture, whereas inferior infarctions are associated with perforations of the basal septum. The physical examination characteristically reveals a new harsh, loud holosystolic murmur that is best heard at the left sternal border.

28. b. In this case, there is progressive improvement of global systolic function and regional wall motion with increasing doses of dobutamine. The exception is function of the apical septum which exhibits initial improvement and then deterioration of function at peak dose (biphasic response). Testing for viability is usually reserved for patients with significant ischemic LV dysfunction who are potential candidates for revascularization in the hope that ventricular function and prognosis will improve with revascularization of viable myocardium. Low-dose dobutamine stress echocardiography is one of the established modalities used for viability assessment. The uncoupling of the inotropic and chronotropic effects of dobutamine at low doses (≤10 μg/kg/min) permits improvement of contractile function in stunned or hibernating myocardium without major increases in heart rate and myocardial oxygen demand. Viable myocardium will show increased wall thickening or increased endocardial excursion.

29. b. This is Ebstein's anomaly. The usual cause of right-sided heart failure at least with a later presentation is TR. ASD occurs in many patients with Ebstein's anomaly but would have been expected to present somewhat earlier if associated with significant shunting. Severe pulmonary hypertension is relatively rare. There is no evidence of endocarditis; and although tachycardia may occur in this condition, there is no evidence of cardiomyopathy on the images.

30. a. The patient has all the appearances of endocarditis except fever, and fever occasionally does not supervene in this setting. The most likely cause of infection here is staphylococcal perhaps from the time of implantation. Both thrombus formation and ring dehiscence are also possibilities, although somewhat less likely. Dehiscence is also less likely in the absence of associated regurgitation. The lesion is obviously attached to the tricuspid valve and thus is unlikely to be an embolus in transit.

31. c. The physical examination suggests valvular pulmonic stenosis with an ejection click and ejection murmur associated with RV hypertrophy. With more severe stenosis, the P2 becomes softer. The Doppler shows turbulent flow just beyond the pulmonary valve with mild pulmonary insufficiency. Patent ductus arteriosus usually leads to continuous flow in the PA, but this may be attenuated in Eisenmenger physiology. Pulmonary hypertension as part of Eisenmenger syndrome will lead to a loud P2. Infundibular pulmonic stenosis will not have the ejection click of a mobile but dysplastic valve and the turbulent velocity will be proximal to the valve.
32. a. The anterior tricuspid leaflet is flail with resultant severe TR. Cor triatriatum dexter is a rare condition in which a membrane septates the right atrium and presents with findings similar to tricuspid stenosis. Perforation of a tricuspid valve leaflet with an associated vegetation could give this appearance but the whole anterior leaflet is obviously flail in this example. Perforation is difficult to detect on two-dimensional imaging and is usually apparent by detecting an eccentric jet apparently coming through a leaflet on color Doppler examination. Ebstein's anomaly leads to apical displacement and tethering of the tricuspid leaflets—most often the septal leaflet. Carcinoid leads to thickening and reduced motion of the leaflet rather than excess motion as seen here.
33. b. There is no evidence of prolapse (answer A is false). The echocardiographic features are consistent with ischemic mitral regurgitation (answer B is correct). Note the tethered leaflets and stretched mitral chords. There is an override of the anterior leaflet with a posteriorly directed jet of mitral regurgitation. The annulus is of normal size and the valve does not have the appearance of rheumatic disease (answers C and D are false). A posterior chord rupture with a flail segment typically will result in an anteriorly directed jet of mitral regurgitation (answer E is false).
34. e. The images are diagnostic of mitral regurgitation secondary to systolic anterior motion of the mitral valve. This is a common finding in severe dynamic LV outflow obstruction (answer E is correct) due to hypertrophic obstructive cardiomyopathy.
35. c. The images show typical appearance of a flail P2 scallop of the mitral valve, with massive mitral regurgitation. The anterior leaflet is not prolapsing (answer A is false). There is no evidence of a beneficial effect of afterload-reducing agents in normotensive patients (answer B is false). There is a familial form of mitral valve prolapse, which is transmitted as an autosomal trait; screening of first-degree relatives is suggested (answer C is correct). An EF of <60% is likely to reflect LV dysfunction in patients with severe mitral regurgitation and is an indication for surgical intervention (answer D is false). Although a normal lifestyle and regular exercise are encouraged for most patients with mitral valve prolapse, restriction from competitive sports is recommended when moderate LV enlargement, LV dysfunction, uncontrolled tachyarrhythmias, unexplained syncope, or aortic root enlargement are present individually or in combination (answer E is false).

    Transesophageal echocardiographic evaluation of the mitral valve is excellent in assessing mitral valve pathology. Although all views and windows need to be used for full interrogation, we find the commissural view (typically obtained from the esophageal window at an angle of approximately 60 degrees) very useful in defining which mitral scallop is involved. In this view, the imaged scallops from right to left are P1, A2, and P3. A diagram of the echocardiographic appearance of a flail posterior scallop is shown in the bottom row. Note the typical double contour appearance of the flail P2, which is the most common flail scallop.
36. e. The echocardiographic images show a heavily calcified aortic valve, with concomitant presence of mild aortic regurgitation. Although 2D images are suggestive of severe aortic stenosis, no formal quantification is presented. In addition, there are no apparent symptoms from the presented data. Obviously, surgery cannot be recommended on these findings alone (answer A is false). There is no data to support the presence of mitral valve disease.

Presence of a musical murmur at the apex with a harsh murmur over the aortic area is a typical description of the Gallavardin dissociation of aortic stenosis murmur into two components (answer B is false). Presence of severe aortic stenosis, as suggested by a velocity of >4 m/sec is not a formal contraindication for stress test. Current AHA/ACC guidelines give it a class IIb recommendation for exercise testing in apparently asymptomatic patients (answer C is false). With an LVOT TVI/aortic TVI ratio of 0.2, aortic stenosis is severe. If echocardiographic and clinical examinations are concordant, there is no indication for hemodynamic catheterization (answer D is false). Several studies have shown the poor prognosis of severe aortic stenosis in the absence of surgery (answer E is correct).

37. d. Although mitral regurgitation secondary to systolic anterior motion (SAM) is usually corrected by surgical intervention on the LVOT obstruction, residual regurgitation can be seen on postbypass images. In this case, the surgeon performed an edge-to-edge (Alfieri) repair of the mitral valve. In this technique, the anterior and posterior leaflets are sutured together in the mid portion, giving the typical appearance of a double-orifice mitral valve (answer D is correct). The color jet that can be seen on the septal wall represents flow from a coronary-LV fistula. This is a common benign finding after septal myectomy procedures (answer B is false). Double inlet ventricle and cleft mitral valve are congenital diseases.

38. b. The detection of biologic leaflets excludes a mechanical prosthesis. Because of the presence of struts (stents), it is a bioprosthesis. A homograft or stentless prosthesis does not have struts on its sewing ring.

39. c. The scallops of the mitral leaflet can be classified as lateral (A1), middle (A2), and medial (A3) of the anterior mitral leaflet, and lateral (P1), middle (P2), and medial (P3) of the posterior mitral leaflet.

40. b. Dehiscence of a prosthetic valve is present as there is a large perivalvular regurgitation jet at the lateral sewing ring indicated by the large flow convergence. Most valvular dehiscences are due to infection. A mechanical mitral valve can produce a reverberation artifact in the LA simulating a mass.

41. b. The most common location for cardiac myxomas is the left atrium, with the attachment site at the atrial septum. Size is not a reliable way to distinguish between primary cardiac tumors and metastases. Cardiac myxoma may be found as part of a multisystem disease called the Carney complex. Cardiac myxoma is the most common primary cardiac tumor, accounting for 20%–30% of intracardiac tumors. Lipomatous hypertrophy is characterized by fatty infiltration of the atrial septum.

42. c. The valve pathology of carcinoid involves fibrosis, smooth muscle proliferation, and endocardial thickening which give the echocardiographic appearance of a thickened, retracted, and immobile valve. Appearances of the affected valve are pathognomic for carcinoid in the absence of exposure to the appetite suppressants fenfluramine and phentermine, ergot-derived dopamine agonists, and ergot alkaloid agents such as methysergide and ergotamine. In carcinoid heart disease, the tricuspid valve becomes nearly fixed in a partially open position resulting in severe tricuspid regurgitation. A "dagger-shaped" continuous-wave Doppler profile, resulting from severe tricuspid regurgitation that causes early peak pressure and rapid decline, representing equalization of right atrial and ventricular pressures, can be seen in severe disease. Involvement of the left-sided valves occurs in less than 10%–15% of cases and raises the likelihood of a concomitant patent foramen ovale, bronchial carcinoid, or high levels of circulating vasoactive substances. Left-sided valve disease is usually less severe than right-sided valvular lesions. Serotonin is thought to be inactivated as it passes through lung parenchyma. Although there has been significant progress in the treatment of carcinoid heart disease and many patients survive for years, cure is rarely achieved. Carcinoid heart disease is remarkably well-tolerated initially despite severe right-sided valve lesions. Eventually, dyspnea on exertion, lower extremity edema, and fatigue (signs and symptoms of right heart failure) develop.

43. b. There is mild TR. This is based on spatial mapping alone. Not shown here is that the mitral repair looks OK, with only trivial MR. No vegetations were noted.
44. c. There is an abscess of the atrial septum near the aortic prosthesis. It is obviously a pulsatile mass with continuous flow within a cystic area. The history of infection and a previous prosthetic valve helps here. From Video 13-1C, we cannot determine exactly what type of flow is present, where it came from, or where it is exiting. Video 13-1D suggests that the flow in the atrial septum comes from the left ventricle. Note that it is systolic, with expansion of the mass due to transmission of flow from ventricular pressure. There is no flow in the right atrium, so it is not an AV fistula or a Gerbode VSD.
45. b. There is a periprosthetic abscess within the intervalvular fibrosa. Three-dimensional echo allows postexamination exploration of different imaging planes than had been found during active imaging, especially in the operating room. The images show that the abscess extends almost 180 degrees around the prosthesis, and extends superiorly along the area of the sinuses of Valsalva posteriorly. This is why it extended up into the interatrial septum as shown previously in Videos 13-1C and D. The intervalvular fibrosa is indeed involved in the abscess. This structure is part of the fibrous skeleton of the heart, to which the aortic valve is attached anteriorly, and the mitral valve is attached posteriorly.
    The surgery needed begins with complete exoneration of the infected tissue. In this patient, most of the intervalvular fibrosa was débrided. Secondarily, the heart must be reconstructed in a way that will allow normal pumping function.
46. a. The intervalvular fibrosa contains the portion of the cardiac skeleton between the aortic and mitral valves, and represents a portion of the annulus of both valves.
47. a. Actually, the homograft is less available, and more difficult to implant than a standard prosthesis, and the systolic gradient from a homograft is lower than a stented prosthetic valve of the same size. There is often trivial regurgitation of either a homograft or a stented bioprosthesis. There is an advantage of lower rates of persistent infection with a homograft. Videos 13-1I and J show the results of surgery on the postpump TEE, with no TR or AR, and only mild MR. Note that the normal homograft has a unique appearance, which is different than stented aortic prostheses. Note the double density at the walls of the homograft tissue. This results from its implantation as an "inclusion cylinder" which includes the walls of the aortic sinuses from the donor. The band of soft tissue between the double densities should be relatively uniform in thickness and free of any flow in that space demonstrable by color Doppler.
48. b. There is a flail of the middle scallop of the posterior leaflet. Both long-axis views show an untethered portion of the posterior leaflet reflecting chordal rupture. The anterior leaflet is normal. Video 48D is the intercommissural view. Though the left ventricle is forshortened, the image is aligned parallel to a line connecting the medial commissure and the lateral commissure. The medial commissure is on the left side of the image and the lateral commissure is on the right. The image shows that the middle scallop of the posterior leaflet is the primary abnormality. The magnitude (width) of the flail is very large, almost 2 cm in medial-lateral diameter.
49. a. The correct answer is 0.38 cm^2. The formula for ROA, prior to correcting for wall constraint, is:
    $ROA = 2\pi r^2 v/V_{max}$
    The term v is the aliasing velocity derived from the color bar scale setting shown on the image, which is 55 cm/sec in this case. The value for π is 3.14, a constant. V_{max} is 550 cm/sec; keeping all units in centimeters.
    So, the uncorrected ROA=2 × 3.14 × 1.1 × 1.1 × 55/550 which is equal to 0.76 cm^2. The way to correct for wall constraint is to divide the angle, in this case 90 degrees, by 180 degrees, implying that only 50 percent of the hemisphere has its surface area involved with flow at that velocity. So, the presence of an aliasing pattern with wall constraint leads us to multiply the

uncorrected ROA by the observed angle divided by 180 degrees. In this case, the constraint angle of 90 degrees, derives a ratio of ½ (90/180). So, the ROA is one-half of what it would have been if the flow convergence with the same radius had no wall constraint. Therefore, the calculated ROA is 0.38 cm^2. Severe MR is defined as an ROA > 0.40 cm^2.

50. e. The correct answer is posterior leaflet perforation. Posterior leaflet restriction, anterior leaflet flail, and an anterior leaflet prolapse would usually cause a posterior jet direction. In ischemic (functional) MR, the jet is most commonly central in direction, and sometimes posteriorly directed.
51. b. The correct answer is 60%. The EF on this patient appears normal, which is often quoted at 55–65%.
52. c. There is mild aortic stenosis with mild to moderate aortic regurgitation. Notice the anterior leaflet doming of the anterior portion of the valve in Video 13-2G, and the restriction of opening of the right coronary cusp in the short-axis view of Video 13-2F. Not shown here are the data from the preoperative transthoracic continuous-wave Doppler recording, which showed a maximum systolic velocity of 2.2 m/sec.
53. e. The correct answer is "a small aortic atheroma." This aortic atheroma protrudes only 1–2 mm from the intimal surface which seems smooth and normal in all other areas than the one location. Atheromas that protrude into the lumen by 4 mm or more, and ones that show mobility, are considered severe, and are associated with a marked increase in perioperative mortality, mostly from atheroembolic events that shower cholesterol plaques to the liver, kidneys, brain, and skin. The embolic risk of this mild atheroma is low, though risk of atheroemboli is increased by the patient's age.
54. c.
55. c.
56. b. A restrictive LV filling pattern with an E/A ratio of >2 and E-wave deceleration time of <160 milliseconds. In addition, the A wave is truncated indicating that the AV delay has been programmed too short.
57. b. In patients with ischemic heart failure who are candidates for CRT, the accuracy of M-mode echocardiography to evaluate LV dyssynchrony is limited, as demonstrated in several studies. In these patients, echocardiographic techniques based on strain imaging to evaluate LV dyssynchrony may be of interest since they allow identification of those segments with active contraction. Particularly, 2D speckle tracking echocardiography is a powerful technique to evaluate LV dyssynchrony in multiple segments and in the 3 orthogonal directions of LV deformation.
58. d. The apical four-chamber views were obtained from a patient with Ebstein's anomaly. The tricuspid valve leaflets are seen close to the RV apex, and color Doppler shows moderately severe TR. LV EF appears normal, though additional views are needed for confirmation. RA, but not RV, size is increased because of the apical displacement of tricuspid valve leaflets in this condition. Because of reduced pulmonary blood flow, PA pressures are reduced to low normal, unless coexisting disease is present that can lead to pulmonary hypertension. Therefore, the patient would not show a D-shaped septum during systole.
59. a. TEE shows a large RA with predominantly right-to-left shunting across the interatrial septum. The PFO shown in the TEE can be closed percutaneously. The presence of an RA to LA shunt supports the conclusion that RAP is higher than LA pressure.
60. a. The short-axis view shows a D-shaped interventricular septum in systole and diastole, consistent with increased RV systolic pressure. Color Doppler shows flow acceleration across the pulmonic valve consistent with pulmonary stenosis. Therefore, PA systolic pressure is possibly normal. Color Doppler shows mild PR, whereas 2-D imaging shows a hyperdynamic LV EF that is >70%. There is RV hypertrophy, and free wall thickness cannot be normal in this patient.

61. b. Video 61A shows an overriding of the aorta with malaligned VSD. Video 61B shows an infundibular narrowing along with a hypoplastic pulmonary valve and pulmonary artery. This combination of findings is diagnostic of TOF.
62. a. The description given in the case suggests a relatively normal, natural progression of the disease. In TOF, signs and symptoms generally progress secondary to hypertrophy of the infundibular septum. As the child grows, right ventricular outflow tract obstruction increases. Worsening of the right ventricular outflow tract obstruction leads to right ventricular hypertrophy, increased right-to-left shunting, and systemic hypoxemia and thereby worsening of cyanosis. Worsening of cyanosis can be a major determinant of the timing of surgical repair. Cyanosis is more pronounced when the child cries. In tetralogy spells, hypercyanosis persists even when the child is not crying and it is also associated with hyperpnea.
    Hypercyanotic spells are also called hypoxemic episodes or tetralogy spells. These occur due to an acute increase in right-to-left shunting at the VSD. Various etiologies have been proposed, such as dynamic obstruction at infundibular level, increase in pulmonary vascular resistance, and decrease in systemic vascular resistance. Severe and often prolonged decrease in arterial saturation occurs which may lead to metabolic acidosis. Episodes are characterized by severe cyanosis and hyperpnea which is in response to the acute hypoxia and secondary metabolic acidosis. Prolonged episodes may be life-threatening. Clinically, the murmur of pulmonary stenosis may become diminished or completely disappear suggesting diminished blood flow to pulmonary arteries. The child will have hyperpnea and cyanosis along with some irritability and or lethargy. Left ventricular function remains unchanged until a very late stage where it can become compromised secondary to severe metabolic acidosis.
63. d. *Definition:* Transposition is defined as connection of the aorta to the right ventricle and the pulmonary artery to the left ventricle. There is atrioventricular concordance but ventriculoarterial discordance. Transposition occurs in approximately 4%–8% of children born with congenital heart defects. "D-transposition" is a term which refers to the way the conotruncal septum rotates *in utero* ("D" for dextro) and has been commonly applied to this entity. Transposition also occurs in children with other complex forms of congenital heart disease.
    Anatomy: In transposition, the aorta arises from the right ventricle, usually in a position which is anterior and rightward of the pulmonary valve. The two great arteries course parallel to one another; a distinctly different arrangement from the normal pulmonary artery crossing over the aortic root. Echocardiographically, the posterior great artery, which is the pulmonary artery, will be seen taking an immediate posterior course, typical of the pulmonary arteries.
64. b. This patient has Ebstein's anomaly of the tricuspid valve. The desaturation results primarily from a right-to-left shunt at the atrial level. The video clips establish the diagnosis, although they do not specifically show this phenomenon.
65. d. This newborn has tricuspid atresia. The presence of an imperforate linear echo density in the location of the normal tricuspid valve confirms the diagnosis of tricuspid atresia. Tricuspid atresia is divided into three categories: Type I—with normally related great arteries (75% of cases); Type II—D-transposition of great arteries (20%–25%); and Type III—is more complex disease with L-transposition or malposed great arteries (uncommon, 3%).
66. d. Echocardiography shows TAPVR of the supracardiac type. In supracardiac TAPVR, the pulmonary venous confluence drains to the heart by way of an ascending vein to the innominate vein or SVC and then to the right atrium. This is the most common form seen in 35%–50% of cases. In approximately 20% of cases, the confluence drains directly to the coronary sinus or the veins connect directly to the right atrium (cardiac type). In approximately 20%, the confluence drains by way of a descending vein, below the diaphragm, to the portal vein, hepatic vein, inferior vena cava, or ductus venosus (infracardiac type). A mixed type of TAPVR may also be seen and is a combination of the other forms. The mixed type accounts for

about 10% of TAPVR cases. Obstruction of venous return is virtually always present when the pulmonary venous return is below the diaphragm or infracardiac. In the supracardiac type, some form of obstruction is present in 50% of cases, but it is often mild. Obstruction is rarely seen in the cardiac type of TAPVR. In all forms of TAPVR, some form of atrial communication is almost always present. Profound cyanosis is unusual at any age. Some forms of TAPVR may go undetected until later in life, although this is unusual.

67. d. Papillary fibroelastomas account for approximately 85% of valve-associated tumors. Papillary fibroelastomas are not easily distinguishable from vegetations. Papillary fibroelastomas are small, generally 0.5–2.0 cm in diameter, and are often confused with vegetations. The distinction between papillary fibroelastomas and vegetations can be difficult by echocardiography. Therefore, the correct diagnosis often depends on the clinical context. Although papillary fibroelastomas occur on valves, they usually do not result in significant valvular regurgitation. Papillary fibroelastomas most often attach to the arterial side of semilunar valves and the atrial surface of the atrioventricular valves. Symptoms of papillary fibroelastoma are usually caused by embolization, either of the tumor itself or an associated thrombus. The most common clinical presentation is cerebrovascular accident or transient ischemic attack.

68. c. The valve pathology of carcinoid involves fibrosis, smooth muscle proliferation, and endocardial thickening which give the echocardiographic appearance of a thickened, retracted, and immobile valve. Appearances of the affected valve are pathognomic for carcinoid in the absence of exposure to the appetite suppressants fenfluramine and phentermine, ergot-derived dopamine agonists, and ergot alkaloid agents such as methysergide and ergotamine. In carcinoid heart disease, the tricuspid valve becomes nearly fixed in a partially open position resulting in severe tricuspid regurgitation. A "dagger-shaped" continuous-wave Doppler profile, resulting from severe tricuspid regurgitation that causes early peak pressure and rapid decline, representing equalization of right atrial and ventricular pressures, can be seen in severe disease. Involvement of the left-sided valves occurs in less than 10%–15% of cases and raises the likelihood of a concomitant patent foramen ovale, bronchial carcinoid, or high levels of circulating vasoactive substances. Left-sided valve disease is usually less severe than right-sided valvular lesions. Serotonin is thought to be inactivated as it passes through lung parenchyma. Although there has been significant progress in the treatment of carcinoid heart disease and many patients survive for years, cure is rarely achieved. Carcinoid heart disease is remarkably well-tolerated initially despite severe right-sided valve lesions. Eventually, dyspnea on exertion, lower extremity edema, and fatigue (signs and symptoms of right heart failure) develop.

69. a. The posterior sewing ring (arrow) of the aortic prosthesis is dehisced from the aortic annulus and demonstrates rocking motion, which is not well appreciated in these still images. Severe aortic regurgitation is expected when there is dehiscence of the prosthesis. A large pedunculated vegetation is present. No definite flail prosthetic leaflet is detected.

70. a. The vegetation is attached to the posterior mitral valve leaflet. However, it is unclear which scallop the vegetation is attached to. Other views are necessary to determine its exact attachment site; the best view to localize the specific scallop is the transgastric short-axis view of the mitral valve at 0 degree.

35

Critical Care

1. Painful condition which does not respond with tricyclic antidepressants:
   a. Diabetic nephropathy
   b. Tension headache
   c. Migraine headache
   d. Postsurgical pain
2. Primary hyperparathyroidism is associated with all, except:
   a. Renal calculi
   b. Ectopic calcification
   c. Increased serum phosphate
   d. An increase in serum alkaline phosphatase
3. Features of small bowel obstruction may include all, except:
   a. Bile-stained vomit
   b. Severe abdominal pain worse on movement
   c. Abdominal distension
   d. Constipation
4. A 36-year-old woman develops a purpuric rash during an undiagnosed septic illness. Possible diagnosis includes all, except:
   a. Disseminated intravascular coagulation (DIC)
   b. Bacterial endocarditis
   c. Drug toxicity
   d. Systemic lupus erythematosus (SLE)
5. Daily noncaloric protein requirement of a catabolic patient without renal failure is:
   a. 1 g/kg/day
   b. 0.8 g/kg/day
   c. 1.5 g/kg/day
   d. 2.5 g/kg/day
6. All of the following drugs are active against anaerobic organism, except:
   a. Clindamycin
   b. Metronidazole
   c. Meropenem
   d. Aztreonam
7. Regarding the Glasgow Coma Scale (GCS) which one is true?
   a. Ranges from 0 to 15
   b. Reliably assesses brainstem function
   c. Includes scoring up to 6 points for best motor response
   d. Is suitable for use in children under 5 years of age
8. Syntocinon given quickly often results in:
   a. Tachycardia
   b. Diuresis
   c. Nausea and vomiting
   d. Respiratory arrest

1. d 2. c 3. b 4. b 5. c 6. d 7. c 8. a

9. In near-drowning:
   a. Sea water inhalation can cause hypovolemia
   b. Sea water inhalation frequently leads to an increase in serum sodium
   c. Acute renal failure is a common occurrence
   d. Steroids confer neurological protection

10. Gastric acid aspiration at pH_2 may initially cause all, except:
   a. Chemical pneumonitis
   b. Wheezing
   c. Bacterial pneumonitis
   d. Decreased lung compliance

11. In paracetamol poisoning all are true, except:
   a. A raised aspartate transaminase is an early sign
   b. Prolonged prothrombin time is the best guide to liver damage
   c. Renal failure may supervene without liver damage
   d. Loss of consciousness is often delayed

12. Recognized cause of stridor in infancy include all, except:
   a. Bronchiolitis
   b. Laryngomalacia
   c. Laryngotracheobronchitis
   d. Epiglottitis

13. Transfusion of mismatched blood is associated with all, except:
   a. Wheezing
   b. Polyuria
   c. A positive Coombs' test
   d. Fever

14. A confused 60-year-old man has the following arterial blood gases (ABGs):

PaO_2	60 mm Hg
$PaCO_2$	60 mm Hg
Hb	16.9 g/dL

   These values are compatible with:
   a. Pneumonia
   b. Pulmonary edema
   c. Pulmonary embolus
   d. Chronic obstructive pulmonary disease (COPD)

15. The following values are appropriate for cerebrospinal fluid (CSF), except:
   a. *Protein:* 400 mg/L
   b. *Glucose:* 6 mmol/L
   c. *Pressure:* 8 cm H_2O
   d. *Cells:* Less than 5 lymphocytes per mm^3

16. Characteristic features of salicylate overdose include all, except:
   a. Tinnitus
   b. Hypoventilation
   c. Hyperpyrexia
   d. Epigastric pain

17. Tetanus:
   a. Commonly has an incubation period of more than 20 days
   b. Can be complicated by severe autonomic dysfunction
   c. Can be reliably diagnosed by culture of *Clostridium tetani* from the wound
   d. Should be treated with intrathecal antitoxin

18. Synchronized direct current (DC) cardioversion is indicated in all, except:
   a. Pulseless ventricular tachycardia (VT)
   b. Atrial flutter
   c. Ventricular fibrillation (VF)
   d. Supraventricular tachycardia

9. a 10. c 11. a 12. d 13. b 14. d 15. b 16. b
17. b 18. c

19. In an acute severe asthma attack all are true, except:
    a. Pulsus paradoxus is a reliable indicator of severity
    b. A high $PaCO_2$ is an indication of immediate ventilation
    c. Sodium chromoglycate is of no immediate benefit
    d. Oxygen therapy should be at 28% until arterial blood gases are available

20. Acute intermittent porphyria (AIP) is associated with all, except:
    a. Abdominal pain
    b. Raised porphobilinogen and δ-aminolevulinic acid levels
    c. Autosomal dominant inheritance
    d. Raised fecal porphyrins

21. Postoperative nausea and vomiting (PONV):
    a. Has the same incidence in male and female
    b. Is more common in children
    c. Is increased by the use of dopamine antagonists
    d. Rarely occurs with spinal or epidural anesthesia

22. Regarding postoperative shivering all are true, except:
    a. Is associated with hypoxemia
    b. Causes a respiratory acidosis
    c. Occurs rarely with spinal anesthesia
    d. Responds to the administration of opiates

23. Effective neuroprotection following a severe head injury includes:
    a. Steroids
    b. Hypothermia
    c. Hyperventilation below a $PaCO_2$ of 25 mm Hg
    d. Thiopentone

24. A rise in intracranial pressure (ICP) can be evidenced by:
    a. Tachycardia
    b. Pupillary constriction
    c. Reduced conscious level
    d. Rhinorrhea

25. Disequilibrium syndrome with hemodialysis all are true, except:
    a. Is more commonly found with hemodialysis than with peritoneal dialysis
    b. Is a result of autonomic nervous system dysfunction
    c. Can be overcome by using bicarbonate dialysate
    d. May cause convulsions

26. Intravenous patient controlled analgesia (PCA) with opiates:
    a. Cannot be used with other analgesic regimens
    b. Is not possible with fentanyl
    c. Avoids the risk of respiratory depression
    d. Can be successfully used by a 5-year-old child

27. Reliable indicators of nutritional status in the critically ill include:
    a. Lymphocyte count
    b. Urinary nitrogen excretion
    c. Weight loss
    d. Triceps skinfold thickness

19. d 20. d 21. b 22. b 23. b 24. c 25. b 26. d 27. b

28. A urinary specific gravity of 1.030 is compatible with all, except:
    a. Diabetes insipidus
    b. Prerenal failure
    c. Dehydration
    d. Normal renal function

29. A raised arterial pCO_2 is found in:
    a. Those acclimatized to high altitude
    b. The 'Pickwickian' syndrome
    c. Early septic shock
    d. Acidosis from renal causes

30. Fat embolism may cause:
    a. A raised arterial pCO_2
    b. Edema of the retina
    c. Petechial hemorrhages over the upper chest
    d. Hypothermia

31. Disseminated intravascular coagulation (DIC) in pregnancy all are true, except:
    a. May occur in the presence of a normal platelet count
    b. May complicate septicemia
    c. Is a late sign in preeclampsia
    d. Plasma fibrinogen degradation products (FDPs) must be greater than 10 μg/L to be diagnostic

32. The following factors predispose to postoperative renal failure, except:
    a. Prolonged intraoperative hypotension
    b. Administration of radiographic contrast media
    c. Septic shock
    d. Preoperative pneumonia

33. Pulmonary artery catheter which statement is not true?
    a. Has been shown to increase the ICU mortality
    b. Requires training
    c. Can be prone to misinterpretation
    d. Is the most sensitive indicator of myocardial ischemia

34. Transesophageal echocardiography in the ICU all are true, except:
    a. Has been shown to prevent reexploration after cardiac surgery
    b. Is the fastest way for definite diagnosis of hemodynamic instability
    c. Has been shown to improve outcome
    d. Is the quickest way to diagnose aortic dissection

35. Pressure controlled ventilation all are true, excepts:
    a. Is performed in neonates
    b. Is helpful in acute respiratory distress syndrome (ARDS)
    c. Achieves higher peak airway pressure
    d. Requires frequent ventilator adjustments

36. Nitric oxide (NO) all are true, except:
    a. Is beneficial in patients with high pulmonary vascular resistance
    b. Is not very expensive
    c. Requires special equipment for administration
    d. Requires methemoglobin estimation

37. Percutaneous tracheostomy:
    a. Requires no training
    b. Is inexpensive
    c. Is done through cricothyroid membrane
    d. Is done between 2/3rds tracheal cartilages

28. a 29. b 30. c 31. d 32. d 33. d 34. c 35. c
36. b 37. d

38. Heparin all are true, except:
    a. Is poorly protein bound
    b. Enhances the effect of antithrombin III on factor Xa
    c. Prevents the formation of thrombin from prothrombin
    d. Thrombocytopenia may occur during treatment

39. In methanol toxicity all are true, except:
    a. There will be a severe metabolic acidosis
    b. Ethyl alcohol has a role in treatment
    c. Methanol will be metabolized to acetaldehyde
    d. Gluconeogenesis will be inhibited

40. The following are metabolized by the lung, except:
    a. Angiotensin II
    b. Propofol
    c. Bradykinin
    d. Prostaglandin F

41. Arterial pulse pressure may be increased if:
    a. The stroke volume falls
    b. The ratio of stroke volume to arterial vascular compliance falls
    c. There is an increase in heart rate
    d. There is a persistent ductus arteriosus

42. Carbon monoxide all are true, except:
    a. Moves the oxyhemoglobin dissociation curve to the right
    b. May cause blistering at toxic concentrations
    c. Occurs naturally in the human body
    d. Causes metabolic acidosis

43. Examination of the cerebrospinal fluid in viral meningitis will show:
    a. Turbidity
    b. Increased lymphocytes count
    c. Increased glucose concentration
    d. Increased lactate concentration

44. Within 12 hours of overdosage with paracetamol:
    a. There will be increased ventilation
    b. There will be hypothermia
    c. There will be acidosis
    d. Treatment with n-acetylcysteine is appropriate

45. A patient with fulminant hepatic failure may have all, except:
    a. Hypokalemia
    b. Hypoalbuminemia
    c. An elevated serum bilirubin concentration
    d. Hypoglycemia

46. When measuring systemic arterial pressure, falsely high readings may be caused by all, except:
    a. The use of too narrow a cuff
    b. Arteriosclerosis
    c. Obese arms
    d. Use of the stethoscope diaphragm

47. Tetanus:
    a. Does not present in infancy
    b. Can be prevented by antibiotics
    c. Presents with dysphagia early in the disease
    d. May present with ocular involvement

38. a 39. c 40. d 41. d 42. a 43. b 44. d 45. b
46. d 47. b

48. An area of lung with a decreased ventilation/perfusion ratio which one is false:
    a. Is an area of physiological dead space
    b. Is responsible for a fall in PaO_2 without a change in $PaCO_2$
    c. Will show hypoxic vasoconstriction
    d. May be compensated for by increasing ventilation

49. Features of pulmonary thromboembolism may include:
    a. Elevated $PaCO_2$
    b. Reduced PaO_2
    c. Increased surfactant activity
    d. Reduced ventilation/perfusion ratio

50. Elevated levels of alkaline phosphatase may be found in all, except:
    a. Myelomatosis
    b. Pregnancy
    c. Cholestasis
    d. Paget's disease of bone

51. A 60-year-old man has an abscess for which his physician prescribes a 7-day course of clindamycin. Before completion of the course the patient returns to the office with cramps, diarrhea, and a fever of 102.2°F. The patient is admitted to the hospital for sigmoidoscopy. Results demonstrate yellowish-white patchy areas on the wall of the colon all of the following are true, except:
    a. A Gram stain from the pseudomembrane would yield dark purple rods
    b. The pseudomembranous infection can be fatal if not treated
    c. Clindamycin should be discontinued, and an aminoglycoside should be used until the pseudomembranes resolve
    d. The causative agent of the pseudomembranes is aerobic

52. The incubation period for hepatitis A is:
    a. Less than 15 days
    b. 15-40 days
    c. 40-60 days
    d. 60-160 days

53. In cardiac resuscitation all are used, except:
    a. Epinephrine
    b. Atropine
    c. Esmolol
    d. Vasopressin

54. Which of the following statements concerning the etiology and pathology of hemochromatosis is true?
    a. The excess iron accumulates primarily in cells of the mononuclear phagocyte system
    b. The most severe form of the disease is found in patients with thalassemia and sideroblastic anemia
    c. The iron accumulates due to a failure of renal excretion
    d. Approximately two-thirds of patients with hemochromatosis share a common human leukocyte antigen

55. The following data were obtained from an arterial blood sample drawn from a hospitalized patient:
    pH= 7.55
    pCO_2 = 25 mm Hg
    $[HCO_3^-]$ = 22.5 mEq/L
    Recall that $CO_2 = 0.03 \times PCO_2$ (in mmol/L)
    This patient's arterial blood findings are consistent with a diagnosis of:
    a. Metabolic alkalosis
    b. Respiratory alkalosis
    c. Metabolic acidosis
    d. Respiratory acidosis

48. a 49. b 50. d 51. c 52. b 53. c 54. d 55. b

56. A CT scan of 75-year-old woman suffering from a cerebrovascular accident shows a focal nonhemorrhagic infarction in the right hemisphere. During the physical examination, no muscular weakness is noted; however, the patient is not responding to any visual, auditory, or tactile stimuli on the left side of her body. Also has a deficit involving only the inferior portion of her left visual field in both eyes. Which lobe of the brain has been principally affected by this stroke?
    a. Parietal
    b. Frontal
    c. Occipital
    d. Temporal

57. Angiography of a 75-year-old woman suffering from a cerebrovascular accident showed occlusion in a small branch of the middle cerebral artery with no other significant findings. Which one of the following diagnoses best explains the cause of the woman's cerebrovascular accident?
    a. Berry aneurysm
    b. Deep venous thrombosis
    c. Atrial fibrillation with mural thrombus
    d. Congestive heart failure

58. A 68-year-old woman working in a kindergarden suddenly develops a fever of 38.2°C and a severe headache one evening. The following morning she also experiences a stiff neck and uncharacteristic drowsiness. At the emergency room, her temperature is 38.8°C, and there are pain and resistance on flexion of her neck. The patient is noted to be mentally competent although lethargic. A cerebrospinal fluid (CSF) sample is obtained by lumbar puncture. On the basis of the history and physical examination of this patient, what is the most probable diagnosis ?
    a. Viral meningitis
    b. Fungal meningitis
    c. Bacterial meningitis
    d. Viral encephalitis

59. On the basis of the patient's age, the probable etiologic agent is:
    a. *Staphylococcus aureus*
    b. *Haemophilus influenzae*
    c. *Neisseria meningitidis*
    d. *Streptococcus pneumoniae*

60. Opening pressure on lumbar puncture was slightly elevated, and the diagnosis was acute bacterial meningitis based upon the finding of gram-positive cocci in pairs in the CSF. Which of the empirical antibiotics you will choose?
    a. Gentamycin
    b. Ceftriaxone
    c. Pipracillin + Tazobactom
    d. Ciprofloxacin

61. In sepsis all interventions increase survival, except:
    a. Early and appropriate antibiotic therapy
    b. Hydrocortisone
    c. Early goal directed therapy
    d. Immunoglobulin

62. Which one of the following statements concerning infectious hepatitis is correct?
    a. Hepatitis C infection requires hepatitis B infection
    b. *Diagnosis with hepatitis B carries a grave prognosis:* Many people die from fulminant hepatitis, and nearly 25% of infected patients progress to hepatocellular carcinoma
    c. Hepatitis E antigen (Hbe Ag) indicates carrier state with infectivity
    d. The carrier state is common in patients infected with hepatitis A

63. In the general format of the Henderson–Hasselbach equation:
log (protonated form/unprotonated form) + pK'a = pH
Phenobarbital is a weak acid. In an emergency situation, a useful maneuver to hasten its elimination in an intoxicated person might be:

56. a 57. c 58. c 59. d 60. b 61. d 62. c

a. Inhalation of CO_2
b. Infusion of $NaHCO_3$
c. Infusion of NH_4CI
d. Induction of P_{450} enzymes with a separate barbiturate

64. Which of the antibiotics is not active against methicillin resistance *Staphylococcus aureus*?
a. Vancomycin
b. Cotrimoxazole
c. Linzolid
d. Meropenem

65. Which of the following areas of the central nervous system (CNS) contains structures that are considered to be phylogenically the oldest parts of the brain?
a. Frontal lobe
b. Limbic system
c. Cerebellum
d. Visual cortex

66. The treatment of ventricular tachycardia associated with myocardial ischemia in a hospitalized patient includes:
a. Digitalis
b. Diltiazem
c. Lidocaine
d. Propranolol

67. Which one of the following clinical procedures best demonstrates damage to the cerebellum?
a. Testing for voluntary weakness by having the patient grasp the examiner's fingers and squeeze as hard as possible
b. Tapping the patellar tendon and observing the reflex response
c. Having the patient flex the neck, touching the chin to the sternum, to determine if this action elicits pain
d. Finger nose test

68. The upstroke of the ventricular action potential is primarily due to which one of the following actions?
a. An inward flux of Ca^{2+}
b. An inward K^+ current
c. An outward K^+ current
d. An inward Na^+ current

69. Which one of the following statements best describes the regulations of vascular smooth muscle during exercise?
a. There is vasoconstriction in all vessels due to the increased sympathetic outflow that occurs during exercise
b. Increased circulating levels of metabolic products such as H^+, CO_2, and adenosine cause vasodilation in all vessels
c. Increased blood flow during exercise causes cascade of events leading to release of nitric oxide and vasoconstriction
d. Local metabolic vasodilator signals in the vessels of active skeletal muscle can overcome the vasoconstrictor signals of increased sympathetic outflow and cause a net vasodilation and increased perfusion of those muscles

70. A 42-year-old woman comes to the emergency room with acute onset of severe abdominal pain following a routine dinner. During a physical examination, the physician notes that she is mildly obese, and her abdominal pain is confined principally to the right upper quadrant. The physician suspects that she may have gallstones.

63. b 64. d 65. b 66. c 67. d 68. d 69. d

Which of the following symptoms is most specific for cholelithiasis?
a. Excessive flatulence following a meal
b. Hemoccult-positive stool
c. Severe right upper quadrant pain that comes in waves over a period of hours
d. Rigid abdominal wall with diffuse rebound tenderness

71. The patient has a fever of 39.4°C and an elevated white cell count (12,400/mm^3). All of the following organisms are likely pathogens in acute cholecystitis, except:
a. Group D streptococci (enterococci)
b. *Escherichia coli*
c. *Klebsiella* species
d. *Neisseria* species

72. For the eradication of *H. pylori* infection which one is not used ?
a. Bismuth salicylate
b. Tetracycline
c. Omeprazole
d. Ampicillin

73. All of the following are known predisposing factors for cholesterol and mixed stone formation, except:
a. Diabetes mellitus
b. Alcoholic cirrhosis
c. Obesity
d. Ileal resection

74. In ARDS which treatment modalities has increased the survival?
a. Pressure control ventilation
b. Low tidal volume ventilation
c. Prone ventilation
d. Nitric oxide ventilation

75. Drug of choice for ICU psychosis?
a. Benzodiazapines
b. Morphine
c. Haloperidol
d. Chlorpromazine

76. All move the hemoglobin dissociation curve to the right, except:
a. Acidosis
b. Hypothermia
c. Fever
d. CO_2

77. Normal mixed venous saturation:
a. 100%
b. 40%
c. 50%
d. 70%

78. To see the treatment response in thyrotoxicosis which test should be done?
a. TSH
b. T3
c. Free T4
d. Free T3

79. All of the following statements about Gamma-aminobutyric acid (GABA) are true, except:
a. Its receptor is coupled to a benzodiazepine receptor
b. It is a widely distributed inhibitory neurotransmitter
c. Its activity is increased in hepatic encephalopathy
d. Its activity is decrease with antiseizure drugs

80. Asthma is characterized by an increased responsiveness of the trachea and bronchi to various stimuli and is manifested by widespread narrowing of the airway. Results of pulmonary function tests during an acute asthma attack will demonstrate all of the following except:
a. Decreased forced expiratory volume in 1 second (FEV1)
b. Increased forced vital capacity (FVC)
c. Decreased FEV1/FVC
d. Normal or increased total lung capacity (TLC)

70. c 71. d 72. d 73. b 74. b 75. c 76. b 77. d
78. c 79. d 80. b

81. A 62-year-old man experiences crushing substernal chest pain. After 4 days of circulatory support in the intensive care unit, he dies. Histologic study of his heart would show all of the following findings, except:
    a. Coagulative necrosis
    b. Liquefactive necrosis
    c. Hypereosinophilic wavy fibers
    d. Neutrophilic infiltrate

82. Serious complications in a patient who has just suffered an acute myocardial infarction include all of the following, except:
    a. Cardiac tamponade
    b. Peripheral embolism
    c. Mitral valve incompetence
    d. Aortic aneurysm

83. Which one of the following description is typically associated with a nephrotic syndrome?
    a. Red blood cell casts, a low level of proteinuria, and granular casts
    b. Heavy proteinuria, oval fat bodies, and fatty casts
    c. Hematuria, granular casts, and broad waxy casts
    d. A proliferative glomerulonephritis on renal biopsy

84. An increased BUN and creatinine ratio is found in all, except:
    a. Hyperalimentation
    b. Glucocorticoid therapy
    c. Prerenal azotemia
    d. Aminoglycoside therapy

85. Which of the following drug is not used in asthma?
    a. Methotrexate
    b. Magnesium sulfate
    c. Norepinephirne
    d. Montelukast

86. Which one is not a usual feature of asthma?
    a. Cough
    b. Wheezing
    c. Dyspnea
    d. Hemoptysis

87. Regarding equivalent doses of different steroid preparation which one is correct?
    a. Methylprednisolone is most potent
    b. Dexamethasone is least potent
    c. Hydrocortisone and betamethasone are equipotent
    d. Methylprednisolone and triamcinolone are equipotent

88. In co-oxymetry, how many wavelengths are used?
    a. One
    b. Two
    c. Three
    d. Four

89. Immediate treatment of acid aspiration includes:
    a. Pulmonary lavage
    b. Intravenous hydrocortisone
    c. Intravenous H_2 blockers such as ranitidine
    d. Immediate intubation and ventilation
    e. Intravenous antibiotics

90. Regarding nutrition:
    a. A normal adult requires 30-40 g of protein daily
    b. Only L-amino acids are required for protein replacement
    c. Starvation causes loss of lean muscle mass
    d. A BMI of 22 suggests undernutrition
    e. Kwashiorkor is due to lack of all energy source

81. b 82. d 83. b 84. d 85. c 86. d 87. d 88. d
89. a 90. c

91. Regarding pain measurement:
    a. A visual analogue scale (VAS) measures intensity of pain
    b. 30% of patients are unable to use a VAS accurately
    c. Self-reporting is superior to observer reporting
    d. The Magill pain questionnaire (MPQ) is unsuitable for children under 12 years of age
    e. The Dartmouth pain questionnaire (DPQ) assessses acute pain

92. Postoperative shivering:
    a. Can usually be avoided by active warming of the patient
    b. Is associated with hypoxemia
    c. Causes a respiratory acidosis
    d. Occurs rarely with spinal anesthesia
    e. Responds to the administration of opiates

93. Nitric oxide (NO):
    a. Is beneficial in patients with high pulmonary vascular resistance
    b. Is not very expensive
    c. Requires special equipment for administration
    d. Can be switched off when not anymore required
    e. Requires methemoglobin estimation

94. Heparin:
    a. Can only be extracted from bovine liver
    b. Is poorly protein bound
    c. Enhances the effect of antithrombin III on factor Xa
    d. Prevents the formation of thrombin from prothrombin
    e. Thrombocytopenia may occur during treatment

95. An area of lung with a decreased ventilation/perfusion ratio:
    a. Is an area of shunt
    b. Is an area of physiological dead space
    c. Is responsible for a fall in PaO_2 without a change in $PaCO_2$
    d. Will show hypoxic vasoconstriction
    e. May be compensated for by increasing ventilation

96. Cyclosporin A and FK-506 are often used in the treatment of transplant recipients. Both drugs interfere with the synthesis of the cytokine interleukin-2 (IL-2). These drugs are used to:
    a. Decrease plasma levels of IL-2 so that it will not bind to the foreign cells of the transplanted organ and cause rejection
    b. Inhibit the IL-2 stimulus for proliferation of T-cells and prevent organ rejection
    c. Prevent the activation of macrophages by IL-2 and prevent organ rejection
    d. Decrease the IL-2 stimulation of immunoglobulin E (IgE) producing plasma cells and therefore hinder the recipient's allergic response to the foreign cells of the transplanted organ
    e. Inhibit the suppression of T-cells by IL-2 and prevent organ rejection

97. Opening pressure on lumbar puncture was slightly elevated, and the diagnosis was acute bacterial meningitis based upon the finding of gram-positive cocci in pairs in the CSF. The cell count was elevated. The prominent cell type most likely was:
    a. Mononuclear cells
    b. Neutrophils
    c. Lymphocytes
    d. Red cells
    e. Segmented neutrophils

91. e 92. a 93. d 94. a 95. a 96. b 97. b

98. Protein and glucose concentrations in the CSF probably were:
    a. Both elevated
    b. Elevated and low, respectively
    c. Low and elevated, respectively
    d. Both low
    e. Unaffected

99. Which one of the following statements concerning expiration is correct?
    a. At lung volumes close to vital capacity (VC), expiratory air flow is independent of expiratory effort
    b. At lung volumes close to VC, airway resistance is at its peak
    c. At lung volumes close to VC, expiratory air flow increases with increasing pleural pressures
    d. At 50% of VC, increased expiratory effort results in decreased airway resistance
    e. At lung volumes close to residual volume, the elastic recoil of the chest wall is directed inward.

100. Which of the following statements best characterizes the pevalence of asymptomatic gallstones in western countries ?
    a. The prevalence of gallstones in men over 40 years is greater than 60%
    b. The prevalence of gallstones in men over 40 years is between 20% and 60%
    c. The prevalence of gallstones in men over 40 years is less than 3%
    d. The prevalence of gallstones in women over 40 years is greater than 60%
    e. The prevalence of gallstones in women over 40 years is between 20% and 60%

101. Which one of the following disease processes is most likely manifesting itself?
    a. A thyroid adenoma that is secreting thyroxine
    b. Inappropriate hypothalamic secretion of thyrotropin-releasing hormone (TRH)
    c. Graves' disease
    d. Hashimoto's disease
    e. Sick euthyroid syndrome

102. Which other finding would most likely be expected on further physical examination?
    a. Sparse, dry hair that easily falls out
    b. Pericardial effusion
    c. Jaundice
    d. Dermopathy over the dorsum of the leg
    e. Diffuse hyperpigmentation of the skin

103. All of the following laboratory test results are consistent with the clinical picture, except:
    a. Decreased triiodothyronine resin uptake (T_3RU)
    b. Decreased serumthyroid-stimulating hormone (TSH) response to a TRH challenge
    c. Decreased serum TSH concentration
    d. Increased serum thyroxine (T4) concentration
    e. Positive test for circulating antibodies against the TSH receptor

104. A thyroid radioactive iodine uptake scintiscan is performed and reveals uniform uptake across the gland. Which of the following conditions best describes the histopathology of this woman's thyroid gland?
    a. Multinodular goite
    b. Multiple adenomas
    c. Single carcinoma
    d. Lymphocytic infiltration (especially plasma cells) with atrophic follicles
    e. Diffuse hyperplasia and hypertrophy

98. b 99. c 100. e 101. c 102. d 103. a 104. e

105. All of the following statements correctly pair a useful medication with its mechanism of action except:
   a. Propylthiouracil blocks the coupling reaction in T4 synthesis
   b. Methimazole reduces peripheral conversion of T4 to T3
   c. Radioactive iodine destroys follicular cells in the thyroid
   d. Propranolol blocks the sympathetic components of thyrotoxicosis
   e. Prednisone may relieve the mechanical exophthalmos and ophthalmoplegia by reducing inflammation

106. A 24-year-old man has a mild fever and is noticeably jaundiced. The patient has not been feeling well for approximately 10 days.The patient's symptoms are vomiting, anorexia, fatigue, a sore throat, and joint pain. Laboratory results are significant for elevated aspartate aminotransferase (AST), alanine aminotransferase (ALT), and bilirubin. Test results show positive for anti-hepatitis A virus immunoglobulin G. All of the following statements are correct, except:
   a. The most common mode of transmission of the causative organism is the fecal-oral route
   b. The prognosis for this patient is poor because his condition frequently progresses to a chronic disease
   c. Prophylactic measures are available for this disease
   d. This patient does not require treatment and should recover completely over the next couple of weeks
   e. Antihepatitis A virus immunoglobulin G is never found in people who do not have a history of severe hepatitis

107. In the early detection of an air embolism, the following are useful:
   a. ECG
   b. Ultrasound
   c. Fall in blood pressure
   d. Change in ventilatory pattern

108. High central venous pressure, low blood pressure and acute circulatory failure are found in all except:
   a. Pulmonary embolism
   b. Congestive cardiac failure
   c. Venous air embolism
   d. Hemorrhage

109. In acute cardiac tamponade there are all except:
   a. Hypotension
   b. Bradycardia
   c. A prominent 'a' wave in the CVP trace
   d. Cyanosis and cold extremities

110. Immediate treatment of venous air embolism during posterior fossa surgery should include the following all except:
   a. Give mannitol
   b. Raise the intracranial venous pressure
   c. Give a rapid fluid infusion
   d. Turn off nitrous oxide

111. Recognised features of fat embolism include all except:
   a. Mental confusion
   b. Bradycardia
   c. Petechial rash
   d. Respiratory distess syndrome
   e. Pyrexia

112. In cardiopulmonary resuscitation:
   a. Lignocaine should be given before adrenaline in ventricular fibrillation
   b. The optimal treatment of ventricular tachycardia involves synchronized 50-joule DC shock
   c. The tracheal dose of adrenaline is 0.5 mg
   d. 50 mL $NaHCO_3$ should be given every 10 minutes
   e. Calcium should be given to renal failure patients on dialysis

105. b 106. b 107. b 108. d 109. b 110. a 111. b 112. e

113. Hypokalemia:
   a. Causes ST segment depression on the ECG
   b. Causes mental depression
   c. Precipitates digoxin toxicity
   d. May precipitate muscle paralysis
   e. Occurs in untreated hyperosmolar non-ketotic diabetic coma

114. After massive inhalation of gastric acid one would expect the following all except:
   a. Lung abscess
   b. Severe hypercapnia
   c. Bacteraemia
   d. Hypovolemia

115. Postoperative hypoxia at 15 minutes may be due to all except:
   a. Mild hypercapnia
   b. Nitrous oxide diffusion
   c. Central depression
   d. Increased V/Q scatter
   e. Shivering

116. Ventricular arrhythmias are more common in the presence of:
   a. Hypokalemia
   b. Hypoxia
   c. Thyrotoxicosis
   d. Cardiopulmonary bypass and digoxin treatment
   e. All of the above

117. Treatment of acute anaphylaxis includes all except:
   a. IM adrenaline
   b. H_1 and H_2 antagonists
   c. Hydrocortisone
   d. IM chlorpromazine
   e. IV salbutamol

118. Air embolus is signified by all except:
   a. ECG changes
   b. Doppler ultrasound
   c. Pulsus paradoxus
   d. Raised CVP
   e. Decreased end-tidal CO_2

119. Total parenteral nutrition for an average adult should include:
   a. Magnesium
   b. 14 grams of nitrogen daily
   c. 1 mL water for each kcal
   d. Fat solutions in hepatic failure
   e. All of the above

120. In carbon monoxide poisoning the following all are seen except:
   a. Arrhythmias
   b. Hypotension
   c. Extensor plantars
   d. Cyanosis
   e. Hyperventilation

121. Pulmonary oxygen toxicity during oxygen therapy is associated with:
   a. Prolonged exposure
   b. High altitude
   c. Increased muscle activity
   d. Increased carbon dioxide tension
   e. Anemia

122. Oxygen toxicity to the lung is due to all except:
   a. Inspired oxygen (FiO_2) above 0.6
   b. Prolonged exposure
   c. Increased arterial partial pressure of oxygen
   d. The effect of oxygen on pulmonary vessels

113. b 114. d 115. b 116. e 117. d 118. c 119. e 120. d
121. a 122. c

123. At 30°C:
   a. Oxygen consumption is one-third that of 37°C
   b. Oxygen solubility is raised
   c. Active rewarming should be commenced
   d. Carbon dioxide solubility is reduced

124. A thyrotoxic crisis should be immediately treated by:
   a. Radioactive iodine
   b. Propranolol
   c. Lugol's iodine
   d. Adrenaline

125. Appropriate management of an acute head injury includes:
   a. Naloxone
   b. Methylprednisolone 30 mg/kg
   c. Hyperventilation to a $PaCO_2$ of 3.3–4 kPa
   d. Mannitol 2 mg/kg

126. All is true about Helium, except:
   a. Is useful in treating bronchospasm
   b. Is stored as liquid in brown cylinders
   c. Has a lower viscosity than oxygen
   d. Causes an alteration in voice

127. A poor prognosis in tetanus is associated with:
   a. A long incubation period
   b. Minimal muscle damage
   c. Distal injury
   d. Severe muscle spasm

128. In patients with hemorrhagic shock, all statements are true, except:
   a. Physiological dead-space is increased
   b. Renal blood flow is decreased
   c. Antidiuretic hormone (ADH) secretion is increased
   d. The oxygen dissociation curve is shifted to the left
   e. Oxygen delivery is decreased

129. Recognized effects of PEEP include all, except:
   a. Sodium retention
   b. Fall in cardiac output
   c. Rise in closing volume
   d. Rise in FRC

130. Raised left ventricular end-diastolic pressure (LVEDP) implies:
   a. Increased left ventricular compliance
   b. Decreased left ventricular systemic work index (LVSWI)
   c. Decreased oxygen flux
   d. Decreased myocardial oxygen demand

131. Pulmonary capillary wedge pressure (PCWP) is a reliable parameter in all, except:
   a. In mitral stenosis
   b. After anterior myocardial infarction
   c. In pulmonary stenosis
   d. In aortic stenosis

132. In septic shock:
   a. Peripheral hypothermia is associated with a good prognosis
   b. The patients usually have an increased cardiac output
   c. The causative organisms are always Gram-negative
   d. Antibiotics should not be given before blood culture results are available

133. An 8-year-old child is rescued 20 minutes after drowning and has a core temperature of 30°C and fixed dilated pupils. Further appropriate treatment includes:
   a. Phenobarbitone
   b. Rapid rewarming
   c. Hypoventilation
   d. Steroids

123. b 124. b 125. c 126. a 127. d 128. d 129. c 130. c
131. a 132. b 133. b

134. The following findings occur with a large pulmonary embolus in all, except:
   a. An increase in pulmonary artery pressure
   b. An increase in right ventricular pressure
   c. An increase in left atrial pressure
   d. An increase in physiological dead-space

135. Increased left ventricular end-diastolic pressure:
   a. Causes increased compliance of the left ventricle
   b. Causes decreased tension in left ventricular wall
   c. Causes decreased left ventricular stroke work index
   d. Occurs in mitral stenosis
   e. All of the above

136. In the oxygen dissociation curve, causes of a right shift include:
   a. Low-molecular-weight dextran
   b. Digitalis
   c. Metabolic acidosis
   d. Respiratory alkalosis

137. An increased alveolar–arterial (A–a) gradient is associated with all, except:
   a. An increased FiO_2
   b. A decreased FiO_2
   c. A decreased FRC
   d. An increased V/Q ratio
   e. An increased shunt

138. Complications of PEEP include all, except:
   a. Alteration of the alveolar–arterial (A–a) gradient
   b. Decreased cardiac output
   c. Increased renal output
   d. Pneumothorax in an emphysematous patient

139. PEEP added to intermittent mandatory ventilation (IMV) is indicated in all, except:
   a. To hasten weaning
   b. If it has already been used for IPPV
   c. If FiO_2^- 0.6 and PaO_2^- 10 kPa
   d. If respiratory rate is greater than 30 breaths per minute

140. All is true about PEEP, except:
   a. Decreases cardiac output
   b. Increases CVP
   c. Increases closing volume
   d. Increases FRC

141. Pulmonary artery capillary wedge pressure can be increased in all, except:
   a. After myocardial infarction
   b. In mitral stenosis
   c. In aortic regurgitation
   d. In pulmonary fibrosis

142. In early sepsis syndrome all are true, except:
   a. Cardiac output is normal
   b. A decreased white cell count is a poor prognostic sign
   c. ACTH levels are low
   d. Insulin is raised
   e. PaO_2 is lowered

134. c 135. e 136. c 137. b 138 c 139. d 140. c 141. d 142. c

143. Features of dissemated intravascular coagulation include in all, except:
    a. A lowered fibrinogen level
    b. A normal prothrombin time and activated partial thromboplastin time
    c. May occur secondary to malaria
    d. May have a compensated phase with no bleeding

143. b

36

Infection Control

1. Growth replication determined by environment:
   a. Bacteria
   b. Fungi
   c. Viruses
   d. Protozoa

2. Tend to mutate or change during replication making it very difficult for a host to develop adequate immunity:
   a. Bacteria
   b. Fungi
   c. Viruses
   d. Protozoa

3. Occurring when respiratory of salivary secretions containing pathogens such as influenza or TB are expelled from the body:
   a. Direct contact
   b. Indirect contact
   c. Droplet transmission
   d. Vector-borne
   e. Nosocomial

4. Causes skin infection:
   a. Staphylococci
   b. Streptococci
   c. Diplococci

5. Genetic material takes over control of the host cell, using the host's capacity for cell metabolism for replication:
   a. Bacteria
   b. Fungi
   c. Viruses
   d. Protozoa

6. AIDS is caused by:
   a. The herpes virus
   b. Poor personal hygiene
   c. The HIV virus
   d. Contaminated

7. Bacteria and viruses can enter the body through:
   a. Oily skin
   b. Dry skin
   c. Broken skin
   d. Moist skin

8. Involving intermediary such as a contaminated hand or food or inanimate objects:
   a. Direct contact
   b. Indirect contact
   c. Droplet transmission
   d. Vector-borne
   e. Nosocomial

1. a 2. c 3. c 4. a 5. c 6. c 7. c 8. b

9. Require oxygen, carbs, a specific pH, temp:
   a. Bacteria
   b. Fungi
   c. Viruses
   d. Protozoa

10. Hand to hand control, they can hide the human cell; they can alter the host cell chromosomes, thus leading to the development of malignant cells or cancer:
   a. Bacteria
   b. Fungi
   c. Viruses
   d. Protozoa

11. A very small parasite that requires a living host cell for replication:
   a. Bacteria
   b. Fungi
   c. Viruses
   d. Protozoa

12. Ultrasonic bath cleaners are an effective way to clean tiny crevices in implements only when used with:
   a. 70% isopropyl alchohol
   b. Sodium hypochlorite
   c. An effective disinfectant
   d. An effective astringent

13. Some remain latent after invasion; they enter the host cells and replicate very slowly or not at all until some later time:
   a. Bacteria
   b. Fungi
   c. Viruses
   d. Protozoa

14. For prevention of catheter related blood stream infections, one of the following is wrong:
   a. Sterile gown
   b. Sterile gloves
   c. Sterile large drops
   d. Shave the site

15. Complications of suctioning, done to clear the secretions include all, except:
   a. Hypoxia
   b. Arrhythmias
   c. Mucosal trauma
   d. Decreased ICD

16. Which one of the following topical aseptic solutions, has lowest incidence of BSI?
   a. 2% chlorhexidine gluconate
   b. 0.5% chlorhexidine gluconate
   c. 10% povidone – iodine
   d. 70% alcohol

17. Delinium in ICU may be due to all, except:
   a. Fever
   b. Inotropes
   c. Excessive sleep
   d. Infections

18. Dexmedetomidine, used in the ICU is ideal because of its:
   a. Long term analgesia
   b. Nonsedative effective
   c. B_1 agonist properties
   d. Noncardiorespiratory depression

19. Antidepressants in the ICU are generally prescribed for which type of pain?
   a. Somatic
   b. Visceral neuropathic
   c. Combination—mixed type

20. What is true about selective decontamination of the oral and digestive tract?
   a. Used in nonventilated patients
   b. Use of topical antimicrobials only
   c. Use of PE antimicrobials only
   d. Use of combination of topical and parenteral antimicrobials

9. a	10. c	11. c	12. c	13. c	14. d	15. d	16. a
17. c	18. d	19. c	20. d				

21. Risk factors for CAUTI include all, except:
    a. Diabetes
    b. Male sex
    c. Malnutrition
    d. Presence of a ureteral stent

22. To reduce the incidence of VAP, all are true, except:
    a. Maximize mechanical ventilation
    b. Reduce colonization of upper respiratory tract
    c. Prevent aspiration
    d. Decontaminate the digestive tract

23. One of the following is not a sedation scoring system:
    a. Addenbroke
    b. Ramsay
    c. BIS
    d. Minneasota

24. Big Bang Theory is associated with:
    a. Infection control
    b. ECMO
    c. Hemodynamic monitoring
    d. Antibiotic prophylaxis

25. Josesph Lister in 1867 introduced:
    a. Antibiotics
    b. Gloves
    c. Masks
    d. Laryngeal masks

26. The following are prophylactic measures for infection control, except:
    a. Hand hygiene
    b. Space between beds
    c. Antibiotic prophylaxis
    d. Glove and gown hygiene

27. Factors that increase cross infections are all, except:
    a. Excessive antibiotic use
    b. Isolation facilities
    c. Overtoffing
    d. Lack of isolation facilities

28. One of the following in true for hand-washing hygiene:
    a. Alcohol based hand sanitizers are ubiquitous
    b. Alcohol based hand sanitizers are not easy to use
    c. They are not effective bactericidal agents
    d. 40-50% alcohol strength is adequate

29. When an insect or animal serves as an intermediary in a disease such as malaria:
    a. Direct contact
    b. Indirect contact
    c. Droplet transmission
    d. Vector–borne

30. More complex organism, unicellular, mobile, lack a cell wall and may change shapes:
    a. Bacteria
    b. Fungi
    c. Viruses
    d. Protozoa

31. One of the following is not isolated with increasing frequency in the ICU?
    a. MRSA
    b. *E. coli*
    c. VRE
    d. Streptococci

32. The best composition of catheters to present CAUTI is:
    a. Aluminum
    b. Silicone
    c. Gold
    d. Silver

21. b 22. b 23. d 24. a 25. a 26. c 27. c 28. a
29. d 30. d 31. b 32. d

37

Extracorporeal Membrane Oxygenation

1. Definition of ARDS is all, except:
   a. Chronic Onset
   b. Vilateral unfiltrate
   c. R/o cardiogenic (PCWP <18)
   d. Hypoxemia
2. This is a PA view X-ray of:

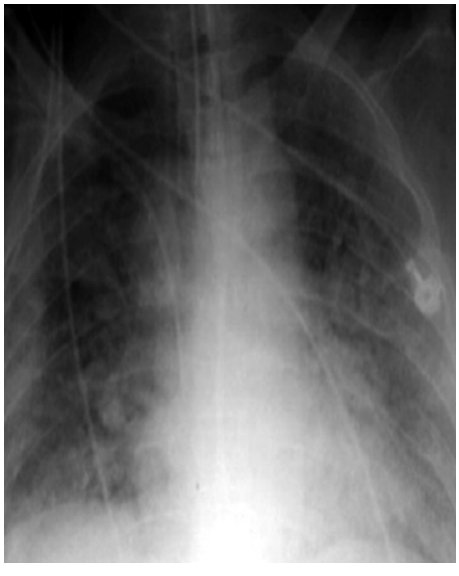


Fig. 37.1

   a. Eisenmenger's syndrome
   b. ARDS
   c. Ebstein anomaly
   d. Patient of TR postoperative
3. Criticisms of definition for ARDS is all, except:
   a. What constitutes B infiltrates?
   b. No head-nod to etiology of ARDS
   c. FIO_2+/–PEEP
   d. Viral cause

1. a 2. b 3. d

4. Non-pulmonary causes for putting on ECMO are all, except:
   a. Pneumonia
   b. Aspiration
   c. Toxic inhalation
   d. Drug underdosage

5. ECMO *NOT* for:
   a. Sepsis
   b. Coagulopathy
   c. Pancreatitis
   d. Drug overdosage

6. The dynamics of ECMO include:
   a. Deoxygenate
   b. Add carbondioxide
   c. Hemodilute
   d. Oxygenate

7. ECMO is recommended in:
   a. Drug overdoses leading to profound myocardial depression
   b. Asepsis
   c. Non-viral infections
   d. Compensated cardiomyopathy

8. What is true about veno-arterial ECMO?
   a. Blood drained from venous system and returned to the arterial system
   b. Does not provide respiratory support
   c. Achieved by only central cannulation
   d. Achieved by only peripheral cannulation

9. Cesar Trial in ECMO was done for:
   a. Pediatric cardiac arrest
   b. Adult cardiac arrest
   c. Pediatric respiratory failure
   d. Adult respiratory failure

10. Basic ECMO flow is:
    a. 80-100 ml/kg/min
    b. 2-3 ml/kg/min
    c. 100-120 ml/kg/min
    d. 10-15 ml/kg/min

11. The goal of ECMO use for respiratory failure is to:
    a. Allow time for the reactive nature of the pulmonary vasculature to subside or decrease in intensity
    b. Allow time for parenchymal lung processes to heal
    c. Provide adequate oxygenation and ventilation without barotrauma and oxygen toxicity
    d. All of the above

12. When assessing a patient's oxygenation status on VV ECMO, which of the following is the best indicator of adequacy of oxygenation?
    a. Patient arterial saturation
    b. Patient PaO_2
    c. Pre-membrane saturation
    d. All of the above

13. The following factors influence oxygenation on VV ECMO with no native lung function:
    a. Pump flow rate
    b. Recirculation
    c. Cardiac output
    d. All of the above

14. Why are heat exchangers used in ECMO made of stainless steel?
    a. Reduced corrosion
    b. Less expensive
    c. Superior heating characteristics
    d. More durable

4. d 5. b 6. d 7. a 8. a 9. d 10. a 11. d
12. c, d 13. d 14. c

15. In VA ECMO, a circuit venous saturation monitor can help determine:
    a. Amount of recirculation
    b. Adequacy of oxygen delivery
    c. Direct measure of oxygen utilization
    d. Membrane function

16. Correctly label the following picture from the words given below dash line:

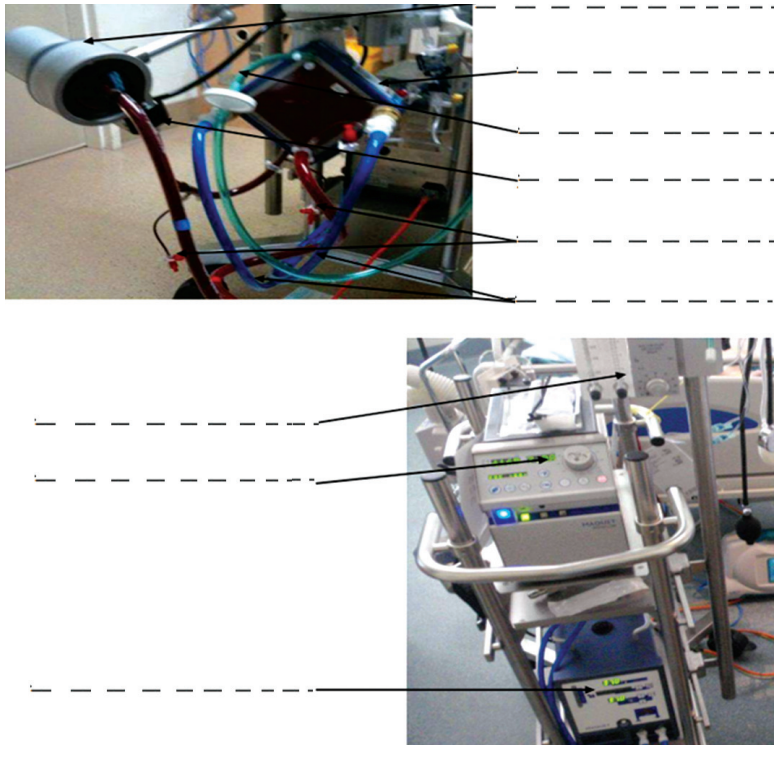


Fig. 37.2

- Oxygenator
- O_2 supply
- Warming lines
- O_2/Gas flow control
- Flow control
- Rotaflow
- Flow sensor
- CVVHDF connection points
- Fluid warmer

17. ECMO therapy is indicated for:
    a. Life threatening respiratory failure not responding to antibiotic treatment
    b. Elderly long term ventilated patient who shows little improvement
    c. Life threatening cardiac failure where patient is unsuitable for surgery
    d. Patient with a potentially reversible life threatening respiratory/cardiac failure unresponsive to conventional therapy

15. b 16. Labels 17. d

18. ECMO treatment:
    a. Is a short term measure that supports the work of the lungs
    b. Is a long term treatment and the patient will need a lung transplant
    c. May last several days to weeks and replaces the work of the lungs
    d. Is only used for treating H1N1

19. ECMO treatment in ICU at the RAH…more than one correct answer:
    a. Is overseen by an ECMO trained intensivist
    b. Can be done on any patient
    c. Uses a Quadrox-D Oxygenator
    d. Cannot be done on patients with MRSA

20. The Quadrox–D oxygenator…all are correct, except:
    a. Is a hollow fiber membrane
    b. Has an integrated heat exchanger
    c. Readily leaks plasma
    d. Is heparin bonded
    e. Can develop clots

21. In VV ECMO if the color of the access blood is the same as the return blood, bright red, this indicates:
    a. The patients lungs are very sick
    b. The patients lungs are improving
    c. The blood is recirculating through the circuit
    d. Nothing, this is normal
    e. The oxygenator is failing

22. To maintain sterility and decrease the incidence of infections, all bloodied circuit components should be cleaned with:
    a. Alcohol
    b. Remove adhesive wipes
    c. Persist plus
    d. Neutral detergent and water

23. Hemolysis can be caused by…more than one correct answer:
    a. Thrombus in the pump head
    b. Continuing enteric feeding
    c. Thrombus in the oxygenator
    d. Poor blood access flow to required pump flow ratio

24. Please identify this picture:

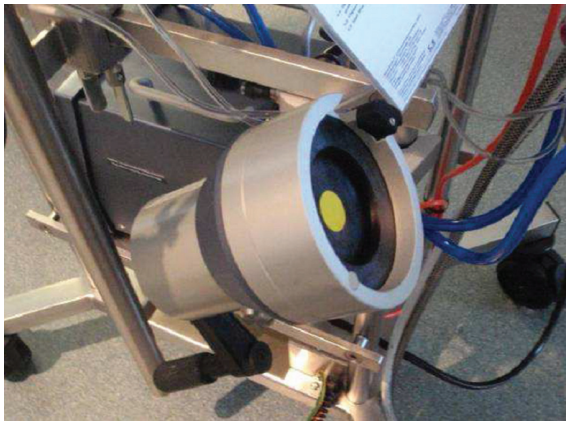


Fig. 37.3

18. c 19. a, c 20. c 21. c 22. d 23. a, c, d

a. ECMO circuit
b. Heat exchanger
c. Membrane oxygenator
d. Emergency hand crank

25. If the emergency hand crank is required…more than one correct answer:
a. It should only be used by the more experienced person present
b. It is able to maintain the required flow for an indefinite period
c. Is able to provide electronic blood flow monitoring for display on the flow control monitor
d. Revolutions indicated on the hand crank LED display will allow up to 3000 rpm

26. Approximate internal battery life with the Jostra pump running at 3000 rpm is:
a. 25 minutes
b. 45 minutes
c. 65 minutes
d. 90 minutes

27. The maximum recommended blood flow through the Quadrox-D oxygenator is:
a. 5 liters/min
b. 7 liters/min
c. 9 liters/min
d. 11 liters/min

28. The maximum gas flow through the Quadrox-D oxygenator is:
a. 6 liters/min
b. 8 liters/min
c. 10 liters/min
d. 12 liters/min

29. You see significant air in the ECMO circuit tubing, the FIRST thing you should do is:
a. Turn the pump off
b. Ring the perfusionist
c. Ring the intensivist
d. Place patient in a steep Trendelenburg position
e. Clamp the lines

30. Plasma free hemoglobin is measured BD it is:
a. Standard measurement of Hb level
b. Measurement of plasma to Hb ratio
c. Measurement of Hb that has been liberated from RBCs into plasma as a result of
d. Hemolysis
e. Another unnecessary costly blood test

31. Pre- and post-oxygenator membrane pressures are recorded on the Phillips monitor as UVP and UAP (these labels are essentially meaningless!!) the importance of the recording is…more than one correct answer:
a. Indicates sudden changes in mean arterial pressure
b. The ideal pre- to post-pressure drop (transmembrane pressure gradient) should be less than 60 mm Hg
c. Increased pressure drop may indicate thrombus formation within the oxygenator
d. Gradual changes in trans-membrane pressure drop is a sign that the oxygenator may need replacing

32. During patient positioning the ECMO circuit was accidentally pulled-on, subsequently an odd "clattering" sound is noted coming from the Jostra pump head, what does this indicate and how is it fixed? More than one correct answer:
a. The circuit is clotted and needs to be changed
b. The flow magnets within the pump head has become misaligned with the pump magnets
c. Blood flow should be reduced to zero briefly to allow repositioning of pump head then flow is gradually turned back up to previous level
d. Call the perfusionist if problem not quickly corrected

24. d. 25. b, d 26. d 27. b 28. c 29. e
30. c 31. b, c, d 32. b, c, d

33. Oral care is important in all patients. Oral care for ECMO patients…more than one correct answer
    a. Is the standard ICU protocol
    b. Has the potential to cause severe oral bleeding exists
    c. Should not be performed
    d. Can be performed using a gentle care with soft swabs, avoid use of a tooth brush

34. Complete the statements below using following list:

- Lubricating grease
- Is immediately available
- Duoderm
- Glad wrap
- Rescue ventilator orders
- Elevate limbs
- Not
- Drying out
- SIG
- Bedside whiteboard
- Movements
- Creases
- Multiple clamps

    a. Ensure the second ECMO machine _____.
    b. The emergency contact numbers for the on-call Perfusionist and ECMO Intensivist are located on the _____.
    c. For use during possible emergencies such as accidental disconnection, pump failure or air embolus it is necessary to have ready available _____.
    d. Flow signal is maintained by wrapping _____ around the flow sensor thereby reducing _____on the channel.
    e. A tube of _____is located on top of the machine.
    f. Drying out of the flow monitoring channel around the circuit will lead to a _____alarm.
    g. This is _____a life threatening development.
    h. _____ are noted and attached to the ventilator.
    i. Other than turning what other ways are used to reduce pressure area and maintain integument, _____on pillow, use barriers such as _____on pressure points, regular slight limb_____ and minimize _____ on pillow and linen.

35. When taking a plasma free Hb…more than one correct answer:
    a. Use a vacuette to collect specimen
    b. Shake specimen several times prior to sending via the shute
    c. Hand carry specimen to the IMVS
    d. Use a green or purple specimen bottle

36. How often is plasma free Hb measured?
    a. Every 5 minutes for 3 hours
    b. Every 10 minutes for 6 hours
    c. Hourly for the life of the ECMO circuit
    d. Following the ICU ECMO first 24 hours blood test checklist, then BD

37. The ACT measurement should be:
    a. <130
    b. 130-150
    c. 150-180
    d. >180

33. b, d
34. a. is immediately available; b. bedside whiteboard; c. multiple clamps; d. glad wrap, drying out; e. lubricating grease; f. SIG; g. not; h. rescue ventilation orders, ECMO intensivist; i. elevate limbs, duoderm, movements, creases
35. c, d 36. d 37. c

38. An adequate platelet level while on ECMO is:
    a. <50,000
    b. 60,000
    c. 70,000
    d. >80,000

39. Why is it important to connect the dialysis circuit after the Rotaflow pump?
    a. Its not important, does not make any difference
    b. That's where the manufacturer put the connections
    c. Before the pump negative pressure is created which risks drawing in air
    d. So dialysed blood can be reoxygenated

40. During the weaning of a patient on VV ECMO we…more than one correct answer:
    a. Sometimes need to reverse heparin with protamine
    b. Always need to reduce the blood flow
    c. Lower the heparin infusion rate
    d. May have a reduction in the gas flow
    e. Should increase the ventilation via the ventilator

41. Complete the statements below using following list:
    - Hemostasis
    - 4 hours
    - 6
    - Decannulation
    - Two intensivists
    - Clot dislodgement

    If the patient is stable without ECMO support for _____ hours then _____ may be considered. The heparin is held for _____. Cannula would then removed by _____, one of which would stay with the patient until_____ has been achieved. Increased sedation may be required during this period to prevent _____.

42. Who succeeded in performing first ECMO when the patient survived:
    a. Hill
    b. Bartlett
    c. Gattinoni
    d. Baffes

43. Indications for ECMO are all, except:
    a. Bridge to heart or lung transplantation
    b. Pneumonia associated ARDS, refractory to conventional therapy
    c. Pulmonary embolism
    d. Hemodynamic support in patient with severe aortic regurgitation

44. Criteria for ECMO are all, except:
    a. Oxygen index >40%
    b. Muray's score >3.0
    c. Q – A gradient >600
    d. Patient on ventilator for > 15 days

45. Pathological conditions suitable for V-V ECMO are all, except:
    a. Status asthmaticus
    b. ARDS
    c. Drug overdose with profound cardiac depression
    d. Pneumonia

38. d 39. c 40. d, e
41. 6, decannulation, 4 hours, two intensivists, hemostasis, clot dislodgement
42. b 43. d 44. d 45. c

46. Pathological condition suitable for V-A ECMO are, except:
    a. Cardiogenic shock
    b. Unable to wean off cardiopulmonary bypass postcardiac surgery
    c. Alveolar proteinosis
    d. Pulmonary embolism

47. Absolute contraindication to all forms of ECMO is:
    a. Age > 65
    b. Multiple organ failure
    c. Alveolar proteinosis
    d. Status asthmaticus

48. The most appropriate statement regarding veno-venous ECMO is
    a. A minimum of 2 cannulae are required
    b. Hemorrhage is rare
    c. Thrombocytopenia is not commonly encountered
    d. V-V ECMO can be continued during patient transportation

49. Veno-venous ECMO relies on which organ to function normally?
    a. Kidney
    b. Liver
    c. Heart
    d. Lung

50. The roller pump uses _____ to pull blood into the biohead and direct it through the circuit.
    a. Positive displacement
    b. Afterload
    c. Constrained vortex
    d. Preload

51. Advantages of the roller pump include:
    a. Low hemolysis
    b. Traps air
    c. Constant flow with variable preload
    d. Reduced likelihood of cavitation

52. The oxygenator membrane is made of what material?
    a. Polycarbonate
    b. Silicon rubber
    c. Tygon
    d. Polyvinyl chloride

53. The ACT might be prolonged in all of the following circumstances, except:
    a. Active patient diuresis
    b. Oliguria
    c. Thrombocytopenia
    d. DIC

54. Low levels of AT III in a patient on ECMO bypass may lead to:
    a. Bleeding
    b. Thrombocytopenia
    c. Hemolysis
    d. Heparin resistance

55. The ACT or Activated clotting time is:
    a. A bedside test of 'true' clotting time
    b. Equivalent to the PT
    c. A bedside test of clotting function using an accelerant to obtain a quick result
    d. An unreliable test of clotting function

56. A heparin bolus is given to the patient prior to ECMO cannulation in order to:
    a. Prevent clotting of the ECMO cannula during the procedure
    b. Calibrate the bedside ACT machine
    c. Act as an antifibrinolytic on pre-existing clots

46. c 47. a 48. d 49. b 50. a 51. c
52. b 53. a 54. d 55. c 56. a

57. Amicar (Aminocaproic acid) is used in the ECMO patient to:
    a. Prevent clotting
    b. Potentiate the action of heparin
    c. Prevent lysis of pre-existing clots
    d. Prevent thrombocytopenia

58. Cryoprecipitate is the blood product of choice for a patient on ECMO to treat:
    a. Low fibrinogen levels
    b. Factor depletion
    c. Hypovolemia
    d. AT III deficiency

59. Platelets should be transfused:
    a. On the venous side of the circuit
    b. Every 8 hours around the clock
    c. When the PTT is prolonged
    d. Post oxygenator

60. Bleeding on ECMO may be treated in the following manner:
    a. Decrease ACT goals to 180 - 200 or lower.
    b. Use of aminocaproic acid (Amicar)
    c. Give inotropes to increase blood pressure
    d. Correction of coagulation studies

57. c 58. a 59. d 60. b