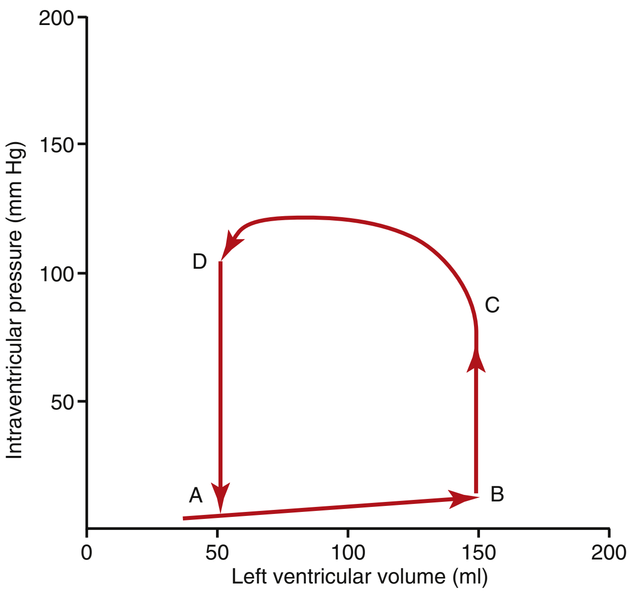
UNIT III

الاسئلة الي معنا عندها لون احمر ، ممكن في اسئله معنا ما انتبهت الها
ممكن في اسئلة مش النا بس محددة
نعتذر عن الخطأً إن ورد
الإجابات في نهاية الملف
بالتوفيق

The Heart

Questions 1–4

A 60-year-old woman has a resting heart rate of 70 beats per minute, arterial pressure of 130/85 mm Hg, and normal body temperature. Use the pressure-volume diagram of her left ventricle below to answer Questions 1–4.



1. What is her cardiac output in milliliters per minute?
   A) 2000
   B) 3000
   C) 4000
   D) 6000
   E) 7000

2. When does the first heart sound occur in the ventricular pressure–volume relationship?
   A) At point B
   B) Between point A and point B
   C) Between point B and point C
   D) Between point C and point D
   E) Between point D and point A

3. When does the fourth heart sound occur in the ventricular pressure–volume relationship?
   A) At point D
   B) Between point A and point B
   C) Between point B and point C
   D) Between point C and point D
   E) Between point D and point A

4. What is her ventricular ejection fraction?
   A) 33%
   B) 50%
   C) 60%
   D) 67%
   E) 80%

5. Which statement about cardiac muscle is most accurate?
   A) The T-tubules of cardiac muscle can store much less calcium than the T-tubules in skeletal muscle
   B) The strength and contraction of cardiac muscle depends on the amount of calcium surrounding cardiac myocytes
   C) In cardiac muscle, the initiation of the action potential causes an immediate opening of slow calcium channels
   D) Cardiac muscle repolarization is caused by opening of sodium channels
   E) Mucopolysaccharides inside the T-tubules bind chloride ions

6. A 30-year-old man has an ejection fraction of 0.25 and an end-systolic volume of 150 milliliters. What is his end-diastolic volume?
   A) 50 milliliters
   B) 100 milliliters
   C) 125 milliliters
   D) 200 milliliters
   E) 250 milliliters

7. In a resting adult, the typical ventricular ejection fraction has what value?
   A) 20%
   B) 30%
   C) 40%
   D) 60%
   E) 80%

8. In which phase of the ventricular muscle action potential is the potassium permeability the highest?
   A) 0
   B) 1
   C) 2
   D) 3
   E) 4

9. A 60-year-old man's ECG shows that he has an R-R interval of 1.5 seconds at rest. Which statement best explains his condition?
   A) He has fever
   B) He has a normal heart rate
   C) He has decreased parasympathetic stimulation of the S-A node
   D) He is a trained athlete at rest
   E) He has normal polarization of the S-A node

10. Which of the following is most likely to cause the heart to go into spastic contraction?
   A) Increased body temperature
   B) Increased sympathetic activity
   C) Decreased extracellular fluid potassium ions
   D) Excess extracellular fluid potassium ions
   E) Excess extracellular fluid calcium ions

11. What happens at the end of ventricular isovolumic relaxation?
   A) The A-V valves close
   B) The aortic valve opens
   C) The aortic valve closes
   D) The mitral valve opens
   E) The pulmonary valve closes

12. Which event is associated with the first heart sound?
   A) Closing of the aortic valve
   B) Inrushing of blood into the ventricles during diastole
   C) Beginning of diastole
   D) Opening of the A-V valves
   E) Closing of the A-V valves

13. Which condition will result in a dilated, flaccid heart?
   A) Excess calcium ions in the blood
   B) Excess potassium ions in the blood
   C) Excess sodium ions in the blood
   D) Increased sympathetic stimulation
   E) Increased norepinephrine concentration in the blood

14. A 25-year-old well-conditioned athlete weighs 80 kilograms (176 pounds). During maximal sympathetic stimulation, what is the plateau level of his cardiac output function curve?
   A) 3 liters per minute
   B) 5 liters per minute
   C) 10 liters per minute
   D) 13 liters per minute
   E) 25 liters per minute

15. Which phase of the cardiac cycle follows immediately after the beginning of the QRS wave?
   A) Isovolumic relaxation
   B) Ventricular ejection
   C) Atrial systole
   D) Diastasis
   E) Isovolumic contraction

16. Which of the following structures will have the slowest rate of conduction of the cardiac action potential?
   A) Atrial muscle
   B) Anterior internodal pathway
   C) A-V bundle fibers
   D) Purkinje fibers
   E) Ventricular muscle

17. What is the normal total delay of the cardiac impulse in the A-V node + bundle?
   A) 0.22 second
   B) 0.18 second
   C) 0.16 second
   D) 0.13 second
   E) 0.09 second

18. Sympathetic stimulation of the heart does which of the following?
   A) Releases acetylcholine at the sympathetic endings
   B) Decreases sinus nodal discharge rate
   C) Decreases excitability of the heart
   D) Releases norepinephrine at the sympathetic endings
   E) Decreases cardiac contractility

19. If the S-A node discharges at 0.00 seconds, when will the action potential normally arrive at the epicardial surface at the base of the left ventricle?
   A) 0.22 second
   B) 0.18 second
   C) 0.16 second
   D) 0.12 second
   E) 0.09 second

20. Which condition at the A-V node will cause a decrease in heart rate?
   A) Increased sodium permeability
   B) Decreased acetylcholine levels
   C) Increased norepinephrine levels
   D) Increased potassium permeability
   E) Increased calcium permeability

21. Which statement best explains how sympathetic stimulation affects the heart?
   A) The permeability of the S-A node to sodium decreases
   B) The permeability of the A-V node to sodium decreases
   C) The permeability of the S-A node to potassium increases
   D) There is an increased rate of upward drift of the resting membrane potential of the S-A node
   E) The permeability of the cardiac muscle to calcium decreases

22. What is the membrane potential (threshold level) at which the S-A node discharges?
A) −40 millivolt
B) −55 millivolt
C) −65 millivolt
D) −85 millivolt
E) −105 millivolt

23. Which condition at the S-A node will cause heart rate to decrease?
A) Increased norepinephrine level
B) Increased sodium permeability
C) Increased calcium permeability
D) Increased potassium permeability
E) Decreased acetylcholine level

24. In which phase of the ventricular muscle action potential is the sodium permeability the highest?
A) 0
B) 1
C) 2
D) 3
E) 4

25. If the S-A node discharges at 0.00 seconds, when will the action potential normally arrive at the A-V bundle (bundle of His)?
A) 0.22 second
B) 0.18 second
C) 0.16 second
D) 0.12 second
E) 0.09 second

26. If the Purkinje fibers, situated distal to the A-V junction, become the pacemaker of the heart, what is the expected heart rate?
A) 30/min
B) 50/min
C) 60/min
D) 70/min
E) 80/min

27. If the S-A node discharges at 0.00 seconds, when will the action potential normally arrive at the A-V node?
A) 0.03 second
B) 0.09 second
C) 0.12 second
D) 0.16 second
E) 0.80 second

28. What is the delay between the S-A node discharge and arrival of the action potential at the ventricular septum?
A) 0.80 second
B) 0.16 second
C) 0.12 second
D) 0.09 second
E) 0.03 second

29. A patient had an ECG at the local emergency department. The attending physician stated that the patient had an A-V nodal rhythm. What is the likely heart rate?
A) 30/min
B) 50/min
C) 65/min
D) 75/min
E) 85/min

30. Which condition at the A-V node will cause a decrease in heart rate?
A) Increased sodium permeability
B) Decreased acetylcholine level
C) Increased norepinephrine level
D) Increased potassium permeability
E) Increased calcium permeability

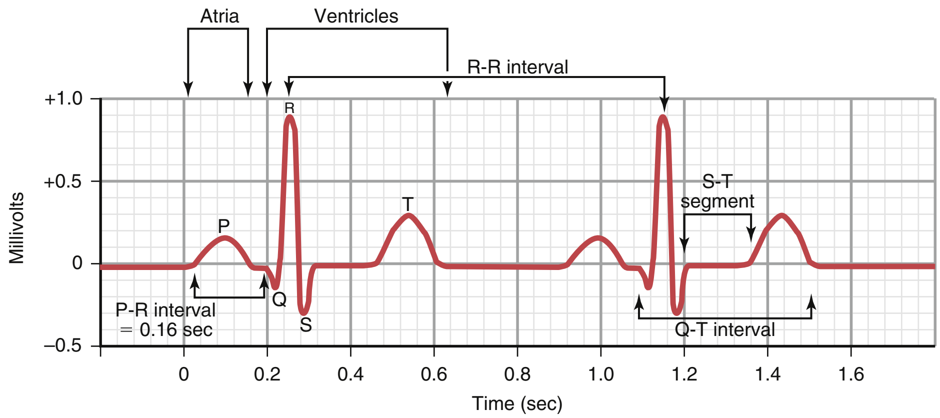
31. When recording lead aVL on an ECG, which is the positive electrode?
A) Left arm
B) Left leg
C) Right leg
D) Left arm + left leg
E) Right arm + left leg

32. When recording lead II on an ECG, the right arm is the negative electrode and the positive electrode is the
A) Left arm
B) Left leg
C) Right leg
D) Left arm + left leg
E) Right arm + left leg

33. Sympathetic stimulation of the heart normally causes which condition?
A) Acetylcholine release at the sympathetic endings
B) Decreased heart rate
C) Decreased rate of conduction of the cardiac impulse
D) Decreased force of contraction of the atria
E) Increased force of contraction of the ventricles

Questions 34 and 35

A 70-year-old woman had an ECG at her annual checkup. Use her lead II recording below to answer Questions 34 and 35.



34. What is her heart rate in beats per minute?
    A) 70
    B) 78
    C) 84
    D) 94
    E) 104

35. According to Einthoven's law, if the QRS voltage in lead III is 0.4 millivolt, what is the QRS voltage in lead I?
    A) 0.05 millivolt
    B) 0.50 millivolt
    C) 1.05 millivolts
    D) 1.25 millivolts
    E) 2.05 millivolts

36. What is the normal QT interval?
    A) 0.03 second
    B) 0.13 second
    C) 0.16 second
    D) 0.20 second
    E) 0.35 second

37. When recording lead II on an ECG, the negative electrode is the
    A) Right arm
    B) Left leg
    C) Right leg
    D) Left arm + left leg
    E) Right arm + left leg

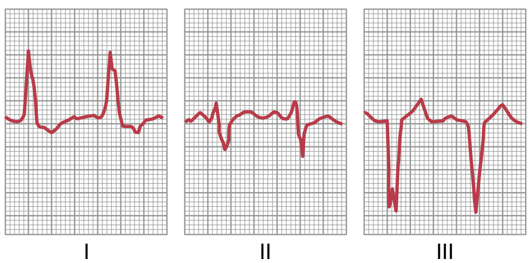
38. When recording lead I on an ECG, the right arm is the negative electrode and the positive electrode is the
    A) Left arm
    B) Left leg
    C) Right leg
    D) Left arm + left leg
    E) Right arm + left leg

39. A 65-year-old man had an ECG at a local emergency department after a biking accident. His weight was 80 kilograms (176 pounds), and his aortic blood pressure was 160/90 mm Hg. The QRS voltage was 0.5 millivolt in lead I and 1.5 millivolts in lead III. What is the QRS voltage in lead II?
    A) 0.5 millivolt
    B) 1.0 millivolt
    C) 1.5 millivolts
    D) 2.0 millivolts
    E) 2.5 millivolts

40. A ventricular depolarization wave, when traveling –60 degrees in the frontal plane, will cause a large negative deflection in which lead?
    A) aVR
    B) aVL
    C) Lead II
    D) Lead III
    E) aVF

Questions 41–43

A 60-year-old woman had an ECG recorded at a local emergency department after an automobile accident. Her weight was 70 kilograms (154 pounds), and her aortic blood pressure was 140/80 mm Hg. Use this information and the figure below to answer Questions 41–43.



41. What is the mean electrical axis calculated from standard leads I, II, and III shown in the woman's ECG?
   A) −90 degrees
   B) −50 degrees
   C) −12 degrees
   D) +100 degrees
   E) +170 degrees

42. What is the heart rate using lead I for the calculation?
   A) 70
   B) 88
   C) 100
   D) 112
   E) 148

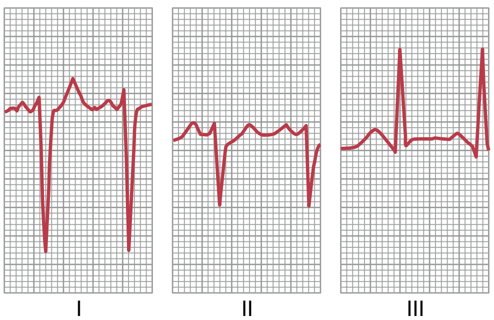
43. What is her likely diagnosis?
   A) Tricuspid valve stenosis
   B) Left bundle branch block
   C) Pulmonary valve stenosis
   D) Pulmonary valve insufficiency
   E) Aortic insufficiency

44. Which condition will usually result in left axis deviation in an ECG?
   A) Systemic hypertension
   B) Pulmonary valve stenosis
   C) Pulmonary valve regurgitation
   D) Rightward angulation of the heart
   E) Pulmonary hypertension

45. A ventricular depolarization wave, when traveling 60 degrees in the frontal plane, will cause a large positive deflection in which of the following leads?
   A) aVR
   B) aVL
   C) Lead I
   D) Lead II
   E) aVF

Questions 46 and 47

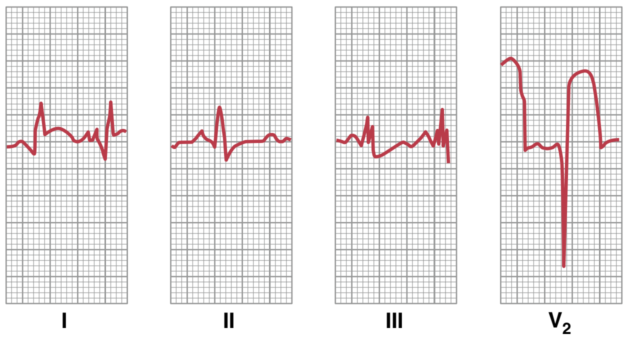
A 50-year-old woman was admitted to a local emergency department after a motorcycle accident. The following ECG was obtained.



46. What is her heart rate? Use lead I for the calculation.
   A) 56
   B) 66
   C) 76
   D) 103
   E) 152

47. What type of murmur is present in this patient?
   A) Aortic valve insufficiency
   B) Left bundle branch block
   C) Pulmonary valve stenosis
   D) Right bundle branch block
   E) Systemic hypertension

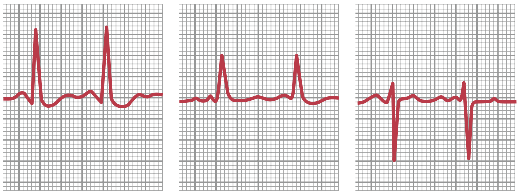
48. Mr. Smith had an ECG at a local hospital, but his records were lost. The ECG technician remembered that the QRS deflection was large and positive in lead II and 0 in aVL. What is his mean electrical axis in the frontal plane?
   A) 90 degrees
   B) 60 degrees
   C) 0 degree
   D) −60 degrees
   E) −90 degrees



49. A 70-year-old woman came to a hospital emergency department because she was experiencing chest pain. Based on the ECG shown above, what is the likely diagnosis?
   A) Acute anterior infarction in the left ventricle of the heart
   B) Acute anterior infarction in the right ventricle of the heart
   C) Acute posterior infarction in the left ventricle of the heart
   D) Acute posterior infarction in the right ventricle of the heart
   E) Right ventricular hypertrophy

50. A 55-year-old man underwent an ECG at an annual physical, and his net deflection (R wave minus Q or S wave) in standard limb lead I was −1.2 millivolts. Standard limb lead II has a net deflection of +1.2 millivolts. What is the mean electrical axis of his QRS?
   A) −30 degrees
   B) +30 degrees
   C) +60 degrees
   D) +120 degrees
   E) −120 degrees

51. During the T-P interval in an ECG of a patient with a damaged cardiac muscle, which of the following is true?
A) The entire ventricle is depolarized
B) The entire ventricle is depolarized except for the damaged cardiac muscle
C) About half the ventricle is depolarized
D) The entire ventricle is repolarized
E) The entire ventricle is repolarized except for the damaged cardiac muscle

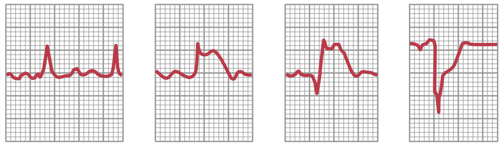


52. A 50-year-old man is a new employee at ABC Software. The above ECG was recorded during a routine physical examination. What is his likely diagnosis?
A) Chronic systemic hypertension
B) Chronic pulmonary hypertension
C) Second-degree heart block
D) Paroxysmal tachycardia
E) Tricuspid valve stenosis

53. A 30-year-old man had an ECG at his physician's office, but his records were lost. The ECG technician remembered that the QRS deflection was large and positive in lead aVF and 0 in lead I. What is the mean electrical axis in the frontal plane?
A) 90 degrees
B) 60 degrees
C) 0 degree
D) −60 degrees
E) −90 degrees

54. A 60-year-old woman tires easily. Her ECG shows a QRS complex that is positive in the aVF lead and negative in standard limb lead I. What is a likely cause of this condition?
A) Chronic systemic hypertension
B) Pulmonary hypertension
C) Aortic valve stenosis
D) Aortic valve regurgitation

55. A 65-year-old patient with a heart murmur has a mean QRS axis of 120 degrees, and the QRS complex lasts 0.18 second. What is the likely diagnosis?
A) Aortic valve stenosis
B) Aortic valve regurgitation
C) Pulmonary valve stenosis
D) Right bundle branch block
E) Left bundle branch block



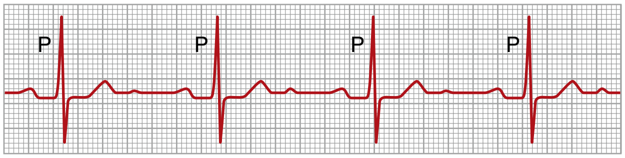
56. A 60-year-old woman came to the hospital emergency department and reported chest pain. Based on the ECG tracing shown above, what is the most likely diagnosis?
A) Acute anterior infarction in the base of the heart
B) Acute anterior infarction in the apex of the heart
C) Acute posterior infarction in the base of the heart
D) Acute posterior infarction in the apex of the heart
E) Right ventricular hypertrophy

57. A 50-year-old man has been having fainting "spells" for about 2 weeks. During the episodes, his ECG shows a ventricular rate of 25 beats/min and 100 P waves per minute. After about 30 seconds of fainting, a normal sinus rhythm recurs. What is his likely diagnosis?
A) Atrial flutter
B) First-degree A-V block
C) Second-degree A-V block
D) Third-degree A-V block
E) Stokes-Adams syndrome

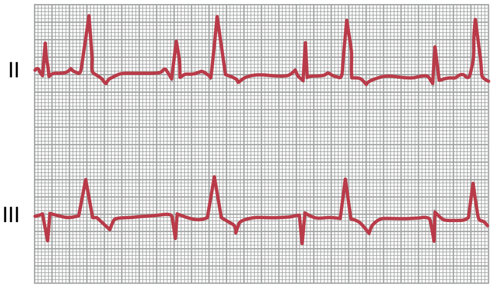
58. An 80-year-old man had an ECG taken at his local doctor's office, and the diagnosis was atrial fibrillation. Which condition is likely in someone with atrial fibrillation?
A) Ventricular fibrillation, which normally accompanies atrial fibrillation
B) Strong P waves on the ECG
C) An irregular and fast rate of ventricular contraction
D) A normal atrial "a" wave
E) A smaller atrial volume than normal

59. Circus movements in the ventricle can lead to ventricular fibrillation. Which condition in the ventricular muscle will increase the tendency for circus movements?
A) Decreased refractory period
B) Low extracellular potassium concentration
C) Increased refractory period
D) Shorter conduction pathway (decreased ventricular volume)
E) Increase in parasympathetic impulses to the heart

60. A 50-year-old man has a blood pressure of 140/85 mm Hg and weighs 90.7 kilograms (200 pounds). He reports that he is not feeling well, his ECG has no P waves, he has a heart rate of 46 beats/min, and the QRS complexes occur regularly. What is his likely condition?
A) First-degree heart block
B) Second-degree heart block
C) Third-degree heart block
D) Sinoatrial heart block
E) Sinus bradycardia



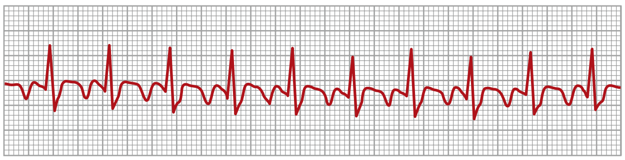
61. The following ECG tracing was obtained for a 60-year-old man who weighs 99.8 kilograms (220 pounds). Standard lead II is shown above. What is his diagnosis?
    - A) A-V nodal rhythm
    - B) First-degree A-V heart block
    - C) Second-degree A-V heart block
    - D) Third-degree A-V heart block
    - E) Atrial flutter



62. A 35-year-old woman had unusual sensations in her chest after she smoked a cigarette. Her ECG tracing is shown above. What is the likely diagnosis?
    - A) Premature contraction originating in the atrium
    - B) Premature contraction originating high in the A-V node
    - C) Premature contraction originating low in the A-V node
    - D) Premature contraction originating in the apex of the ventricle
    - E) Premature contraction originating in the base of the ventricle

Questions 63 and 64

A 55-year-old man had the below ECG tracing recorded at his doctor's office at a routine physical examination. Use this tracing to answer Questions 63 and 64.

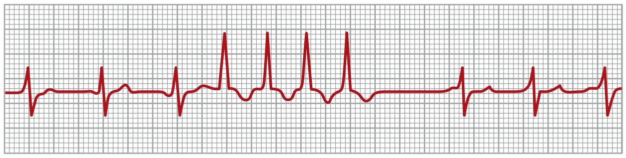


63. What is his diagnosis?
    - A) Normal ECG
    - B) Atrial flutter
    - C) A high A-V junctional pacemaker
    - D) A middle A-V junctional pacemaker
    - E) A low A-V junctional pacemaker

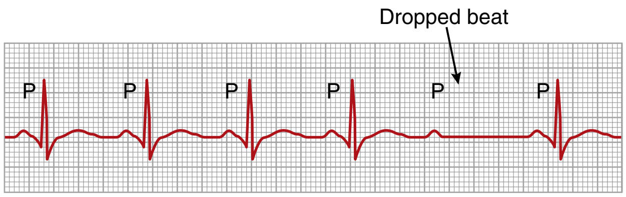
64. What is his ventricular heart rate in beats/min?
    - A) 37.5
    - B) 60
    - C) 75
    - D) 100
    - E) 150

65. What decreases the risk of ventricular fibrillation?
    - A) A dilated heart
    - B) An increased ventricular refractory period
    - C) Decreased electrical conduction velocity
    - D) Exposure of the heart to 60-cycle alternating current
    - E) Epinephrine administration

66. Which of the following will usually result in an inverted P wave that occurs after the QRS complex?
    - A) Premature contraction originating in the atrium
    - B) Premature contraction originating high in the A-V junction
    - C) Premature contraction originating in the middle of the A-V junction
    - D) Premature contraction originating low in the A-V junction
    - E) Atrial fibrillation



67. A 65-year-old woman who had a myocardial infarction 10 days ago returned to her family physician's office and reported that her pulse rate felt rapid. Based on the above ECG tracing, what is the likely diagnosis?
    - A) Stokes-Adams syndrome
    - B) Atrial fibrillation
    - C) A-V nodal tachycardia
    - D) Atrial paroxysmal tachycardia
    - E) Ventricular paroxysmal tachycardia



68. A 65-year-old man had the above ECG tracing recorded at his annual physical examination. What is the likely diagnosis?
    - A) Atrial paroxysmal tachycardia
    - B) First-degree A-V block
    - C) Second-degree A-V block
    - D) Third-degree A-V block
    - E) Atrial flutter

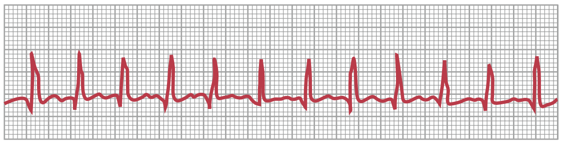
69. A 60-year-old woman has been diagnosed with atrial fibrillation. Which statement best describes this condition?
    A) The ventricular rate of contraction is 140 beats/min
    B) The P waves of the ECG are pronounced
    C) Ventricular contractions occur at regular intervals
    D) The QRS waves are more pronounced than normal
    E) The atria are smaller than normal

70. What occurs after electrical shock of the heart with a 60-cycle alternating current?
    A) A normal arterial pressure
    B) A decreased ventricular refractory period
    C) Increased electrical conduction velocity
    D) A shortened conduction pathway around the heart
    E) Normal cardiac output

71. A 55-year-old man has been diagnosed with Stokes-Adams syndrome. Two minutes after the syndrome starts to cause active blockade of the cardiac impulse, which of the following is the pacemaker of the heart?
    A) Sinus node
    B) A-V node
    C) Purkinje fibers
    D) Cardiac septum
    E) Left atrium

Questions 72 and 73

A man had a myocardial infarction at age 55 years. He is now 63 years old. Use the standard limb lead I tracing on his ECG shown below to answer Questions 72 and 73.

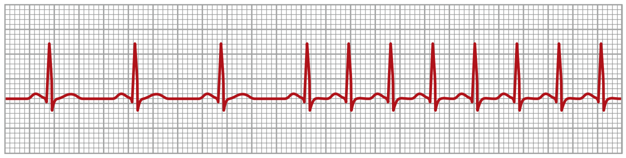


72. What is his heart rate?
    A) 40 beats/min
    B) 50 beats/min
    C) 75 beats/min
    D) 100 beats/min
    E) 150 beats/min

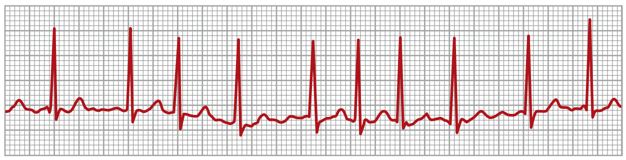
73. What is his current diagnosis?
    A) Sinus tachycardia
    B) First-degree heart block
    C) Second-degree heart block
    D) ST segment depression
    E) Third-degree heart block

74. Which statement best describes a patient with premature atrial contraction?
    A) The pulse taken from the radial artery immediately after the premature contraction will be weak
    B) Stroke volume immediately after the premature contraction will be increased
    C) The P wave is never seen
    D) The probability of these premature contractions occurring is decreased in people with a large caffeine intake
    E) It causes the QRS interval to be lengthened

75. If the origin of the stimulus that causes atrial paroxysmal tachycardia is near the A-V node, which statement about the P wave in standard limb lead I is most accurate?
    A) The P wave will originate in the sinus node
    B) The P wave will be upright
    C) The P wave will be inverted
    D) The P wave will be missing



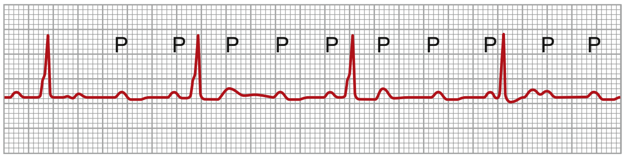
76. A 45-year-old man had the above ECG recorded at his annual physical. What is the likely diagnosis?
    A) Atrial paroxysmal tachycardia
    B) First-degree A-V block
    C) Second-degree A-V block
    D) Ventricular paroxysmal tachycardia
    E) Atrial flutter



77. A 60-year-old woman sees her physician for her annual physical examination. The physician ordered an ECG, which is shown above. What is the likely diagnosis?
    A) First-degree A-V block
    B) Second-degree A-V block
    C) Third-degree A-V block
    D) Atrial paroxysmal tachycardia
    E) Atrial fibrillation

Questions 78 and 79

An 80-year-old man went to his family physician for his annual checkup. Use the ECG tracing shown below to answer Questions 78 and 79.



78. What is his heart rate?

A) 105
B) 95
C) 85
D) 75
E) 37

79. What is the likely diagnosis?

A) Left bundle branch block
B) First-degree A-V block
C) Second-degree A-V block
D) Electrical alternans
E) Complete A-V block

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ANSWERS

1. **E)** This patient has a heart rate of 70 beats per minute. The cardiac output can be determined by using the following formula: cardiac output = heart rate × stroke volume. The stroke volume can be determined from the figure, which is the volume change during the C-D segment, or 100 milliliters. By using this formula, you can determine that the cardiac output is 7000 milliliters per minute.
   TMP13 p. 118

2. **A)** During the diastolic filling phase, the mitral and tricuspid valves open and blood flows into the ventricles. At point B the isovolumic contraction phase begins, which closes the A-V valves. The closing of these valves causes the first heart sound.
   TMP13 p. 114

3. **B)** Between points A and B is the period of ventricular filling. The vibration of the ventricular walls makes this sound after atrial contraction forces more blood into the ventricles.
   TMP13 p. 114

4. **D)** The ejection fraction is the stroke volume/end-diastolic volume. Stroke volume is 100 milliliters, and the end-systolic volume at point D is 150 milliliters. Thus, the ejection fraction is 0.667, or in terms of percentage, 66.7%.
   TMP13 p. 118

5. **B)** The cardiac muscle stores much more calcium in its tubular system than does skeletal muscle and is much more dependent on extracellular calcium than is the skeletal muscle. An abundance of calcium is bound by the mucopolysaccharides inside the T-tubule. This calcium is necessary for contraction of cardiac muscle, and its strength of contraction depends on the calcium concentration surrounding the cardiac myocytes. At the initiation of the action potential, the fast sodium channels open first, which is followed later by opening of the slow calcium channels.
   TMP13 p. 111

6. **D)** The end-diastolic volume is always greater than the end-systolic volume. Multiplication of the ejection fraction by the end-diastolic volume provides the stroke volume, which is 50 milliliters in this problem. Therefore, the end-diastolic volume is 50 milliliters greater than the end-systolic volume and has a value of 200 milliliters.
   TMP13 p. 118

7. **D)** The typical ejection fraction is 60%, and lower values are indicative of a weakened heart.
   TMP13 p. 115

8. **D)** During phase 3 of the ventricular muscle action potential, the potassium permeability of ventricular muscle greatly increases, which causes a more negative membrane potential.
   TMP13 p. 113

9. **D)** Heart rate is determined by the formula 60/R-R interval. The heart rate for this patient is 40 beats per minute. This heart rate is slow, which would occur in a trained athlete. A fever would increase heart rate. Excess parasympathetic stimulation and hyperpolarization of the S-A node both decrease heart rate.
   TMP13 p. 121

10. **E)** The heart goes into spastic contraction after a large increase in the calcium ion concentration surrounding the cardiac myofibrils, which occurs if the extracellular fluid calcium ion concentration increases too much. An excess potassium concentration in the extracellular fluids causes the heart to become dilated because of the decrease in resting membrane potential of the cardiac muscle fibers.
    TMP13 p. 121

11. **D)** At the end of isovolumic relaxation, the mitral and tricuspid valves open, which is followed by the period of diastolic filling.
    TMP13 pp. 117-118

12. **E)** As seen in Chapter 9, the first heart sound by definition occurs just after the ventricular pressure exceeds the atrial pressure, which causes the A-V valves to mechanically close. The second heart sound occurs when the aortic and pulmonary valves close.
    TMP13 p. 114

13. **B)** Having excess potassium ions in the blood and extracellular fluid causes the heart to become dilated and flaccid and also slows the heart. This effect is important because of a decrease in the resting membrane potential in the cardiac muscle fibers. As the membrane potential decreases, the intensity of the action potential decreases, which makes the contraction of the heart progressively weaker. Excess calcium ions in the blood and sympathetic stimulation and increased norepinephrine concentration of the blood all cause the heart to contract vigorously.
    TMP13 p. 121

14. E) The normal plateau level of the cardiac output function curve is 13 L/min. This level decreases in any kind of cardiac failure and increases markedly during sympathetic stimulation.
TMP13 p. 121

15. E) Immediately after the QRS wave, the ventricles begin to contract, and the first phase that occurs is isovolumic contraction. Isovolumic contraction occurs before the ejection phase and increases the ventricular pressure enough to mechanically open the aortic and pulmonary valves.
TMP13 p. 118

16. C) The atrial and ventricular muscles have a relatively rapid rate of conduction of the cardiac action potential, and the anterior internodal pathway also has fairly rapid conduction of the impulse. However, the A-V bundle myofibrils have a slow rate of conduction because their sizes are considerably smaller than the sizes of the normal atrial and ventricular muscle. In addition, their slow conduction is partly caused by diminished numbers of gap junctions between successive muscle cells in the conducting pathway, causing a great resistance to conduction of the excitatory ions from one cell to the next.
TMP13 p. 124

17. D) The impulse from the S-A node travels rapidly through the internodal pathways and arrives at the A-V node at 0.03 second, at the A-V bundle at 0.12 second, and at the ventricular septum at 0.16 second. The total delay is thus 0.13 second.
TMP13 p. 127

18. D) Increased sympathetic stimulation of the heart increases heart rate, atrial contractility, and ventricular contractility and also increases norepinephrine release at the ventricular sympathetic nerve endings. It does not release acetylcholine. It does cause an increased sodium permeability of the A-V node, which increases the rate of upward drift of the membrane potential to the threshold level for self-excitation, thus increasing the heart rate.
TMP13 pp. 121, 128

19. A) After the S-A node discharges, the action potential travels through the atria, through the A-V bundle system, and finally to the ventricular septum and throughout the ventricle. The last place that the impulse arrives is at the epicardial surface at the base of the left ventricle, which requires a transit time of 0.22 second.
TMP13 p. 127

20. D) The increase in potassium permeability causes a hyperpolarization of the A-V node, which will decrease the heart rate. Increases in sodium permeability will actually partially depolarize the A-V node, and an increase in norepinephrine levels increases the heart rate.
TMP13 p. 110

21. D) During sympathetic stimulation, the permeabilities of the S-A node and the A-V node increase. In addition, the permeability of cardiac muscle to calcium increases, resulting in an increased contractile strength. Furthermore, an upward drift of the resting membrane potential of the S-A node occurs. Increased permeability of the S-A node to potassium does not occur during sympathetic stimulation.
TMP13 p. 128

22. A) The normal resting membrane potential of the S-A node is −55 millivolts. As the sodium leaks into the membrane, an upward drift of the membrane potential occurs until it reaches −40 millivolts. This is the threshold level that initiates the action potential at the S-A node.
TMP13 p. 124

23. D) Increases in sodium and calcium permeability at the S-A node result in an increase in heart rate. An increased potassium permeability causes a hyperpolarization of the S-A node, which causes the heart rate to decrease.
TMP13 p. 128

24. A) Sodium permeability is highest during phase 0. Calcium permeability is highest during phase 2, and potassium is most permeable in phase 3.
TMP13 p. 124

25. D) The action potential arrives at the A-V bundle at 0.12 second. It arrives at the A-V node at 0.03 second and is delayed 0.09 second in the A-V node, which results in an arrival time at the bundle of His of 0.12 second.
TMP13 p. 127

26. A) If the Purkinje fibers are the pacemaker of the heart, the heart rate ranges between 15 and 40 beats/min. In contrast, the rate of firing of the A-V nodal fibers are 40 to 60 times a minute, and the sinus node fires at 70 to 80 times per minute. If the sinus node is blocked for some reason, the A-V node will take over as the pacemaker, and if the A-V node is blocked, the Purkinje fibers will take over as the pacemaker of the heart.
TMP13 pp. 127-128

27. A) It takes 0.03 second for the action potential to travel from the S-A node to the A-V node.
TMP13 p. 127

28. B) The impulse coming from the S-A node to the A-V node arrives at 0.03 second. Then there is a total delay of 0.13 second in the A-V node and bundle system, allowing the impulse to arrive at the ventricular septum at 0.16 second.
TMP13 p. 127

29. B) The normal rhythm of the A-V node is 40 to 60 beats per minute. Purkinje fibers have a rhythm of 15 to 40 beats per minute.
TMP13 p. 127

30. D) An increase in potassium permeability causes a decrease in the membrane potential of the A-V node. Thus, it will be extremely hyperpolarized, making it much more difficult for the membrane potential to reach its threshold level for conduction, resulting in a decrease in heart rate. Increases in sodium and calcium permeability and norepinephrine levels increase the membrane potential, causing a tendency to increase the heart rate.
TMP13 p. 128

31. A) By convention, the left arm is the positive electrode for lead aVL of an ECG.
TMP13 p. 136

32. B) By convention, the left leg is the positive electrode for lead II of an ECG.
TMP13 pp. 134–135

33. E) Sympathetic stimulation of the heart normally causes an increased heart rate, increased rate of conduction of the cardiac impulse, and increased force of contraction in the atria and ventricles. However, it does not cause acetylcholine release at the sympathetic endings because they contain norepinephrine. Parasympathetic stimulation causes acetylcholine release. The sympathetic nervous system firing increases in the permeability of the cardiac muscle fibers, the S-A node, and the A-V node to sodium and calcium.
TMP13 p. 128

34. A) The heart rate can be calculated by 60 divided by the R-R interval, which is 0.86 second. This results in a heart rate of 70 beats/min.
TMP13 p. 133

35. B) Einthoven's law states that the voltage in lead I plus the voltage in lead III is equal to the voltage in lead II. In this case the voltage in lead II is 0.9 millivolt and the voltage in lead III is 0.4 millivolt. The lead I voltage is thus 0.5 (0.9 – 0.4 millivolt = 0.5 millivolt).
TMP13 p. 135

36. E) The contraction of the ventricles lasts almost from the beginning of the Q wave and continues to the end of the T wave. This interval is called the Q-T interval and ordinarily lasts about 0.35 second.
TMP13 p. 133

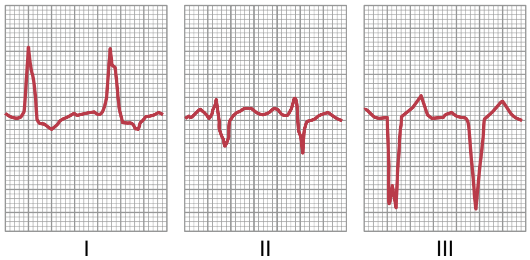
37. A) By convention, the right arm is the negative electrode for lead II of an ECG.
TMP13 p. 135

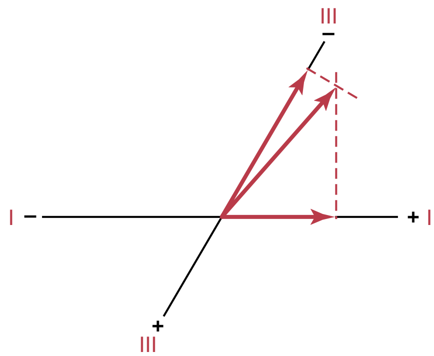
38. A) By convention, the left arm is the negative electrode for lead I of an ECG.
TMP13 p. 134

39. D) Einthoven's law states that the voltage in lead I plus the voltage in lead III is equal to the voltage in lead II, which in this case is 2.0 millivolts.
TMP13 p. 135

40. D) Different ECG lead axes are shown in the figure. Lead III has a positive portion at 120 degrees and a negative portion at −60 degrees. Therefore, lead III has correct axes for this question.
TMP13 p. 140

41. B) The mean electrical axis can be determined by plotting the resultant voltage of the QRS for leads I, II, and III. The result is shown below and has a value of −50 degrees.
TMP13 pp. 144-145





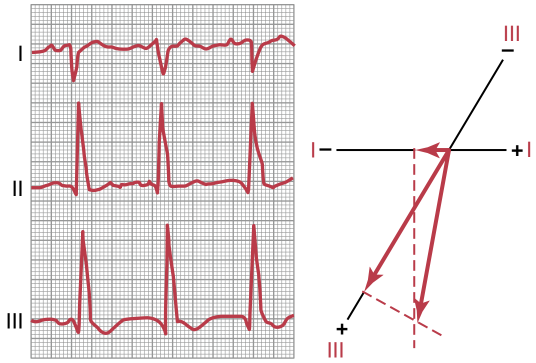
42. A) The heart rate can be calculated by 60 divided by the R-R interval, which is 0.68 second. This calculation results in a heart rate of 88 beats/min.
TMP13 p. 133

43. B) In the figure, the QRS width is greater than 0.12 second, which indicates a bundle branch block. Right bundle branch block is not a listed answer. The correct answer is therefore left bundle branch block.
TMP13 p. 146

44. A) Systemic hypertension results in a left axis deviation because of the enlargement of the left ventricle. Pulmonary valve stenosis and pulmonary valve regurgitation result in an enlarged right ventricle and right axis deviation. A rightward angulation of the heart will cause a rightward shift in the mean electrical axis. Pulmonary hypertension causes enlargement of the right heart and thus causes right axis deviation.
TMP13 p. 145

45. D) Lead II has a positive vector at the 60-degree angle. The negative end of lead II is at −120 degrees.
TMP13 p. 140

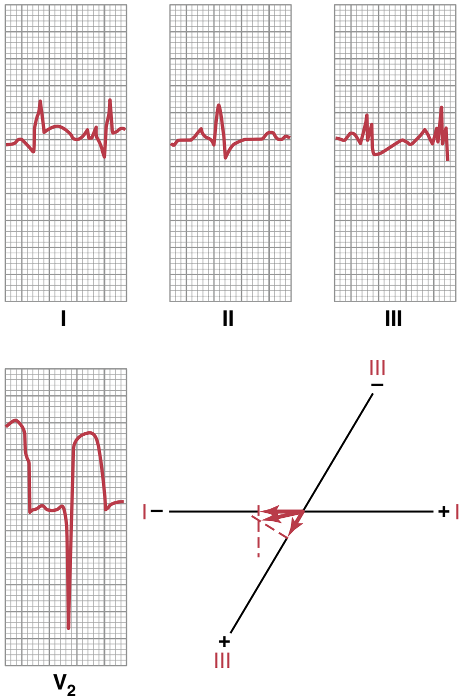
46. A) Note in the figure below that the QRS complex has a large negative deflection in lead I and a positive deflection in lead III, which indicates that there is a rightward axis deviation. Heart rate is calculated by 60/R-R interval and is 103 beats per minute.
TMP13 pp. 133, 146



47. C) The right axis deviation in this patient has to occur because of a change in muscle mass in the right ventricle, which occurs in pulmonary valve stenosis. Aortic valve insufficiency and systemic hypertension will cause a left axis shift. The QRS width is not greater than 0.12 second, so the patient does not have bundle branch block.
TMP13 p. 146

48. B) The patient has a mean electrical axis of 60 degrees because of the large deflection in lead II and zero in lead aVL. The axis of aVL is −30 degrees, which is perpendicular to lead II, and this indicates that the axis must be 60 degrees.
TMP13 p. 148

49. A) This patient has an acute anterior infarction in the left ventricle of the heart. This diagnosis can be determined by plotting the currents of injury from the different leads (see figure below). The limb leads are used to determine whether the infarction is coming from the left or right side of the ventricle and from the base or inferior part of the ventricle. The chest leads are used to determine whether it is an anterior or posterior infarct. When we analyze the currents of injury, a negative potential, caused by the current of injury, occurs in lead I and a positive potential, caused by the current of injury, occurs in lead III. This is determined by subtracting the J point from the TP segment. The negative end of the resultant vector originates in the ischemic area, which is therefore the left side of the heart. In lead V_2, the chest lead, the electrode is in a field of very negative potential, which occurs in patients with an anterior lesion.
TMP13 pp. 150-151

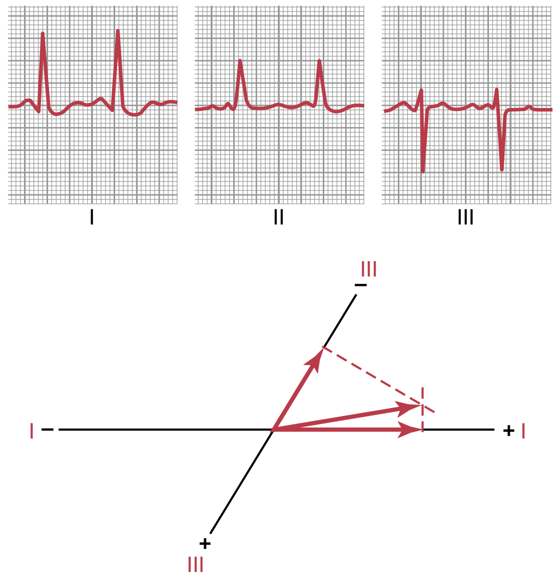


50. D) The QRS wave plotted on lead I was −1.2 millivolts, and lead II was +1.2 millivolts, so the absolute value of the deflections was the same. Therefore, the mean electrical axis must be exactly halfway in between these two leads, which is halfway between the lead II axis of 60 degrees and the lead I negative axis of 180 degrees, which provides a value of 120 degrees.
TMP13 p. 144

51. E) During the T-P interval in a patient with a damaged ventricle, the only area depolarized is the damaged muscle. Therefore, the remainder of the ventricle is repolarized. At the J point the entire ventricle is depolarized in a patient with a damaged cardiac muscle or in a patient with a normal cardiac muscle. The area of the heart that is damaged will not repolarize but remains depolarized at all times.
TMP13 p. 150

52. A) Note in the figure below that the QRS complex has a positive deflection in lead I and a negative in lead III, which indicates that there is a leftward axis deviation, which occurs during chronic systemic hypertension. Pulmonary hypertension increases the ventricular mass on the right side of the heart, which gives a right axis deviation.

TMP13 p. 145



53. A) Because the deflection in this ECG is 0 in lead I, the axis has to be 90 degrees away from this lead. Therefore, the mean electrical axis must be +90 degrees or −90 degrees. Because the aVF lead has a positive deflection, the mean electrical axis must be at +90 degrees.

TMP13 p. 140

54. B) The ECG from this patient has a positive deflection in aVF and a negative deflection in standard limb lead I. Therefore, the mean electrical axis is between 90 degrees and 180 degrees, which is a rightward shift in the ECG mean electrical axis. Systemic hypertension, aortic valve stenosis, and aortic valve regurgitation cause hypertrophy of the left ventricle and thus a leftward shift in the mean electrical axis. Pulmonary hypertension causes a rightward shift in the axis and is therefore characterized by this ECG.

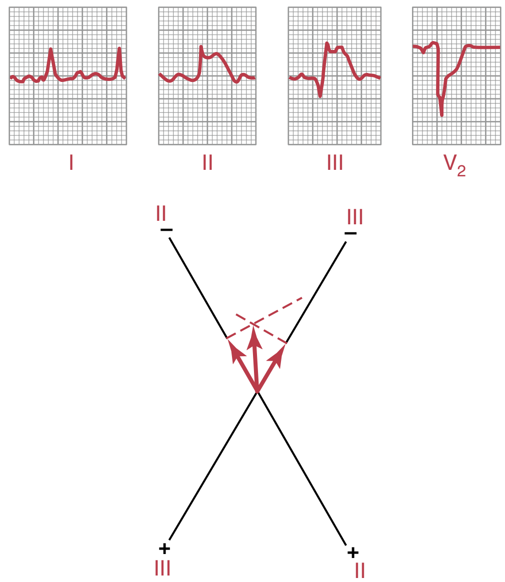
TMP13 p. 146

55. D) A QRS axis of 120 degrees indicates a rightward shift. Because the QRS complex is 0.18 second, this indicates a conduction block. Therefore, the diagnosis that fits with these characteristics is a right bundle branch block.

TMP13 p. 146

56. D) In the figure below, the current of injury is plotted at the bottom of the graph. This is not a plot of the QRS voltages but the current of injury voltages. They are plotted for leads II and III, which are both negative, and the resultant vector is nearly vertical. The negative end of the vector points to where the current of injury originated, which is in the apex of the ventricle. The elevation of the TP segment above the J point indicates a posterior lesion. Therefore, the ECG is consistent with acute posterior infarction in the apex of the ventricle.

TMP13 p. 151



57. E) This patient has a difference in the atrial rate of 100 and in the ventricular rate of 25. The 25 rate in the ventricles is indicative of a rhythm starting in the Purkinje fibers. A-V block is occurring, but it comes and goes, which is only fulfilled by Stokes-Adams syndrome.

TMP13 p. 157

58. C) A person with atrial fibrillation has a rapid, irregular heart rate. The P waves are missing or are very weak. The atria exhibit circus movements, and atrial volume is often increased, causing the atrial fibrillation.

TMP13 pp. 164-165

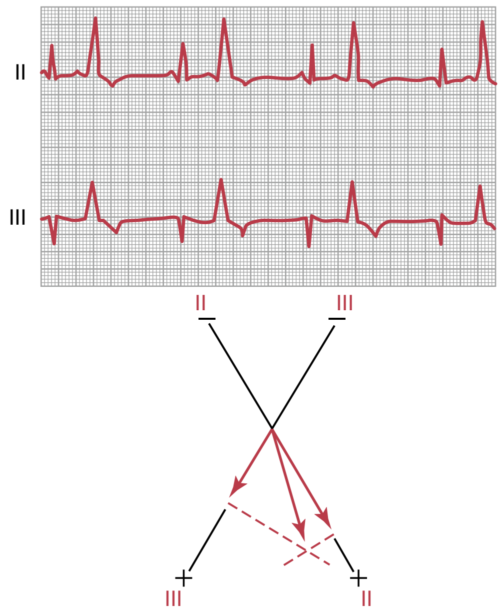
59. A) Circus movements occur in ventricular muscle, particularly in persons with a dilated heart or decreases in conduction velocity. High extracellular potassium and sympathetic stimulation, not parasympathetic stimulation, increase the tendency for circus movements. A longer refractory period tends to prevent circus movements of the heart, because when the impulses travel around the heart and contact the area of ventricular muscle that has a longer refractory period, the action potential stops at this point.

TMP13 pp. 161-162

60. D) When a patient has no P waves and a low heart rate, it is likely that the impulse leaving the sinus node is totally blocked before entering the atrial muscle, which is called sinoatrial block. The ventricles pick up the new rhythm, usually initiated in the A-V node at this point, which results in a heart rate of 40 to 60 per minute. In contrast, during sinus bradycardia, P waves are still associated with each QRS complex. In first-, second-, and third-degree heart block, P waves are present in each of these instances, although some are not associated with QRS complex.
TMP13 p. 156

61. B) By definition, first-degree A-V heart block occurs when the P-R interval exceeds a value of 0.20 second but without any dropped QRS waves. This ECG shows first degree block. In this figure the P-R interval is about 0.30 second, which is considerably prolonged. However, there are no dropped QRS waves. During second-degree A-V block, QRS waves are dropped.
TMP13 p. 157

62. E) In the figure below, note that the premature ventricular contractions (PVCs) have a wide and tall QRS wave in the ECG. The mean electrical axis of the premature contraction can be determined by plotting these large QRS complexes on the standard limb leads. The PVC originates at the negative end of the resultant mean electrical axis, which is at the base of the ventricle. Notice that the QRS of the PVC is wider and much taller than the normal QRS waves in this ECG.
TMP13 p. 159



63. B) This patient has atrial flutter, which is characterized by several P waves for each QRS complex. This ECG has two P waves for every QRS. Notice the rapid heart rate, which is characteristic of atrial flutter.
TMP13 p. 165

64. E) The average ventricular rate is 150 beats/min in this ECG, which is typical of atrial flutter. Once again notice that the heart rate is irregular because of the inability of the impulses to quickly pass through the A-V node because of its refractory period.
TMP13 p. 133

65. B) A dilated heart increases the risk of occurrence of ventricular fibrillation because of an increase in the likelihood of circus movements. Also, if the conduction velocity decreases, it will take a longer period for the impulse to travel around the heart, which decreases the risk of ventricular fibrillation. Exposure of the heart to 60-cycle alternating current or epinephrine administration increases the irritability of the heart. If the refractory period is long, the likelihood of re-entrant type of pathways decreases, because when the impulse travels around the heart, the ventricles remain in a refractory period.
TMP13 pp. 161-162

66. D) An inverted P wave occurs in patients with a premature contraction originating in the A-V junction. If the P wave occurs after the QRS complex, the junctional contraction started low in the A-V junction. Junctional contractions originating high in the A-V junction will have a P wave that occurs before the QRS, and likewise one originating in the middle of junction occurs during the QRS.
TMP13 p. 157

67. E) The term "paroxysmal" means that the heart rate becomes rapid in paroxysms, with the paroxysm beginning suddenly and lasting for a few seconds, a few minutes, a few hours, or much longer. Then the paroxysm usually ends as suddenly as it began and the pacemaker shifts back to the S-A node. The mechanism by which this phenomenon is believed to occur is by a re-entrant circus movement feedback pathway that sets up an area of local repeated self–re-excitation. The ECG shown is ventricular paroxysmal tachycardia. That the origin is in the ventricles can be determined because of the changes in the QRS complex, which have high voltages and look much different than the preceding normal QRS complexes. This is very characteristic of a ventricular irritable locus.
TMP13 pp. 160-161

68. C) Notice in this ECG that a P wave precedes each of the first four QRS complexes. After that we see a P wave but a dropped QRS wave, which is characteristic of second-degree A-V block.
TMP13 p. 157

69. A) A person with atrial fibrillation has a rapid, irregular heart rate. The P waves are missing or are very weak. The atria exhibit circus movements and often are very enlarged, causing the atrial fibrillation.
TMP13 pp. 164-165

70. B) Ventricular fibrillation often occurs in a heart exposed to a 60-cycle alternating current. An increased conduction velocity through the heart muscle or a shortened conduction pathway around the heart decreases the probability of re-entrant pathways. A shortened ventricular refractory period increases the possibility of fibrillation. Thus, when the electrical stimulus travels around the heart and reaches the ventricular muscle that was again initially stimulated, the risk of ventricular fibrillation increases because the muscle will be out of the refractory period.

TMP13 p. 162

71. B) During a Stokes-Adams syndrome attack, total A-V block suddenly begins, and the duration of the block may be a few seconds or even several weeks. The new pacemaker of the heart is distal to the point of blockade but is usually deep in the A-V node or the A-V bundle.

TMP13 p. 157

72. E) The heart rate can be determined by 60 divided by the R-R interval, which gives a value of 150 beats/min. This patient has tachycardia, which is defined as a heart rate greater than 100 beats/min.

TMP13 p. 133

73. A) The relationship between the P waves and the QRS complexes appears to be normal, and there are no missing beats. Therefore, this patient has a sinus rhythm, and there is no heart block. There is also no ST segment depression in this patient. Because we have normal P and QRS and T waves, this condition is sinus tachycardia.

TMP13 p. 156

74. A) The heartbeat immediately following a premature atrial contraction weakens because the diastolic period is very short in this condition. Therefore, the ventricular filling time is very short, and thus the stroke volume decreases. The P wave is usually visible in this arrhythmia unless it coincides with the QRS complex. The probability of these premature contractions increases in people with toxic irritation of the heart and local ischemic areas.

TMP13 p. 158

75. C) During atrial paroxysmal tachycardia, the impulse is initiated by an ectopic focus somewhere in the atria. If the point of initiation is near the A-V node, the P wave travels backward toward the S-A node and then forward into the ventricles at the same time. Therefore, the P wave will be inverted.

TMP13 p. 160

76. A) This ECG has characteristics of atrial paroxysmal tachycardia, which means that the tachycardia may come and go at random times. The basic shape of the QRS complex and its magnitude are virtually unchanged from the normal QRS complexes, which eliminates the possibility of ventricular paroxysmal tachycardia. This ECG is not characteristic of atrial flutter because there is only one P wave for each QRS complex.

TMP13 p. 160

77. E) First-, second-, and third-degree heart blocks, as well as atrial paroxysmal tachycardia, all have P waves in the ECG. However, there are usually no evident P waves during atrial fibrillation, and the heart rate is irregular. Therefore, this ECG is characteristic of atrial fibrillation.

TMP13 pp. 164-165

78. E) This patient's heart rate is 37 beats/min, which can be determined by dividing 60 by the R-R interval. This is characteristic of some types of A-V block.

TMP13 p. 133

79. E) This ECG is characteristic of complete A-V block, which is also called third-degree A-V block. The P waves seem to be totally dissociated from the QRS complexes, because sometimes there are three P waves and sometimes two P waves between QRS complexes. First-degree A-V block causes a lengthened P-R interval, and second-degree A-V block has long P-R intervals with dropped beats. However, this does not seem to be occurring in this ECG, because there is no relationship between the ORS waves and the P waves.

TMP13 p. 157

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UNIT IV

The Circulation

1. Listed below are the hydrostatic and oncotic pressures within a microcirculatory bed.

   Plasma colloid osmotic pressure = 25 mm Hg
   Capillary hydrostatic pressure = 25 mm Hg
   Venous hydrostatic pressure = 5 mm Hg
   Arterial pressure = 80 mm Hg
   Interstitial fluid hydrostatic pressure = −5 mm Hg
   Interstitial colloid osmotic pressure = 10 mm Hg
   Capillary filtration coefficient = 10 ml/min/mm Hg

What is the rate of net fluid movement across the capillary wall?

A) 25 ml/min
B) 50 ml/min
C) 100 ml/min
D) 150 ml/min
E) 200 ml/min

2. A healthy 60-year-old woman with a 10-year history of hypertension stands up from a supine position. Which set of cardiovascular changes is most likely to occur in response to standing up from a supine position?

	Sympathetic Nerve Activity	Parasympathetic Nerve Activity	Heart Rate
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↑	↓	↑
E)	↓	↓	↓
F)	↓	↓	↑
G)	↓	↑	↑
H)	↓	↑	↓

3. In an experimental study, administration of a drug decreases the diameter of arterioles in the muscle bed of an animal subject. Which set of physiological changes would be expected to occur in response to the decrease in diameter?

	Vascular Conductance	Capillary Filtration	Blood Flow
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

4. A 60-year-old woman has experienced dizziness for the past 6 months when getting out of bed in the morning and when standing up. Her mean arterial pressure is 130/90 mm Hg while lying down and 95/60 while sitting. Which set of physiological changes would be expected in response to moving from a supine to an upright position?

	Parasympathetic Nerve Activity	Plasma Renin Activity	Sympathetic Activity
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

5. A 35-year-old woman visits her family practitioner for an examination. She has a blood pressure of 160/75 mm Hg and a heart rate of 74 beats/min. Further tests by a cardiologist reveal that the patient has moderate aortic regurgitation. Which set of changes would be expected in this patient?

	Pulse Pressure	Systolic Pressure	Stroke Volume
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

6. A healthy 27-year-old female medical student runs a 5K race. Which set of physiological changes is most likely to occur in this woman's skeletal muscles during the race?

	Arteriole Diameter	Vascular Conductance	Tissue Oxygen Concentration
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↑	↓	↑
E)	↓	↓	↓
F)	↓	↓	↑
G)	↓	↑	↑
H)	↓	↑	↓

7. Cognitive stimuli such as reading, problem solving, and talking all result in significant increases in cerebral blood flow. Which set of changes in cerebral tissue concentrations is the most likely explanation for the increase in cerebral blood flow?

	Carbon Dioxide	pH	Adenosine
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

8. Histamine is infused into the brachial artery. Which set of microcirculatory changes would be expected in the infused arm?

	Capillary Water Permeability	Capillary Hydrostatic Pressure	Capillary Filtration Rate
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↑	↓	↑
E)	↓	↓	↓
F)	↓	↓	↑
G)	↓	↑	↑
H)	↓	↑	↓

9. An increase in shear stress in a blood vessel results in which change?

A) Decreased endothelin production
B) Decreased cyclic guanosine monophosphate production
C) Increased nitric oxide release
D) Increased renin production
E) Decreased prostacyclin production

10. A 65-year-old man with a 10-year history of essential hypertension is being treated with an angiotensin-converting enzyme (ACE) inhibitor. Which set of changes would be expected to occur in response to the ACE inhibitor drug therapy?

	Plasma Renin Concentration	Total Peripheral Resistance	Renal Sodium Excretory Function
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↑	↓	↑
E)	↓	↓	↓
F)	↓	↓	↑
G)	↓	↑	↑
H)	↓	↑	↓

11. The diameter of a precapillary arteriole is increased in a muscle vascular bed. A decrease in which of the following would be expected?

A) Capillary filtration rate
B) Vascular conductance
C) Capillary blood flow
D) Capillary hydrostatic pressure
E) Arteriolar resistance

12. A 55-year-old man with a history of normal health visits his physician for a checkup. The physical examination reveals that his blood pressure is 170/98 mm Hg. Further tests indicate that he has renovascular hypertension as a result of stenosis in the left kidney. Which set of findings would be expected in this man with renovascular hypertension?

	Total Peripheral Resistance	Plasma Renin Activity	Plasma Aldosterone Concentration
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

13. Under control conditions, flow through a blood vessel is 100 ml/min with a pressure gradient of 50 mm Hg. What would be the approximate flow through the vessel after increasing the vessel diameter by 50%, assuming that the pressure gradient is maintained at 100 mm Hg?

A) 100 ml/min
B) 150 ml/min
C) 300 ml/min
D) 500 ml/min
E) 700 ml/min

14. A 24-year-old woman delivers a 6-pound, 8-ounce baby girl. The newborn is diagnosed as having patent ductus arteriosus. Which set of changes would be expected in this baby?

	Pulse Pressure	Stroke Volume	Systolic Pressure
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

15. A 72-year-old man had surgery to remove an abdominal tumor. Pathohistological studies revealed that the tumor mass contained a large number of vessels. The most likely stimulus for the growth of vessels in a solid tumor is an increase in which of the following?

A) Growth hormone
B) Plasma glucose concentration
C) Angiostatin growth factor
D) Vascular endothelial growth factor
E) Tissue oxygen concentration

16. Which set of changes would be expected to cause the greatest increase in the net movement of sodium across a muscle capillary wall?

	Wall Permeability to Sodium	Wall Surface Area	Concentration Difference Across Wall
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↑	↓	↑
E)	↓	↓	↓
F)	↓	↓	↑
G)	↓	↑	↑
H)	↓	↑	↓

17. While participating in a cardiovascular physiology laboratory, a medical student isolates an animal's carotid artery proximal to the carotid bifurcation and partially constricts the artery with a tie around the vessel. Which set of changes would be expected to occur in response to constriction of the carotid artery?

	Heart Rate	Sympathetic Nerve Activity	Total Peripheral Resistance
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↑	↓	↑
E)	↓	↓	↓
F)	↓	↓	↑
G)	↓	↑	↑
H)	↓	↑	↓

18. A 35-year-old woman visits her family practice physician for an examination. She has a mean arterial blood pressure of 105 mm Hg and a heart rate of 74 beats/min. Further tests by a cardiologist reveal that the patient has moderate aortic valve stenosis. Which set of changes would be expected in this patient?

	Pulse Pressure	Stroke Volume	Systolic Pressure
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

19. A 60-year-old man visits his family practitioner for an annual examination. He has a mean blood pressure of 130 mm Hg and a heart rate of 78 beats/min. His plasma cholesterol level is in the upper 25th percentile, and he is diagnosed as having atherosclerosis. Which set of changes would be expected in this patient?

	Pulse Pressure	Arterial Compliance	Systolic Pressure
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

20. While participating in a cardiovascular physiology laboratory, a medical student isolates the carotid artery of an animal and partially constricts the artery with a tie around the vessel. Which set of changes would be expected to occur in response to constriction of the carotid artery?

	Sympathetic Nerve Activity	Renal Blood Flow	Total Peripheral Resistance
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

21. Which mechanism would tend to decrease capillary filtration rate?
    A) Increased capillary hydrostatic pressure
    B) Decreased plasma colloid osmotic pressure
    C) Increased interstitial colloid osmotic pressure
    D) Decreased capillary water permeability
    E) Decreased arteriolar resistance

22. A 72-year-old man had surgery to remove an abdominal tumor. Findings of pathohistological studies reveal that the tumor mass contains a large number of blood vessels. The most likely stimulus for the growth of vessels in a solid tumor is an increase in which of the following?
    A) Growth hormone
    B) Plasma glucose concentration
    C) Angiostatin growth factor
    D) Tissue oxygen concentration
    E) Vascular endothelial growth factor (VEGF)

23. The diameter of a precapillary arteriole is decreased in a muscle vascular bed. Which change in the microcirculation would be expected?
    A) Decreased capillary filtration rate
    B) Increased interstitial volume
    C) Increased lymph flow
    D) Increased capillary hydrostatic pressure
    E) Decreased arteriolar resistance

24. A 50-year-old man has a 3-year history of hypertension. He reports fatigue and occasional muscle cramps. There is no family history of hypertension. The patient has not had any other significant medical problems in the past. Examination reveals a blood pressure of 168/104 mm Hg. Additional laboratory tests indicate that the patient has primary hyperaldosteronism. Which set of findings would be expected in this man with primary hyperaldosteronism hypertension?

	Extracellular Fluid Volume	Plasma Renin Activity	Plasma Potassium Concentration
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

25. An increase in which of the following would tend to increase lymph flow?
    A) Hydraulic conductivity of the capillary wall
    B) Plasma colloid osmotic pressure
    C) Capillary hydrostatic pressure
    D) Arteriolar resistance
    E) A and C

26. In control conditions, flow through a blood vessel is 100 ml/min under a pressure gradient of 50 mm Hg. What would be the approximate flow through the vessel after increasing the vessel diameter to four times normal, assuming that the pressure gradient was maintained at 50 mm Hg?
    A) 300 ml/min
    B) 1600 ml/min
    C) 1000 ml/min
    D) 16,000 ml/min
    E) 25,600 ml/min

27. A 50-year-old woman has a renal blood flow of 1200 ml/min and hematocrit of 50. Her arterial pressure is 125 mm Hg, and her renal venous pressure is 5 mm Hg. She also has a plasma colloid osmotic pressure of 25 mm Hg and a glomerular capillary hydrostatic pressure of 50 mm Hg. What is the total renal vascular resistance (in mm Hg/ml/min) in this woman?
   A) 0.05
   B) 0.10
   C) 0.50
   D) 1.00
   E) 1.50

28. An increase in which of the following would be expected to decrease blood flow in a vessel?
   A) Pressure gradient across the vessel
   B) Radius of the vessel
   C) Plasma colloid osmotic pressure
   D) Viscosity of the blood
   E) Plasma sodium concentration

29. Assuming that vessels A to D are the same length, which one has the greatest flow?

	Pressure Gradient	Radius	Viscosity
A)	100	1	10
B)	50	2	5
C)	25	4	2
D)	10	6	1

30. A 22-year-old man enters the hospital emergency department after severing a major artery in a motorcycle accident. It is estimated that he has lost approximately 700 milliliters of blood. His blood pressure is 90/55 mm Hg. Which set of changes would be expected in response to hemorrhage in this man?

	Heart Rate	Sympathetic Nerve Activity	Total Peripheral Resistance
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

31. A healthy 28-year-old woman stands up from a supine position. Moving from a supine to a standing position results in a transient decrease in arterial pressure that is detected by arterial baroreceptors located in the aortic arch and carotid sinuses. Which set of cardiovascular changes is most likely to occur in response to activation of the baroreceptors?

	Mean Circulatory Filling Pressure	Strength of Cardiac Contraction	Sympathetic Nerve Activity
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

32. An ACE inhibitor is administered to a 65-year-old man with a 20-year history of hypertension. The drug lowered his arterial pressure and increased his plasma levels of renin and bradykinin. Which mechanism would best explain the decrease in arterial pressure?
   A) Inhibition of angiotensin I
   B) Decreased conversion of angiotensinogen to angiotensin I
   C) Increased plasma levels of bradykinin
   D) Increased plasma levels of renin
   E) Decreased formation of angiotensin II

33. A 25-year-old man enters the hospital emergency department after severing a major artery during a farm accident. It is estimated that the patient has lost approximately 800 milliliters of blood. His mean blood pressure is 65 mm Hg, and his heart rate is elevated as a result of activation of the chemoreceptor reflex. Which set of changes in plasma concentration would be expected to cause the greatest activation of the chemoreceptor reflex?

	Oxygen	Carbon Dioxide	Hydrogen
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

34. Under normal physiological conditions, blood flow to the skeletal muscles is determined mainly by which of the following?
   A) Sympathetic nerves
   B) Angiotensin II
   C) Vasopressin
   D) Metabolic needs
   E) Capillary osmotic pressure

35. A healthy 22-year-old female medical student has an exercise stress test at a local health club. An increase in which of the following is most likely to occur in this woman's skeletal muscles during exercise?
    A) Vascular conductance
    B) Blood flow
    C) Carbon dioxide concentration
    D) Arteriolar diameter
    E) All the above

36. Which of the following segments of the circulatory system has the highest velocity of blood flow?
    A) Aorta
    B) Arteries
    C) Capillaries
    D) Venules
    E) Veins

37. Listed below are the hydrostatic and oncotic pressures within a microcirculatory bed.

    Plasma colloid osmotic pressure = 25 mm Hg
    Capillary hydrostatic pressure = 25 mm Hg
    Venous hydrostatic pressure = 5 mm Hg
    Arterial pressure = 80 mm Hg
    Interstitial hydrostatic pressure = −5 mm Hg
    Interstitial colloid osmotic pressure = 5 mm Hg
    Filtration coefficient = 15 ml/min/mm Hg

What is the filtration rate (ml/min) of the capillary wall?
    A) 100
    B) 150
    C) 200
    D) 250
    E) 300

38. Which blood vessel has the highest vascular resistance?

	Blood Flow (ml/min)	Pressure Gradient (mm Hg)
A)	1000	100
B)	1200	60
C)	1400	20
D)	1600	80
E)	1800	40

39. A twofold increase in which of the following would result in the greatest increase in the transport of oxygen across the capillary wall?
    A) Capillary hydrostatic pressure
    B) Intercellular clefts in the capillary wall
    C) Oxygen concentration gradient
    D) Plasma colloid osmotic pressure
    E) Capillary wall hydraulic permeability

40. A balloon catheter is advanced from the superior vena cava into the heart and inflated to increase atrial pressure by 5 mm Hg. An increase in which of the following would be expected to occur in response to the elevated atrial pressure?
    A) Atrial natriuretic peptide
    B) Angiotensin II
    C) Aldosterone
    D) Renal sympathetic nerve activity

41. Which of the following vessels has the greatest total cross-sectional area in the circulatory system?
    A) Aorta
    B) Small arteries
    C) Capillaries
    D) Venules
    E) Vena cava

42. An increase in atrial pressure results in which of the following?
    A) Decrease in plasma atrial natriuretic peptide
    B) Increase in plasma angiotensin II concentration
    C) Increase in plasma aldosterone concentration
    D) Increase in sodium excretion

43. Autoregulation of tissue blood flow in response to an increase in arterial pressure occurs as a result of which of the following?
    A) Decrease in vascular resistance
    B) Initial decrease in vascular wall tension
    C) Excess delivery of nutrients such as oxygen to the tissues
    D) Decrease in tissue metabolism

44. Which component of the circulatory system contains the largest percentage of the total blood volume?
    A) Arteries
    B) Capillaries
    C) Veins
    D) Pulmonary circulation
    E) Heart

45. Which set of changes would be expected to occur 2 weeks after a 50% reduction in renal artery pressure?

	Plasma Renin	Plasma Aldosterone Concentration	Glomerular Filtration Rate
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↑	↓	↑
E)	↓	↓	↓
F)	↓	↓	↑
G)	↓	↑	↑
H)	↓	↑	↓

46. An increase in which of the following tends to decrease capillary filtration rate?
 A) Capillary hydrostatic pressure
 B) Plasma colloid osmotic pressure
 C) Interstitial colloid osmotic pressure
 D) Venous hydrostatic pressure
 E) Arteriolar diameter

47. An increase in which of the following would be expected to occur in a person 2 weeks after an increase in sodium intake?
 A) Angiotensin II
 B) Aldosterone
 C) Potassium excretion
 D) Atrial natriuretic peptide

48. A decrease in which of the following tends to increase lymph flow?
 A) Capillary hydrostatic pressure
 B) Interstitial hydrostatic pressure
 C) Plasma colloid osmotic pressure
 D) Lymphatic pump activity
 E) Arteriolar diameter

49. A decrease in the production of which of the following would most likely result in chronic hypertension?
 A) Aldosterone
 B) Thromboxane
 C) Angiotensin II
 D) Nitric oxide

50. Which of the following capillaries has the lowest capillary permeability to plasma molecules?
 A) Glomerular
 B) Liver
 C) Muscle
 D) Intestinal
 E) Brain

51. Which of the following would be expected to occur during a Cushing reaction caused by brain ischemia?
 A) Increase in parasympathetic activity
 B) Decrease in arterial pressure
 C) Decrease in heart rate
 D) Increase in sympathetic activity

52. Which of the following tends to increase the net movement of glucose across a capillary wall?
 A) Increase in plasma sodium concentration
 B) Increase in the concentration difference of glucose across the wall
 C) Decrease in wall permeability to glucose
 D) Decrease in wall surface area without an increase in the number of pores
 E) Decrease in plasma potassium concentration

53. A 65-year-old man has congestive heart failure. He has a cardiac output of 4 L/min, arterial pressure of 115/85 mm Hg, and a heart rate of 90 beats/min. Further tests by a cardiologist reveal that the patient has a right atrial pressure of 10 mm Hg. An increase in which of the following would be expected in this patient?
 A) Plasma colloid osmotic pressure
 B) Interstitial colloid osmotic pressure
 C) Arterial pressure
 D) Cardiac output
 E) Vena cava hydrostatic pressure

54. Which set of changes would be expected to occur in response to a direct increase in renal arterial pressure in kidneys without an intact tubuloglomerular feedback system?

	Glomerular Filtration	Sodium Excretion	Water Excretion Rate
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↑	↓	↑
E)	↓	↓	↓
F)	↓	↓	↑
G)	↓	↑	↑
H)	↓	↑	↓

55. Which part of the circulation has the highest compliance?
 A) Capillaries
 B) Large arteries
 C) Veins
 D) Aorta
 E) Small arteries

56. A decrease in which of the following tends to increase pulse pressure?
 A) Systolic pressure
 B) Stroke volume
 C) Arterial compliance
 D) Venous return
 E) Plasma volume

57. Using the following data, calculate the filtration coefficient for the capillary bed.

Plasma colloid osmotic pressure = 30 mm Hg
Capillary hydrostatic pressure = 40 mm Hg
Interstitial hydrostatic pressure = 5 mm Hg
Interstitial colloid osmotic pressure = 5 mm Hg
Filtration rate = 150 ml/min
Venous hydrostatic pressure = 10 mm Hg

 A) 10 ml/min/mm Hg
 B) 15 ml/min/mm Hg
 C) 20 ml/min/mm Hg
 D) 25 ml/min/mm Hg
 E) 30 ml/min/mm Hg

58. Which set of physiological changes would be expected to occur in a person who stands up from a supine position?

	Venous Hydrostatic Pressure in Legs	Heart Rate	Renal Blood Flow
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↓	↓	↓
E)	↓	↓	↑
F)	↓	↑	↑

59. Blood flow to a tissue remains relatively constant despite a reduction in arterial pressure (autoregulation). Which of the following would be expected to occur in response to the reduction in arterial pressure?

A) Decreased conductance
B) Decreased tissue carbon dioxide concentration
C) Increased tissue oxygen concentration
D) Decreased vascular resistance
E) Decreased arteriolar diameter

60. Which of the following would have the slowest rate of net movement across the capillary wall?

A) Sodium
B) Albumin
C) Glucose
D) Oxygen

61. An increase in which of the following tends to increase capillary filtration rate?

A) Capillary wall hydraulic conductivity
B) Arteriolar resistance
C) Plasma colloid osmotic pressure
D) Interstitial hydrostatic pressure
E) Plasma sodium concentration

62. The tendency for turbulent flow is greatest in which of the following?

A) Arterioles
B) Capillaries
C) Small arterioles
D) Aorta

63. A 60-year-old man has a mean arterial blood pressure of 130 mm Hg, a heart rate of 78 beats/min, a right atrial pressure of 0 mm Hg, and a cardiac output of 3.5 L/min. He also has a pulse pressure of 35 mm Hg and a hematocrit of 40. What is the approximate total peripheral vascular resistance in this man?

A) 17 mm Hg/L/min
B) 1.3 mm Hg/L/min
C) 13 mm Hg/L/min
D) 27 mm Hg/L/min
E) 37 mm Hg/L/min

64. Which pressure is normally negative in a muscle capillary bed in the lower extremities?

A) Plasma colloid osmotic pressure
B) Capillary hydrostatic pressure
C) Interstitial hydrostatic pressure
D) Interstitial colloid osmotic pressure
E) Venous hydrostatic pressure

65. What would tend to increase a person's pulse pressure?

A) Decreased stroke volume
B) Increased arterial compliance
C) Hemorrhage
D) Patent ductus
E) Decreased venous return

66. Movement of solutes such as Na^+ across the capillary walls occurs primarily by which process?

A) Filtration
B) Active transport
C) Vesicular transport
D) Diffusion

67. What would decrease venous hydrostatic pressure in the legs?

A) Increase in right atrial pressure
B) Pregnancy
C) Movement of leg muscles
D) Presence of ascitic fluid in the abdomen

68. A nitric oxide donor is infused into the brachial artery of a 22-year-old man. Which set of microcirculatory changes would be expected in the infused arm?

	Capillary Hydrostatic Pressure	Interstitial Hydrostatic Pressure	Lymph Flow
A)	↑	↑	↑
B)	↑	↑	↓
C)	↑	↓	↓
D)	↑	↓	↑
E)	↓	↓	↓
F)	↓	↓	↑
G)	↓	↑	↑
H)	↓	↑	↓

69. What often occurs in decompensated heart failure?

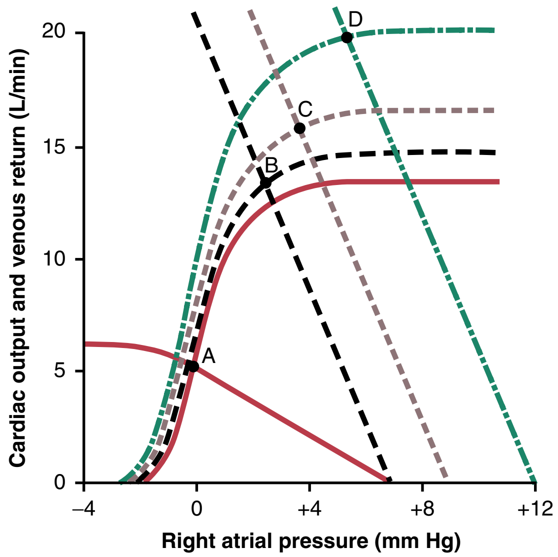
A) Increased renal loss of sodium and water
B) Decreased mean systemic filling pressure
C) Increased norepinephrine in cardiac sympathetic nerves
D) Orthopnea
E) Weight loss

70. Which condition often occurs in progressive hemorrhagic shock?

A) Vasomotor center failure
B) Increased urine output
C) Tissue alkalosis
D) Decreased capillary permeability
E) Increased mean systemic filling pressure

71. A 50-year-old woman received an overdose of furosemide, and her arterial pressure decreased to 70/40. Her heart rate is 120, and her respiratory rate is 30/min. What therapy would you recommend?
   A) Whole blood infusion
   B) Plasma infusion
   C) Infusion of a balanced electrolyte solution
   D) Infusion of a sympathomimetic drug
   E) Administration of a glucocorticoid

72. A 30-year-old woman comes to a local emergency department with severe vomiting. She has pale skin, tachycardia, an arterial pressure of 70/45, and trouble walking. What therapy do you recommend to prevent shock?
   A) Infusion of packed red blood cells
   B) Administration of an antihistamine
   C) Infusion of a balanced electrolyte solution
   D) Infusion of a sympathomimetic drug
   E) Administration of a glucocorticoid



Modified from Guyton AC, Jones CE, Coleman TB: Circulatory Physiology: Cardiac Output and Its Regulation, 2nd ed. Philadelphia: WB Saunders, 1973.

73. In the above figure, for the cardiac output and venous return curves defined by the solid red lines (with the equilibrium at A), which of the following options is true?
   A) Mean systemic filling pressure is 12 mm Hg
   B) Right atrial pressure is 2 mm Hg
   C) Resistance to venous return is 1.4 mm Hg/L/min
   D) Pulmonary arterial flow is approximately 7 L/min
   E) Resistance to venous return is 0.71 mm Hg/L/min

74. A 30-year-old man is resting, and his sympathetic output increases to maximal values. Which set of changes would be expected in response to this increased sympathetic output?

	Resistance to Venous Return	Mean Systemic Filling Pressure	Venous Return
A)	↑	↑	↑
B)	↑	↓	↑
C)	↑	↓	↓
D)	↑	↑	↓
E)	↓	↓	↓
F)	↓	↑	↓
G)	↓	↑	↑
H)	↓	↓	↑

75. If a patient has an oxygen consumption of 240 ml/min, a pulmonary vein oxygen concentration of 180 ml/L of blood, and a pulmonary artery oxygen concentration of 160 ml/L of blood units, what is the cardiac output in L/min?
   A) 8
   B) 10
   C) 12
   D) 16
   E) 20

76. What normally causes the cardiac output curve to shift to the right along the right atrial pressure axis?
   A) Changing intrapleural pressure to −1 mm Hg
   B) Increasing mean systemic filling pressure
   C) Taking a patient off a mechanical ventilator and allowing normal respiration
   D) Decreasing intrapleural pressure to −7 mm Hg
   E) Breathing against a negative pressure

77. What normally causes the cardiac output curve to shift to the left along the right atrial pressure axis?
   A) Surgically opening the chest
   B) Severe cardiac tamponade
   C) Breathing against a negative pressure
   D) Playing a trumpet
   E) Positive pressure breathing

78. What will elevate the plateau of the cardiac output curve?
   A) Surgically opening the thoracic cage
   B) Connecting a patient to a mechanical ventilator
   C) Cardiac tamponade
   D) Increasing parasympathetic stimulation of the heart
   E) Increasing sympathetic stimulation of the heart

79. What is normally associated with an increased cardiac output?
   A) Increased parasympathetic stimulation
   B) Atrioventricular (A-V) fistula
   C) Decreased blood volume
   D) Polycythemia
   E) Severe aortic regurgitation

80. Which condition would be expected to decrease mean systemic filling pressure?
    A) Norepinephrine administration
    B) Increased blood volume
    C) Increased sympathetic stimulation
    D) Increased venous compliance
    E) Skeletal muscle contraction

81. Which statement about resistance to venous return (RVR) is true?
    A) An increase in venous resistance causes an increase in RVR
    B) Increased parasympathetic stimulation causes an increase in RVR
    C) An increase in RVR causes an increase in venous return
    D) Sympathetic inhibition causes an increase in RVR
    E) Changes in arterial resistance have a greater effect on RVR than do equal changes in venous resistance

82. In which condition would you expect a decreased resistance to venous return?
    A) Anemia
    B) Increased venous resistance
    C) Increased arteriolar resistance
    D) Increased sympathetic output
    E) Obstruction of veins

83. What is normally associated with an increased cardiac output?
    A) Increased venous compliance
    B) Cardiac tamponade
    C) Surgically opening the chest
    D) Moderate anemia
    E) Severe aortic stenosis

84. In which condition would you normally expect to find a decreased cardiac output?
    A) Hyperthyroidism
    B) Beriberi
    C) A-V fistula
    D) Anemia
    E) Acute myocardial infarction

85. At the onset of exercise, what normally occurs?
    A) Decreased cerebral blood flow
    B) Increased venous constriction
    C) Decreased coronary blood flow
    D) Decreased mean systemic filling pressure
    E) Increased parasympathetic impulses to the heart

86. What will usually increase the plateau level of the cardiac output curve?
    A) Myocarditis
    B) Severe cardiac tamponade
    C) Decreased parasympathetic stimulation of the heart
    D) Myocardial infarction
    E) Mitral stenosis

87. If a person has been exercising for 1 hour, which organ will have the smallest decrease in blood flow?
    A) Brain
    B) Intestines
    C) Kidneys
    D) Nonexercising skeletal muscle
    E) Pancreas

88. What increases the risk of adverse cardiac events?
    A) Decreased blood levels of low-density lipoprotein (LDL)
    B) Decreased blood levels of high-density lipoprotein (HDL)
    C) Female gender
    D) Moderate hypotension
    E) Decreased blood triglycerides

89. Which vasoactive agent is usually the most important controller of coronary blood flow?
    A) Adenosine
    B) Bradykinin
    C) Prostaglandins
    D) Carbon dioxide
    E) Potassium ions

90. What will elevate the plateau of the cardiac output curve?
    A) Surgically opening the thoracic cage
    B) Connecting a patient to a mechanical ventilator
    C) Cardiac tamponade
    D) Increasing parasympathetic stimulation of the heart
    E) Increasing sympathetic stimulation of the heart

91. Which statement about coronary blood flow is most accurate?
    A) Normal resting coronary blood flow is 500 ml/min
    B) The majority of flow occurs during systole
    C) During systole, the percentage decrease in subendocardial flow is greater than the percentage decrease in epicardial flow
    D) Adenosine release will normally decrease coronary flow

92. Which condition normally causes arteriolar vasodilation during exercise?
    A) Decreased plasma potassium ion concentration
    B) Increased histamine release
    C) Decreased plasma nitric oxide concentration
    D) Increased plasma adenosine concentration
    E) Decreased plasma osmolality

93. At the onset of exercise, the mass sympathetic nervous system strongly discharges. What would you expect to occur?
    A) Increased sympathetic impulses to the heart
    B) Decreased coronary blood flow
    C) Decreased cerebral blood flow
    D) Reverse stress relaxation
    E) Venous dilation

94. Which of the following blood vessels is responsible for transporting the majority of venous blood flow that leaves the ventricular heart muscle?
    A) Anterior cardiac veins
    B) Coronary sinus
    C) Bronchial veins
    D) Azygos vein
    E) Thebesian veins

95. A 70-year-old man with a weight of 100 kilograms (220 pounds) and a blood pressure of 160/90 has been told by his doctor that he has angina caused by myocardial ischemia. Which treatment would be beneficial to this man?
    A) Increased dietary calcium
    B) Isometric exercise
    C) A beta-1 receptor stimulator
    D) Angiotensin II infusion
    E) Nitroglycerin

96. Which event normally occurs during exercise?
    A) Arteriolar dilation in non-exercising muscle
    B) Decreased sympathetic output
    C) Venoconstriction
    D) Decreased release of epinephrine by the adrenals
    E) Decreased release of norepinephrine by the adrenals

97. What is the most frequent cause of decreased coronary blood flow in patients with ischemic heart disease?
    A) Increased adenosine release
    B) Atherosclerosis
    C) Coronary artery spasm
    D) Increased sympathetic tone of the coronary arteries
    E) Occlusion of the coronary sinus

98. A 60-year-old man sustained an ischemia-induced myocardial infarction and died from ventricular fibrillation. In this patient, what factor was most likely to increase the tendency of the heart to fibrillate after the infarction?
    A) Low potassium concentration in the heart extracellular fluid
    B) A decrease in ventricular diameter
    C) Increased sympathetic stimulation of the heart
    D) Low adenosine concentration
    E) Decreased parasympathetic stimulation of the heart

99. A 60-year-old man has been told by his doctor that he has angina caused by myocardial ischemia. Which treatment would be beneficial to this man?
    A) Angiotensin-converting enzyme inhibition
    B) Isometric exercise
    C) Chelation therapy such as ethylenediamine tetraacetic acid (EDTA)
    D) Beta receptor stimulation
    E) Increased dietary calcium

100. What is one of the major causes of death after myocardial infarction?
    A) Increased cardiac output
    B) A decrease in pulmonary interstitial volume
    C) Fibrillation of the heart
    D) Increased cardiac contractility

101. Which statement about the results of sympathetic stimulation is most accurate?
    A) Epicardial flow increases
    B) Venous resistance decreases
    C) Arteriolar resistance decreases
    D) Heart rate decreases
    E) Venous reservoirs constrict

102. What is normally associated with the chronic stages of compensated heart failure? Assume the patient is resting.
    A) Dyspnea
    B) Decreased right atrial pressure
    C) Decreased heart rate
    D) Sweating
    E) Increased mean systemic filling pressure

103. What normally occurs in a person with unilateral left heart failure?
    A) Decreased pulmonary artery pressure
    B) Decreased left atrial pressure
    C) Decreased right atrial pressure
    D) Edema of feet
    E) Increased mean pulmonary filling pressure

104. What normally causes renal sodium retention during compensated heart failure?
    A) Increased formation of angiotensin II
    B) Increased release of atrial natriuretic factor
    C) Sympathetic vasodilation of the afferent arterioles
    D) Increased glomerular filtration rate
    E) Increased formation of antidiuretic hormone (ADH)

105. Which intervention would normally be beneficial to a patient with acute pulmonary edema?
    A) Infuse a vasoconstrictor drug
    B) Infuse a balanced electrolyte solution
    C) Administer furosemide
    D) Administer a bronchoconstrictor
    E) Infuse whole blood

106. A 60-year-old man had a heart attack 2 days ago, and his blood pressure has continued to decrease. He is now in cardiogenic shock. Which therapy would be most beneficial?
    A) Placing tourniquets on all four limbs
    B) Administering a sympathetic inhibitor
    C) Administering furosemide
    D) Administering a blood volume expander
    E) Increasing dietary sodium intake

107. If a 21-year-old male patient has a cardiac reserve of 300% and a maximum cardiac output of 16 L/min, what is his resting cardiac output?
    A) 3 L/min
    B) 4 L/min
    C) 5.33 L/min
    D) 6 L/min
    E) 8 L/min

108. Which of the following occurs during heart failure and causes an increase in renal sodium excretion?
    A) Increased aldosterone release
    B) Increased atrial natriuretic factor release
    C) Decreased glomerular filtration rate
    D) Increased angiotensin II release
    E) Decreased mean arterial pressure

109. Which intervention would be appropriate therapy for a patient in cardiogenic shock?
    A) Placing tourniquets on the four limbs
    B) Withdrawing a moderate amount of blood from the patient
    C) Administering furosemide
    D) Infusing a vasoconstrictor drug

110. Which condition normally accompanies acute unilateral right heart failure?
    A) Increased right atrial pressure
    B) Increased left atrial pressure
    C) Increased urinary output
    D) Increased cardiac output
    E) Increased arterial pressure

111. What is normally associated with the chronic stages of compensated heart failure? Assume the patient is resting.
    A) Decreased mean systemic filling pressure
    B) Increased right atrial pressure
    C) Increased heart rate
    D) Sweating
    E) Dyspnea

112. Patients with pulmonary edema often have dyspnea because of accumulation of fluid in the lungs. Which of the following would normally be the most beneficial for a patient with acute pulmonary edema?
    A) Infusing furosemide
    B) Infusing dobutamine
    C) Infusing saline solution
    D) Infusing norepinephrine
    E) Infusing whole blood

113. Which of the following is associated with compensated heart failure?
    A) Increased cardiac output
    B) Increased blood volume
    C) Decreased mean systemic filling pressure
    D) Normal right atrial pressure

114. Which condition is normally associated with an increase in mean systemic filling pressure?
    A) Decreased blood volume
    B) Congestive heart failure
    C) Sympathetic inhibition
    D) Venous dilation

115. Which condition normally occurs during the early stages of compensated heart failure?
    A) Increased right atrial pressure
    B) Normal heart rate
    C) Decreased angiotensin II release
    D) Decreased aldosterone release
    E) Increased urinary output of sodium and water

116. What often occurs during decompensated heart failure?
    A) Hypertension
    B) Increased mean pulmonary filling pressure
    C) Decreased pulmonary capillary pressure
    D) Increased cardiac output
    E) Increased norepinephrine in the endings of the cardiac sympathetic nerves

117. Which of the following often occurs in decompensated heart failure?
    A) Increased renal loss of sodium and water
    B) Decreased mean systemic filling pressure
    C) Increased norepinephrine in cardiac sympathetic receptors
    D) Orthopnea
    E) Weight loss

118. An 80-year-old male patient at a local hospital was diagnosed with a heart murmur. A chest radiograph showed an enlarged heart but no edema fluid in the lungs. The mean QRS axis of his ECG was 170 degrees. His pulmonary wedge pressure was normal. What is the diagnosis?
    A) Mitral stenosis
    B) Aortic stenosis
    C) Pulmonary valve stenosis
    D) Tricuspid stenosis
    E) Mitral regurgitation

119. The fourth heart sound is associated with which mechanism?
   A) In-rushing of blood into the ventricles from atrial contraction
   B) Closing of the A-V valves
   C) Closing of the pulmonary valve
   D) Opening of the A-V valves
   E) In-rushing of blood into the ventricles in the early to middle part of diastole

120. A 40-year-old woman has been diagnosed with a heart murmur. A " blowing" murmur of relatively high pitch is heard maximally over the left ventricle. The chest radiograph shows an enlarged heart. Arterial pressure in the aorta is 140/40 mm Hg. What is the diagnosis?
   A) Aortic valve stenosis
   B) Aortic valve regurgitation
   C) Pulmonary valve stenosis
   D) Mitral valve stenosis
   E) Tricuspid valve regurgitation

121. In which disorder will left ventricular hypertrophy normally occur?
   A) Pulmonary valve regurgitation
   B) Tricuspid regurgitation
   C) Mitral stenosis
   D) Tricuspid stenosis
   E) Aortic stenosis

122. Which heart murmur is heard during systole?
   A) Aortic valve regurgitation
   B) Pulmonary valve regurgitation
   C) Tricuspid valve stenosis
   D) Mitral valve stenosis
   E) Patent ductus arteriosus

123. An increase in left atrial pressure is most likely to occur in which heart murmur?
   A) Tricuspid stenosis
   B) Pulmonary valve regurgitation
   C) Aortic stenosis
   D) Tricuspid regurgitation
   E) Pulmonary valve stenosis

124. A 50-year-old female patient at a local hospital has been diagnosed with a heart murmur. A murmur of relatively low pitch is heard maximally over the second intercostal space to the right of the sternum. The chest radiograph shows an enlarged heart. The mean QRS axis of the ECG is −45 degrees. What is the diagnosis?
   A) Mitral valve stenosis
   B) Aortic valve stenosis
   C) Pulmonary valve stenosis
   D) Tricuspid valve stenosis
   E) Tricuspid valve regurgitation

125. A 40-year-old female patient has been diagnosed with a heart murmur of relatively high pitch heard maximally in the second intercostal space to the left of the sternum. The mean QRS axis of his ECG is 150 degrees. The arterial blood oxygen content is normal. What is the likely diagnosis?
   A) Aortic stenosis
   B) Aortic regurgitation
   C) Pulmonary valve regurgitation
   D) Mitral stenosis
   E) Tricuspid stenosis

126. In which condition will right ventricular hypertrophy normally occur?
   A) Tetralogy of Fallot
   B) Mild aortic stenosis
   C) Mild aortic insufficiency
   D) Mitral stenosis
   E) Tricuspid stenosis

127. Which heart murmur is only heard during diastole?
   A) Patent ductus arteriosus
   B) Aortic stenosis
   C) Tricuspid valve regurgitation
   D) Interventricular septal defect
   E) Mitral stenosis

128. A person with which condition is most likely to have low arterial oxygen content?
   A) Tetralogy of Fallot
   B) Pulmonary artery stenosis
   C) Tricuspid insufficiency
   D) Patent ductus arteriosus
   E) Tricuspid stenosis

129. Which of the following is associated with the first heart sound?
   A) Inrushing of blood into the ventricles as a result of atrial contraction
   B) Closing of the A-V valves
   C) Closing of the pulmonary valve
   D) Opening of the A-V valves
   E) Inrushing of blood into the ventricles in the early to middle part of diastole

130. A 50-year-old woman had an echocardiogram. The results indicated a thickened right ventricle. Other data indicated that the patient had severely decreased arterial oxygen content and equal systolic pressures in both cardiac ventricles. What condition is present?
   A) Interventricular septal defect
   B) Tetralogy of Fallot
   C) Pulmonary valve stenosis
   D) Pulmonary valve regurgitation
   E) Patent ductus arteriosus

131. Which heart murmur is only heard during diastole?
   - A) Patent ductus arteriosus
   - B) Mitral regurgitation
   - C) Tricuspid valve stenosis
   - D) Interventricular septal defect
   - E) Aortic stenosis

132. Which mechanism is associated with the third heart sound?
   - A) Inrushing of blood into the ventricles as a result of atrial contraction
   - B) Closing of the A-V valves
   - C) Closing of the pulmonary valve
   - D) Opening of the A-V valves
   - E) Inrushing of blood into the ventricles in the early to middle part of diastole

133. Which condition often occurs in a person with progressive hemorrhagic shock?
   - A) Increased capillary permeability
   - B) Stress relaxation of veins
   - C) Tissue alkalosis
   - D) Increased urine output
   - E) Increased mean systemic filling pressure

134. In which condition will administration of a sympathomimetic drug be the therapy of choice to prevent shock?
   - A) Spinal cord injury
   - B) Shock due to excessive vomiting
   - C) Hemorrhagic shock
   - D) Shock caused by excess diuretics

135. The blood pressure of a 60-year-old man decreased to 55/35 mm Hg during induction of anesthesia. His ECG still shows a normal sinus rhythm. What initial therapy do you recommend?
   - A) Infusion of packed red blood cells
   - B) Infusion of plasma
   - C) Infusion of a balanced electrolyte solution
   - D) Infusion of a sympathomimetic drug
   - E) Administration of a glucocorticoid

136. A 65-year-old man enters a local emergency department a few minutes after receiving an influenza inoculation. He has pallor, tachycardia, arterial pressure of 80/50, and trouble walking. What therapy do you recommend to prevent shock?
   - A) Infusion of blood
   - B) Administration of an antihistamine
   - C) Infusion of a balanced electrolyte solution such as saline
   - D) Infusion of a sympathomimetic drug
   - E) Administration of tissue plasminogen activator

137. Which condition often occurs in compensated hemorrhagic shock? Assume systolic pressure is 48 mm Hg.
   - A) Decreased heart rate
   - B) Stress relaxation of veins
   - C) Decreased ADH release
   - D) Decreased absorption of interstitial fluid through the capillaries
   - E) Central nervous system (CNS) ischemic response

138. If a patient undergoing spinal anesthesia experiences a large decrease in arterial pressure and goes into shock, what would be the therapy of choice?
   - A) Plasma infusion
   - B) Blood infusion
   - C) Saline solution infusion
   - D) Glucocorticoid infusion
   - E) Infusion of a sympathomimetic drug

139. A 25-year-old man who has been in a motorcycle wreck enters the emergency department. His clothes are very bloody, and his arterial pressure is decreased to 70/40. His heart rate is 120, and his respiratory rate is 30/min. Which therapy would the physician recommend?
   - A) Infusion of blood
   - B) Infusion of plasma
   - C) Infusion of a balanced electrolyte solution
   - D) Infusion of a sympathomimetic drug
   - E) Administration of a glucocorticoid

140. In which type of shock does cardiac output often increase?
   - A) Hemorrhagic shock
   - B) Anaphylactic shock
   - C) Septic shock
   - D) Neurogenic shock

141. A 20-year-old man who has been hemorrhaging as a result of a gunshot wound enters a local emergency department. He has pale skin, tachycardia, an arterial pressure of 60/40, and trouble walking. Unfortunately, the blood bank is out of whole blood. Which therapy would the physician recommend to prevent shock?
   - A) Administration of a glucocorticoid
   - B) Administration of an antihistamine
   - C) Infusion of a balanced electrolyte solution
   - D) Infusion of a sympathomimetic drug
   - E) Infusion of plasma

142. A 10-year-old girl in the hospital had an intestinal obstruction, and her arterial pressure decreased to 70/40. Her heart rate is 120, and her respiratory rate is 30/min. Which therapy would the physician recommend?
   - A) Infusion of blood
   - B) Infusion of plasma
   - C) Infusion of a balanced electrolyte solution
   - D) Infusion of a sympathomimetic drug
   - E) Administration of a glucocorticoid

143. What often occurs during progressive shock?
   A) Patchy areas of necrosis in the liver
   B) Decreased tendency for blood to clot
   C) Increased glucose metabolism
   D) Decreased release of hydrolases by lysosomes
   E) Decreased capillary permeability

144. Release of which substance causes vasodilation and increased capillary permeability during anaphylactic shock?
   A) Histamine
   B) Bradykinin
   C) Nitric oxide
   D) Atrial natriuretic factor
   E) Adenosine

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ANSWERS

1. **D)** The rate of net fluid movement across a capillary wall is calculated as capillary filtration coefficient × net filtration pressure. Net filtration pressure = capillary hydrostatic pressure − plasma colloid osmotic pressure + interstitial colloid osmotic pressure − interstitial hydrostatic pressure. Thus, the rate of net fluid movement across the capillary wall is 150 ml/min.

$$\text{Filtration rate} = \text{Capillary filtration coefficient } (K_f) \times \text{Net filtration pressure}$$
$$\text{Filtration rate} = K_f \times [Pc - \Pi c + \Pi i - P_I]$$
$$\text{Filtration rate} = 10 \text{ ml/min/mm Hg} \times [25 - 25 + 10 - (-5)]$$
$$\text{Filtration rate} = 10 \times 15 = 150 \text{ ml/min}$$

TMP13 p. 194

2. **D)** Moving from a supine to a standing position causes an acute fall in arterial pressure that is sensed by arterial baroreceptors located in the carotid bifurcation and aortic arch. Activation of the arterial baroreceptors leads to an increase in sympathetic outflow to the heart and peripheral vasculature and a decrease in parasympathetic outflow to the heart. The increase in sympathetic activity to peripheral vessels results in an increase in total peripheral resistance. The increase in sympathetic activity and decrease in parasympathetic outflow to the heart result in an increase in heart rate.
TMP13 pp. 220-221

3. **E)** Administration of a drug that decreases the diameter of arterioles in a muscle bed increases the vascular resistance. The increased vascular resistance decreases vascular conductance and blood flow. The reduction in arteriolar diameter also leads to a decrease in capillary hydrostatic pressure and capillary filtration rate.
TMP13 pp. 175 and 194

4. **G)** Moving from a supine to a standing position causes an acute fall in arterial pressure that is sensed by arterial baroreceptors located in the carotid sinuses and aortic arch. Activation of the baroreceptors results in a decrease in parasympathetic activity (or vagal tone) and an increase in sympathetic activity, which leads to an increase in plasma renin activity (or renin release).
TMP13 pp. 219-222

5. **A)** The difference between systolic pressure and diastolic pressure is the pulse pressure. The two major factors that affect pulse pressure are the stroke volume output of the heart and the compliance of the arterial tree. In patients with moderate aortic regurgitation (due to incomplete closure of aortic valve), the blood that is pumped into the aorta immediately flows back into the left ventricle. The backflow of blood into the left ventricle increases stroke volume and systolic pressure. The rapid backflow of blood also results in a decrease in diastolic pressure. Thus, patients with moderate aortic regurgitation have high systolic pressure, low diastolic pressure, and high pulse pressure.
TMP13 pp. 180-181

6. **B)** The increase in local metabolism during exercise increases oxygen utilization and decreases tissue oxygen concentration. The decrease in tissue oxygen concentration increases arteriolar diameter and increases vascular conductance and blood flow to skeletal muscles.
TMP13 pp. 204-206

7. **B)** Cognitive stimuli increase cerebral blood flow by decreasing cerebral vascular resistance. The diameter of cerebral vessels is decreased by various metabolic factors in response to cognitive stimuli. Metabolic factors that enhance cerebral blood flow include increases in carbon dioxide, hydrogen ion (decreased pH), and adenosine.
TMP13 pp. 203-206

8. **A)** Histamine is a vasodilator that is typically released by mast cells and basophils. Infusion of histamine into a brachial artery would decrease arteriolar resistance and increase water permeability of the capillary wall. The decrease in arteriolar resistance would also increase capillary hydrostatic pressure. The increase in capillary hydrostatic pressure and water permeability leads to an increase in capillary filtration rate.
TMP13 pp. 175 and 194

9. **C)** An increase in shear stress in blood vessels is one of the major stimuli for the release of nitric oxide by endothelial cells. Nitric oxide increases blood flow by increasing cyclic guanosine monophosphate.
TMP13 p. 208

10. **D)** Angiotensin I is formed by an enzyme (renin) acting on a substrate called angiotensinogen. Angiotensin I is converted to angiotensin II by a converting enzyme. Angiotensin II also has a negative feedback effect on juxtaglomerular cells to inhibit renin secretion. Angiotensin II is a powerful vasoconstrictor and sodium-retaining hormone that increases arterial pressure. Administration of an ACE inhibitor would increase plasma renin concentration, decrease angiotensin II formation, enhance renal sodium excretory function, and decrease total peripheral resistance and arterial pressure.
TMP13 pp. 234-235

11. E) An increase in the diameter of a precapillary arteriole would decrease arteriolar resistance. The decrease in arteriolar resistance would lead to an increase in vascular conductance and capillary blood flow, hydrostatic pressure, and filtration rate.
TMP13 pp. 175 and 194

12. A) Stenosis of one kidney results in the release of renin and the formation of angiotensin II from the affected kidney. Angiotensin II stimulates aldosterone production and increases total peripheral resistance by constricting most of the blood vessels in the body.
TMP13 p. 236

13. D) Blood flow in a vessel is directly proportional to the fourth power of the vessel radius. Increasing vessel diameter by 50% (1.5 × control) would increase blood flow 1.5 to the fourth power × normal blood flow (100 ml/min). Thus, blood flow would increase to 100 ml/min × 5.06, or approximately 500 ml/min.
TMP13 p. 175

14. A) In patent ductus arteriosus, a large quantity of the blood pumped into the aorta by the left ventricle immediately flows backward into the pulmonary artery and then into the lung and left atrium. The shunting of blood from the aorta results in a low diastolic pressure, while the increased inflow of blood into the left atrium and ventricle increases stroke volume and systolic pressure. The combined increase in systolic pressure and decrease in diastolic pressure results in an increase in pulse pressure.
TMP13 p. 181

15. D) A decrease in tissue oxygen tension is thought to be an important stimulus for vascular endothelial growth factor and the growth of blood vessels in solid tumors.
TMP13 pp. 209-210

16. A) The net movement of sodium across a capillary wall is directly proportional to the wall permeability to sodium, wall surface area, and concentration gradient across the capillary wall. Thus, increases in permeability to sodium, surface area, and sodium concentration gradient wall would all increase the net movement of sodium across the capillary wall.
TMP13 pp. 190-192

17. A) Constriction of the carotid artery decreases blood pressure at the level of the carotid sinus. A decrease in carotid sinus pressure leads to a decrease in carotid sinus nerve impulses to the vasomotor center, which in turn leads to enhanced sympathetic nervous activity and decreased parasympathetic nerve activity. The increase in sympathetic nerve activity results in peripheral vasoconstriction and an increase in total peripheral resistance and heart rate.
TMP13 pp. 220-221

18. E) Pulse pressure is the difference between systolic pressure and diastolic pressure. The two major factors that affect pulse pressure are the stroke volume output of the heart and the compliance of the arterial tree. An increase in stroke volume increases systolic and pulse pressure, whereas an increase in compliance of the arterial tree decreases pulse pressure. Moderate aortic valve stenosis results in a decrease in stroke volume, which leads to a decrease in systolic pressure and pulse pressure.
TMP13 pp. 180-181

19. B) A person with atherosclerosis would be expected to have decreased arterial compliance. The decrease in arterial compliance would lead to an increase in systolic pressure and pulse pressure.
TMP13 pp. 180-181

20. B) Constriction of the carotid artery reduces blood pressure at the carotid bifurcation where the arterial baroreceptors are located. The decrease in arterial pressure activates baroreceptors, which in turn leads to an increase in sympathetic activity and a decrease in parasympathetic activity (or vagal tone). The enhanced sympathetic activity results in constriction of peripheral blood vessels, including the kidneys. The enhanced sympathetic activity leads to an increase in total peripheral resistance and a decrease in renal blood flow. The combination of enhanced sympathetic activity and decreased vagal tone also leads to an increase in heart rate.
TMP13 pp. 219-222

21. D) Filtration rate is the product of the filtration coefficient (K_f) and the net pressure across the capillary wall. The net pressure for fluid movement across a capillary wall is promoted by increases in capillary hydrostatic pressure and positive interstitial colloid osmotic pressure, whereas negative plasma colloid osmotic pressure and a positive interstitial hydrostatic pressure oppose filtration. Thus, increased capillary hydrostatic pressure, decreased plasma colloid osmotic pressure, and increased interstitial colloid osmotic pressure would all promote filtration. Decreased arteriolar resistance would also promote filtration by increasing capillary hydrostatic pressure. The filtration coefficient is the product of capillary surface area and the capillary water permeability. A decrease in capillary water permeability would decrease the filtration coefficient and reduce the filtration rate.
TMP13 pp. 193-194

22. E) Solid tumors are metabolically active tissues that need increased quantities of oxygen and other nutrients. When metabolism in a tissue is increased for a prolonged period, the vascularity of the tissue also increases. One of the important factors that increases growth of new blood vessels is VEGF. Presumably, a deficiency of tissue oxygen or other nutrients, or both, leads to the formation of VEGF.
TMP13 p. 210

23. A) A decrease in the diameter of a precapillary arteriole increases arteriolar resistance while decreasing vascular conductance and capillary blood flow, hydrostatic pressure, filtration rate, interstitial volume, and interstitial hydrostatic pressure.
TMP13 pp. 175 and 194

24. C) Excess secretion of aldosterone results in enhanced tubular reabsorption of sodium and secretion of potassium. The increased reabsorption of sodium and water leads to an increase in extracellular fluid volume, which in turn suppresses renin release by the kidney. The increase in potassium secretion leads to a decrease in plasma potassium concentration, or hypokalemia.
TMP13 pp. 235-236

25. E) The two main factors that increase lymph flow are an increase in capillary filtration rate and an increase in lymphatic pump activity. An increase in plasma colloid osmotic pressure decreases capillary filtration rate, interstitial volume and hydrostatic pressure, and lymph flow. In contrast, an increase in hydraulic conductivity of the capillary wall and capillary hydrostatic pressure increase capillary filtration rate, interstitial volume and pressure, and lymph flow. An increase in arteriole resistance would decrease capillary hydrostatic pressure, capillary filtration rate, interstitial volume and pressure, and lymph flow.
TMP13 pp. 193-198

26. E) According to Poiseuille's law, flow through a vessel increases in proportion to the fourth power of the radius. A fourfold increase in vessel diameter (or radius) would increase 4 to the fourth power, or 256 times normal. Thus, flow through the vessel after increasing the vessel 4 times normal would increase from 100 to 25,600 ml/min.
TMP13 pp. 175-176

27. B) Vascular resistance is equal to arterial pressure minus venous pressure divided by blood flow. In this example, arterial pressure is 125 mm Hg, venous pressure is 5 mm Hg, and blood flow is 1200 ml/min. Thus, vascular resistance is equal to 120/1200, or 0.10 mm Hg/ml/min.
TMP13 p. 172

28. D) The rate of blood flow is directly proportional to the fourth power of the vessel radius and to the pressure gradient across the vessel. In contrast, the rate of blood flow is inversely proportional to the viscosity of the blood. Thus, an increase in blood viscosity would decrease blood flow in a vessel.
TMP13 pp. 175-176

29. D) The flow in a vessel is directly proportional to the pressure gradient across the vessel and to the fourth power of the radius of the vessel. In contrast, blood flow is inversely proportional to the viscosity of the blood. Because blood flow is proportional to the fourth power of the vessel radius, the vessel with the largest radius (vessel D) would have the greatest flow.
TMP13 p. 176

30. A) The arterial baroreceptors are activated in response to a fall in arterial pressure. During hemorrhage, the fall in arterial pressure at the level of the baroreceptors results in enhanced sympathetic outflow from the vasomotor center and a decrease in parasympathetic nerve activity. The increase in sympathetic nerve activity leads to constriction of peripheral blood vessels, increased total peripheral resistance, and a return of blood pressure toward normal. The decrease in parasympathetic nerve activity and sympathetic outflow would result in an increase in heart rate.
TMP13 pp. 219-222

31. A) Activation of the baroreceptors leads to an increase in sympathetic activity, which in turn increases heart rate, strength of cardiac contraction, and constriction of arterioles and veins. The increase in venous constriction results in an increase in mean circulatory filling pressure, venous return, and cardiac output.
TMP13 pp. 219-222

32. E) The conversion of angiotensin I to angiotensin II is catalyzed by a converting enzyme that is present in the endothelium of the lung vessels and in the kidneys. The converting enzyme also serves as a kininase that degrades bradykinin. Thus, a converting enzyme inhibitor not only decreases the formation of angiotensin II but also inhibits kininases and the breakdown of bradykinin. Angiotensin II is a vasoconstrictor and a powerful sodium-retaining hormone. The major cause for the decrease in arterial pressure in response to an ACE inhibitor is the decrease in formation of angiotensin II.
TMP13 pp. 234-235

33. G) When blood pressure falls below 80 mm Hg, carotid and aortic chemoreceptors are activated to elicit a neural reflex to minimize the fall in blood pressure. The chemoreceptors are chemosensitive cells that are sensitive to oxygen lack, carbon dioxide excess, or hydrogen ion excess (or fall in pH). The signals transmitted from the chemoreceptors into the vasomotor center excite the vasomotor center to increase arterial pressure.
TMP13 p. 222

34. D) Although sympathetic nerves, angiotensin II, and vasopressin are powerful vasoconstrictors, blood flow to skeletal muscles under normal physiological conditions is mainly determined by local metabolic needs.
TMP13 pp. 206-208

35. E) During exercise, tissue levels of carbon dioxide and lactic acid increase. These metabolites dilate blood vessels, decrease arteriolar resistance, and enhance vascular conductance and blood flow.
TMP13 pp. 206-207

36. A) The velocity of blood flow within each segment of the circulatory system is inversely proportional to the total cross-sectional area of the segment. Because the aorta has the smallest total cross-sectional area of all circulatory segments, it has the highest velocity of blood flow.
TMP13 pp. 173-174

37. B) Filtration rate is the product of the filtration coefficient (K_f) and the net pressure across the capillary wall. The net pressure for fluid movement across a capillary wall = capillary hydrostatic pressure − plasma colloid osmotic pressure − interstitial colloid osmotic pressure − interstitial hydrostatic pressure. The net pressure in this question calculates to be 10 mm Hg, and the K_f is 15. Thus, the filtration rate is 15 × 10, or 150 ml/min.
TMP13 pp. 193-194

38. A) Resistance of a vessel = pressure gradient ÷ blood flow of the vessel. In this example, vessel A has the highest vascular resistance (100 mm Hg/1000 ml/min, or 0.1 mm Hg/ml/min).
TMP13 p. 175

39. C) The transport of oxygen across a capillary wall is proportional to the capillary surface area, capillary wall permeability to oxygen, and oxygen gradient across the capillary wall. Thus, a twofold increase in the oxygen concentration gradient would result in the greatest increase in the transport of oxygen across the capillary wall. A twofold increase in intercellular clefts in the capillary wall would not have a significant impact on oxygen transport because oxygen can permeate the endothelial cell wall.
TMP13 pp. 191-192

40. A) Atrial natriuretic peptide is released from myocytes in the atria in response to increases in atrial pressure.
TMP13 p. 222

41. C) The capillaries have the largest total cross-sectional area of all vessels of the circulatory system. The venules also have a relatively large total cross-sectional area, but not as great as the capillaries, which explains the large storage of blood in the venous system compared with that in the arterial system.
TMP13 pp. 172-173

42. D) An increase in atrial pressure would also increase plasma levels of atrial natriuretic peptide, which in turn would decrease plasma levels of angiotensin II and aldosterone and increase sodium excretion.
TMP13 pp. 222-223

43. C) An increase in perfusion pressure to a tissue results in excessive delivery of nutrients such as oxygen to a tissue. The increase in tissue oxygen concentration constricts arterioles and returns blood flow and nutrient delivery toward normal levels.
TMP13 pp. 206-207

44. C) The percentage of total blood volume in the veins is approximately 64%.
TMP13 p. 169

45. B) Constriction of the renal artery increases release of renin, formation of angiotensin II and aldosterone, and arterial pressure. A 50% reduction in renal artery pressure would be below the range of renal autoregulation and would result in a decrease in the glomerular filtration rate.
TMP13 p. 238

46. B) An increase in plasma colloid osmotic pressure would reduce net filtration pressure and capillary filtration rate. Increases in capillary hydrostatic pressure and interstitial colloid osmotic pressure would also favor capillary filtration. An increase in venous hydrostatic pressure and arteriolar diameter would tend to increase capillary hydrostatic pressure and capillary filtration rate.
TMP13 pp. 193-197

47. D) An increase in sodium intake would result in an increase in sodium excretion to maintain sodium balance. Conversely, potassium excretion would only transiently increase after an increase in sodium intake. Angiotensin II and aldosterone would decrease in response to a chronic elevation in sodium intake, whereas plasma atrial natriuretic peptide levels would increase.
TMP13 pp. 236-237

48. C) The rate of lymph flow increases in proportion to the interstitial hydrostatic pressure and the lymphatic pump activity. A decrease in plasma colloid osmotic pressure would increase filtration rate, interstitial volume, interstitial hydrostatic pressure, and lymph flow. A decrease in arteriolar diameter would decrease capillary hydrostatic pressure, capillary filtration, and lymph flow.
TMP13 pp. 193-200

49. D) Nitric oxide is a potent vasodilator and natriuretic substance. Thus, a reduction in nitric oxide production would result in an increase in arterial pressure. In contrast, angiotensin II, thromboxane, and aldosterone are vasoconstrictor and/or antinatriuretic factors. A decrease in the production of these factors would tend to decrease arterial pressure.
TMP13 p. 239

50. E) The brain has tight junctions between capillary endothelial cells that allow only extremely small molecules such as water, oxygen, and carbon dioxide to pass in or out of the brain tissues.
TMP13 p. 190

51. D) The Cushing reaction is a special type of CNS ischemic response that results from increased pressure of the cerebrospinal fluid around the brain in the cranial vault. When the cerebrospinal fluid pressure

rises, it decreases the blood supply to the brain and elicits a CNS ischemic response. The CNS ischemic response includes enhanced sympathetic activity, decreased parasympathetic activity, and increased heart rate, arterial pressure, and total peripheral resistance.
TMP13 p. 223

52. B) The factors that determine the net movement of glucose across a capillary wall include the wall permeability to glucose, the glucose concentration gradient across the wall, and the capillary wall surface area. Thus, an increase in the concentration difference of glucose across the wall would enhance the net movement of glucose.
TMP13 pp. 191-192

53. E) An increase in atrial pressure of 10 mm Hg would tend to decrease venous return to the heart and increase vena cava hydrostatic pressure. Plasma colloid osmotic pressure, interstitial colloid osmotic pressure, arterial pressure, and cardiac output would generally be low to normal in this patient.
TMP13 pp. 184-185

54. A) An increase in renal arterial pressure results in increases in sodium and water excretion. Normally, glomerular filtration rate would be normal or slightly increased in response to an increase in renal artery pressure. However, in the absence of an intact tubuloglomerular feedback system, an important renal autoregulatory mechanism, an increase in renal artery pressure would result in significant increases in glomerular filtration rate.
TMP13 pp. 227-228

55. C) The vascular compliance is proportional to the vascular distensibility and the vascular volume of any given segment of the circulation. The compliance of a systemic vein is 24 times that of its corresponding artery because it is about 8 times as distensible and has a volume about 3 times as great.
TMP13 p. 179

56. C) The difference between systolic pressure and diastolic pressure is called the pulse pressure. The two main factors that affect pulse pressure are stroke volume and arterial compliance. Pulse pressure is directly proportional to the stroke volume and inversely proportional to the arterial compliance. Thus, a decrease in arterial compliance would tend to increase pulse pressure.
TMP13 pp. 180-181

57. B) Filtration coefficient (K_f) = filtration rate ÷ net filtration pressure. Net filtration pressure = capillary hydrostatic pressure − plasma colloid osmotic pressure + interstitial colloid osmotic pressure − interstitial hydrostatic pressure. The net filtration pressure in this example is 10 mm Hg. Thus, K_f = 150 ml/min ÷ 10 mm Hg, or 15 ml/min/mm Hg.
TMP13 pp. 193-198

58. B) Moving from a supine to a standing position results in pooling of blood in the lower extremities and a fall in blood pressure. The pooling of blood in the legs increases venous hydrostatic pressure. The fall in arterial pressure activates the arterial baroreceptors, which in turn increases sympathetic nerve activity and decreases parasympathetic nerve activity. The increase in sympathetic activity constricts renal vessels and reduces renal blood flow. The heart rate also increases.
TMP13 pp. 219-222

59. D) Reduction in perfusion pressure to a tissue leads to a decrease in tissue oxygen concentration and an increase in tissue carbon dioxide concentration. Both events lead to an increase in arteriolar diameter, decreased vascular resistance, and increased vascular conductance.
TMP13 pp. 206-207

60. B) Because oxygen is lipid soluble and can cross the capillary wall with ease, it has the fastest rate of movement across the capillary wall. The ability of lipid-insoluble substances such as sodium, albumin, and glucose to move across a capillary wall depends on the permeability of the capillary to lipid-insoluble substances. Because the capillary wall is relatively impermeable to albumin, it has the slowest rate of net movement across the capillary wall.
TMP13 pp. 191-192

61. A) An increase in capillary wall permeability to water would increase capillary filtration rate, whereas increases in arteriolar resistance, plasma colloid osmotic pressure, and interstitial hydrostatic pressure would all decrease filtration rate. Plasma sodium concentration would have no effect on filtration.
TMP13 pp. 193-198

62. D) The tendency for turbulent flow occurs at vascular sites where the velocity of blood flow is high. The aorta has the highest velocity of blood flow.
TMP13 pp. 175-176

63. E) Total peripheral vascular resistance = arterial pressure − right atrial pressure ÷ cardiac output. In this example, total peripheral vascular resistance = 130 mm Hg ÷ 3.5 L/min, or approximately 37 mm Hg/L/min.
TMP13 pp. 175-176

64. C) Interstitial hydrostatic pressure in a muscle capillary bed is normally negative (−3 mm Hg). Pumping by the lymphatic system is the basic cause of the negative pressure.
TMP13 p. 195

65. A) The two main factors that affect pulse pressure are stroke volume and arterial compliance. Increases in stroke volume increase pulse pressure, whereas an increase in arterial compliance decreases pulse pressure. Hemorrhage and decreased venous return would decrease stroke volume and pulse pressure. In

patients with patent ductus, stroke volume and pulse pressure are increased as a result of shunting of blood from the aorta to the pulmonary artery.
TMP13 pp. 180-181

66. D) The primary mechanism whereby solutes move across a capillary wall is simple diffusion.
TMP13 p. 191

67. C) Movement of the leg muscles causes blood to flow toward the vena cava, which reduces venous hydrostatic pressure. An increase in right atrial pressure would decrease venous return and increase venous hydrostatic pressure. Pregnancy and the presence of ascitic fluid in the abdomen would tend to compress the vena cava and increase venous hydrostatic pressure in the legs.
TMP13 pp. 184-185

68. A) Nitric oxide is a vasodilator that is believed to play a role in regulating blood flow. Infusion of a nitric oxide donor into the brachial artery would increase arteriolar diameter and decrease arteriolar resistance. The decrease in arteriolar resistance would also result in an increase in capillary hydrostatic pressure and filtration rate. The increase in filtration rate leads to an increase in interstitial hydrostatic pressure and lymph flow.
TMP13 pp. 170-171, 200-201

69. D) In persons with decompensated heart failure, the kidneys retain sodium and water, which causes a weight gain and an increase in blood volume. This effect increases the mean systemic filling pressure, which also stretches the heart. Therefore, a decreased mean systemic filling pressure does not occur in decompensated heart failure. The excess blood volume often will overstretch the sarcomeres of the heart, which will prevent them from achieving their maximal tension. An excess central fluid volume also results in orthopnea, which is the inability to breathe properly except in the upright position.
TMP13 pp. 273-275

70. A) During progressive hemorrhagic shock, the vasomotor center often fails, thus reducing sympathetic output. Decreases in arterial pressure will reduce urine output. Decreased blood flow throughout the body causes acidosis because of decreased removal of carbon dioxide. In progressive shock due to hemorrhage, capillary permeability increases and mean systemic filling pressure decreases.
TMP13 p. 296

71. C) With an overdose of furosemide there is a large loss of sodium and water from the body, resulting in dehydration and sometimes shock. The optimal therapy is to replenish the electrolytes that were lost as a result of the overdose of the furosemide. Therefore, infusion of a balanced electrolyte solution is the therapy of choice.
TMP13 pp. 301-302

72. C) Severe vomiting can lead to a large loss of sodium and water from the body, resulting in dehydration and sometimes shock. The best therapy is to replenish the depleted sodium and water lost by vomiting. Therefore, infusion of a balanced electrolyte solution is the therapy of choice.
TMP13 pp. 301-302

73. C) The formula for resistance to venous return is mean systemic filling pressure − right atrial pressure/cardiac output. In this example the mean systemic filling pressure is 7 mm Hg and the right atrial pressure is 0 mm Hg. The cardiac output is 5 L/min. Using these values in the previous formula indicates that the resistance to venous return is 1.4 mm Hg/L/min. Note that this formula only applies to the linear portion of the venous return curve.
TMP13 pp. 253-254

74. A) During increases in sympathetic output to maximal values, several changes occur. First, the mean systemic filling pressure increases markedly, but at the same time the resistance to venous return increases. Venous return is determined by the following formula: mean systemic filling pressure − right atrial pressure/resistance to venous return. During maximal sympathetic output, the increase in systemic filling pressure is greater than the increase in resistance to venous return. Therefore, in this formula the numerator has a much greater increase than the denominator, which results in an increase in the venous return.
TMP13 p. 255

75. C) This problem concerns the Fick principle for determining cardiac output. The formula for cardiac output is oxygen absorbed per minute by the lungs divided by the arterial-venous oxygen difference. In this problem, oxygen consumption of the body is 240 ml/min, and in a steady-state condition, this would exactly equal the oxygen absorbed by the lungs. Therefore, by inserting these values into the equation, we see that the cardiac output will equal 12 L/min.
TMP13 p. 257

76. A) A shift to the right in the cardiac output curve involves an increase in the normal intrapleural pressure of −4 mm Hg. Changing intrapleural pressure to −1 mm Hg will shift the curve to the right. Changing mean systemic filling pressure does not change the cardiac output curve. Taking a patient off of a ventilator, decreasing intrapleural pressure to −7 mm Hg, and breathing against a negative pressure will shift the cardiac output curve to the left.
TMP13 p. 250

77. C) Several factors can cause the cardiac output to shift to the right or to the left. Among those are surgically opening the chest, which makes the cardiac output curve shift 4 mm Hg to the right, and severe cardiac

tamponade, which increases the pressure inside the pericardium, thus tending to collapse the heart, particularly the atria. Playing a trumpet or positive pressure breathing tremendously increases the intrapleural pressure, thus collapsing the atria and shifting the cardiac output curve to the right. Breathing against a negative pressure will shift the cardiac output curve to the left.
TMP13 p. 250

78. E) The plateau level of the cardiac output curve, which is one measure of cardiac contractility, decreases in several circumstances. Some of these circumstances include severe cardiac tamponade, which increases the pressure in the pericardial space, and increasing parasympathetic stimulation of the heart. Increased sympathetic stimulation of the heart increases the level of the cardiac output curve by increasing heart rate and contractility.
TMP13 p. 247

79. B) Cardiac output increases in several conditions because of increased venous return. A-V fistulae also cause a decreased resistance to venous return, thus increasing cardiac output. Cardiac output decreases in patients with hypovolemia, severe aortic regurgitation, and polycythemia. The hematocrit level is high in polycythemia, which increases resistance to venous return.
TMP13 pp. 255-256

80. D) Mean systemic filling pressure is a measure of the tightness of fit of the blood in the circulation. Mean systemic filling pressure is increased by factors that increase blood volume and decrease the vascular compliance. Therefore, an decreased venous compliance, not an increased compliance, would cause an increase in mean systemic filling pressure. Norepinephrine administration and sympathetic stimulation cause arteriolar vasoconstriction and decreased vascular compliance, resulting in an increase in mean systemic filling pressure. Increased blood volume and skeletal muscle contraction, which cause a contraction of the vasculature, also increase this filling pressure.
TMP13 pp. 252-253

81. A) An increase in venous resistance will increase resistance to venous return to a greater degree than an increase in arterial resistance. Venous return of the heart is equal to the mean systemic filling pressure minus the right atrial pressure divided by the resistance to venous return. Parasympathetic stimulation does not affect resistance to venous return, and sympathetic inhibition will reduce resistance to venous return.
TMP13 pp. 253-254

82. A) Anemia will decrease resistance to venous return because of arteriolar dilation. The following mechanisms increase resistance to venous return: increased venous resistance, increased arteriolar resistance, increased sympathetic output, and obstruction of veins.
TMP13 pp. 253-254

83. D) Decreased cardiac output can result from a weakened heart or from a decrease in venous return. Increased venous compliance decreases the venous return of blood to the heart. Cardiac tamponade, surgically opening the chest, and severe aortic stenosis will effectively weaken the heart and thus decrease cardiac output. Moderate anemia will cause an arteriolar vasodilation, which increases venous return of blood back to the heart, thus increasing cardiac output.
TMP13 pp. 249, 255

84. E) Cardiac output increases in several conditions because of increased venous return. Cardiac output increases in hyperthyroidism because of the increased oxygen use by the peripheral tissues, resulting in arteriolar vasodilation and thus increased venous return. Beriberi causes increased cardiac output because a lack of the vitamin thiamine results in peripheral vasodilation. A-V fistulae also cause a decreased resistance to venous return, thus increasing cardiac output. Anemia, because of the decreased oxygen delivery to the tissues, causes an increase in venous return to the heart and thus an increase in cardiac output. Cardiac output decreases in patients with myocardial infarction.
TMP13 pp. 248-249

85. B) During exercise there is very little change in cerebral blood flow, and coronary blood flow increases. Because of the increased sympathetic output, mean systemic filling pressure increases and the veins constrict. During exercise there is also a decrease in parasympathetic impulses to the heart.
TMP13 pp. 255, 260

86. C) The plateau level of the cardiac output curve, which is one measure of cardiac contractility, decreases in several circumstances. Some of these include myocarditis, severe cardiac tamponade that increases the pressure in the pericardial space, myocardial infarction, and various valvular diseases such as mitral stenosis. Decreased parasympathetic stimulation of the heart actually moderately increases the level of the cardiac output curve by increasing the heart rate.
TMP13 p. 247

87. A) During increases in sympathetic output, the main two organs that maintain their blood flow are the brain and the heart. During exercise for 1 hour, the intestinal flow decreases significantly, as does the renal and pancreatic blood flows. The skeletal muscle blood flow to non-exercising muscles also decreases at this time. Therefore, the cerebral blood flow remains close to its control value.
TMP13 p. 260

88. B) Several factors decrease the risk of adverse cardiac events, including decreased levels of LDL, female gender, moderate hypotension, and decreased levels of triglycerides. Decreased levels of HDL will

increase cardiac risks because HDL is a protective cholesterol.
TMP13 pp. 264-265

89. A) Although bradykinin, prostaglandins, carbon dioxide, and potassium ions serve as vasodilators for the coronary artery system, the major controller of coronary blood flow is adenosine. Adenosine is formed as adenosine triphosphate degrades to adenosine monophosphate. Small portions of the adenosine monophosphate are then further degraded to release adenosine into the tissue fluids of the heart muscle, and this adenosine vasodilates the coronary arteries.
TMP13 p. 263

90. E) Sympathetic stimulation directly increases the strength of cardiac contraction and increases the heart rate. In this way the plateau of the Starling curve elevates. Surgically opening the chest and undergoing mechanical ventilation shifts the cardiac output curve to the right. Cardiac tamponade rotates the curve downward, and parasympathetic stimulation depresses the curve.
TMP13 p. 260

91. C) The normal resting coronary blood flow is approximately 225 ml/min. Infusion of adenosine or local release of adenosine normally increases the coronary blood flow. The contraction of the cardiac muscle around the vasculature, particularly in the subendocardial vessels, causes a decrease in blood flow. Therefore, during the systolic phase of the cardiac cycle, the subendocardial flow clearly decreases, while the decrease in epicardial flow is relatively minor.
TMP13 p. 263

92. D) Several factors cause arteriolar vasodilation during exercise, including increases in potassium ion concentration, plasma nitric oxide concentration, plasma adenosine concentration, and plasma osmolality. Although histamine causes arteriolar vasodilation, histamine release does not normally occur during exercise.
TMP13 p. 259

93. A) At the beginning of exercise, increases in sympathetic stimulation of the heart strengthens the heart and increases the heart rate. Coronary and cerebral blood flow are spared from any decrease. Reverse stress relaxation does not occur. Venous constriction occurs, not dilation.
TMP13 p. 260

94. B) The anterior cardiac veins and the thebesian veins both drain venous blood from the heart. However, 75% of the total coronary flow drains from the heart by the coronary sinus.
TMP13 p. 262

95. E) Several drugs have proven to be helpful to patients with myocardial ischemia. Beta receptor blockers (not stimulators) inhibit the sympathetic effects on the heart and are very helpful. ACE inhibition prevents the production of angiotensin II and thus decreases the afterload effect on the heart. Nitroglycerin causes nitric oxide release, resulting in coronary vasodilation. Isometric exercise increases blood pressure markedly and can be harmful, and increased dietary calcium would be of little benefit.
TMP13 p. 269

96. C) During exercise the sympathetic output increases markedly, which causes arteriolar constriction in many places of the body, including non-exercising muscle. The increased sympathetic output also causes venoconstriction throughout the body. During exercise there also is an increased release of norepinephrine and epinephrine by the adrenal glands.
TMP13 pp. 260-261

97. B) Several factors contribute to decreased coronary flow in patients with ischemic heart disease. Some patients will have spasm of the coronary arteries, which acutely decreases coronary flow. However, the major cause of decreased coronary flow is an atherosclerotic narrowing of the lumen of the coronary arteries.
TMP13 p. 264

98. C) Increased sympathetic stimulation excites the cardiac myocytes and makes them much more susceptible to fibrillation. High (not low) potassium increases fibrillation tendency. An increase (not a decrease) in ventricular diameter will allow the cardiac muscle to be out of the refractory period when the cardiac impulse next arrives and can increase the tendency to fibrillate. A low adenosine level will probably only cause some coronary constriction. Decreased parasympathetics will allow the heart rate to increase and has little to do with fibrillation.
TMP13 p. 268

99. A) In a patient with angina due to myocardial ischemia, oxygen use by the heart must be minimized. Oxygen use can be minimized with ACE inhibition, which decreases angiotensin II formation. This will reduce the arterial pressure and decrease myocardial tension and oxygen use. The use of beta sympathetic blockers (not stimulation) will inhibit the effects of excess sympathetic output on the heart, thus reducing wall tension and oxygen use. Isometric exercise should be avoided because of the large increase in arterial pressure that occurs. Chelation therapy with EDTA and increased dietary calcium have little to do with cardiac function.
TMP13 p. 269

100. C) The major causes of death after myocardial infarction include a decrease in cardiac output that prevents tissues of the body from receiving adequate nutrition and oxygen delivery and prevents removal of waste materials. Other causes of death are pulmonary edema, which reduces the oxygenation of the blood, fibrillation of the heart, and rupture of the heart. Cardiac contractility decreases after a myocardial infarction.

TMP13 p. 266

101. E) During sympathetic stimulation, venous reservoirs constrict, venous vascular resistance also increases, arterioles constrict (which increases their resistance), and the heart rate increases. The epicardial coronary vessels have a large number of alpha receptors, but the subendocardial vessels have more beta receptors. Therefore, sympathetic stimulation causes at least a slight constriction of the epicardial vessels. This results in a slight decrease in epicardial flow.

TMP13 pp. 260-261, 263

102. E) Several factors change during compensated heart failure to stabilize the circulatory system. Because of increased sympathetic output, the heart rate increases during compensated heart failure. The kidneys retain sodium and water, which increases blood volume and thus right atrial pressure. The increased blood volume that results causes an increase in mean systemic filling pressure, which will help to increase the cardiac output. Dyspnea usually will occur only in the early stages of compensated failure.

TMP13 pp. 271-272

103. E) In unilateral left heart failure, the kidneys retain sodium and water and thus increase blood volume and the pulmonary veins, in turn, become congested. Therefore, mean pulmonary filling pressure, pulmonary wedge pressure, and left atrial pressure increase. In contrast, in right heart failure, right atrial pressure increases and edema of the lower extremities, including the feet and ankles, occurs.

TMP13 p. 275

104. A) In compensated heart failure, an increased release of angiotensin II also occurs, which causes direct renal sodium retention and also stimulates aldosterone secretion that will, in turn, cause further increases in sodium retention by the kidneys. Because of the low arterial pressure that occurs in compensated heart failure, the sympathetic output increases. One of the results is a sympathetic vasoconstriction (not vasodilation) of the afferent arterioles of the kidney. This decreases the glomerular hydrostatic pressure and the glomerular filtration rate, resulting in an increase in sodium and water retention in the body. The excess sodium in the body will increase osmolality, which increases the release of antidiuretic hormone, which causes renal water retention (but not sodium retention).

TMP13 p. 276

105. C) During acute pulmonary edema, the increased fluid in the lungs diminishes the oxygen content in the blood. This decreased oxygen weakens the heart even further and also causes arteriolar dilation in the body. This results in increases in venous return of blood to the heart, which cause further leakage of the fluid in the lungs and further decreases in oxygen content in the blood. It is important to interrupt this vicious circle to save a patient's life. This can be interrupted by placing tourniquets on all four limbs, which effectively removes blood volume from the chest. The patient can also breathe oxygen, and a bronchodilator can be administered. Furosemide can be administered to reduce some of the fluid volume in the body and especially in the lungs. One thing you do not want to do is infuse whole blood or an electrolyte solution in this patient because it may exacerbate the pulmonary edema that is already present.

TMP13 p. 277

106. D) Cardiogenic shock results from a weakening of the cardiac muscle many times after coronary thrombosis, which can result in a vicious circle because of low cardiac output resulting in a low diastolic pressure. This causes a decrease in coronary flow, which decreases the cardiac strength even more. Therefore, arterial pressure, particularly diastolic pressure, must be increased in patients with cardiogenic shock with either vasoconstrictors or volume expanders. In this patient the best answer is to infuse plasma. Placing tourniquets on all four limbs decreases the central blood volume, which would worsen the condition of the patient in shock.

TMP13 p. 275

107. B) This patient has a resting cardiac output of 4 L/min, and his cardiac reserve is 300% of this resting cardiac output or 12 L/min. This gives a total maximum cardiac output of 16 L/min. Therefore, the cardiac reserve is the percentage increase that the cardiac output can be elevated over the resting cardiac output.

TMP13 p. 277

108. B) Several factors cause sodium retention during heart failure, including aldosterone release, decreased glomerular filtration rate, and an increased angiotensin II release. A decrease in mean arterial pressure also results in decreases in glomerular hydrostatic pressure and causes a decrease in renal sodium excretion. During heart failure, blood volume increases, resulting in an increased cardiac stretch. In particular, the atrial pressure increases, causing a release of atrial natriuretic factor, resulting in an increase in renal sodium excretion.

TMP13 p. 276

109. D) There is a vicious circle of cardiac deterioration in cardiogenic shock. A weakened heart causes a

decreased cardiac output, which decreases arterial pressure. The decreased arterial pressure, particularly the decrease in diastolic pressure, decreases the coronary blood flow and further weakens the heart and thus further decreases cardiac output. The therapy of choice for a patient in cardiogenic shock is to increase the arterial pressure either with a vasoconstrictor drug or with a volume-expanding drug. Placing tourniquets on the four limbs, withdrawing a moderate amount of blood, or administering furosemide decreases the thoracic blood volume and thus worsens the condition of the patient in cardiogenic shock.
TMP13 p. 275

110. A) In unilateral right heart failure, the right atrial pressure decreases and the overall cardiac output decreases, which results in a decrease in arterial pressure and urinary output. However, left atrial pressure does not increase but in fact decreases.
TMP13 p. 275

111. B) During compensated heart failure, many factors combine to increase cardiac output so it returns to normal. The kidneys decrease their urinary output of sodium and water to increase the blood volume. This action, when combined with a depressed cardiac output curve, will increase right atrial pressure. Mean systemic filling pressure increases (not decreases), and the venous return of blood back toward the heart thus increases right atrial pressure. Heart rate is normal, and sweating and dyspnea are absent in the chronic stages of compensated failure.
TMP13 pp. 274-275

112. A) Reduction of fluid in the lungs can prevent rapid deterioration in patients with acute pulmonary edema. Furosemide causes venodilation, which reduces thoracic blood volume and acts as a powerful diuretic. These both reduce excess fluid in the lungs. Blood can actually be removed in moderate quantities from the patient to decrease the volume of blood in the chest. Patients should also breathe oxygen to increase the oxygen levels in the blood. However, they should never be given a volume expander, such as saline, plasma, whole blood, or dextran, because it could worsen the pulmonary edema. Norepinephrine would be of little help in treating pulmonary edema.
TMP13 pp. 277-278

113. B) In compensated heart failure, mean systemic filling pressure increases because of hypervolemia, and cardiac output is often at normal values. The patient has air hunger, called dyspnea, and excess sweating occurs in the early phases of compensated heart failure. However, right atrial pressure becomes elevated to very high values in these patients and is a hallmark of this disease.
TMP13 pp. 272-273

114. B) Mean systemic pressure is increased by factors that increase blood volume or decrease vascular capacity. Sympathetic inhibition and venous dilation both decrease the mean systemic filling pressure. In congestive heart failure, the kidneys retain great quantities of sodium and water, resulting in an increase in blood volume, which causes large increases in mean systemic filling pressure.
TMP13 p. 272

115. A) During compensated heart failure, release of angiotensin II and aldosterone is increased, causing the kidneys retain sodium and water, which increases the blood volume in the body and the venous return of blood to the heart. This situation results in an increase in right atrial pressure. Increased sympathetic output during compensated heart failure will increase heart rate. Air hunger, called dyspnea, occurs during any type of exertion. The patient also has orthopnea, which is the air hunger that occurs from being in a recumbent position.
TMP13 pp. 272-274

116. B) During decompensated heart failure, cardiac output decreases because of weakness of the heart and edema of the cardiac muscle. Pressures in the pulmonary capillary system increase, including the pulmonary capillary pressure and the mean pulmonary filling pressure. Depletion of norepinephrine in the endings of the cardiac sympathetic nerves is another factor that causes weakness of the heart.
TMP13 pp. 273-274

117. D) In decompensated heart failure, the kidneys retain sodium and water, which causes a weight gain and an increase in blood volume. This situation increases the mean systemic filling pressure, which also stretches the heart. Therefore, a decreased mean systemic filling pressure does not occur in decompensated heart failure. The excess blood volume often overstretches the sarcomeres of the heart, which prevents them from achieving their maximal tension. An excess central fluid volume also results in orthopnea, which is the inability to breathe properly except in the upright position.
TMP13 pp. 273-274

118. C) The mean electrical axis of the QRS of this patient is shifted rightward to 170 degrees, which indicates that the right side of the heart is involved. Both aortic stenosis and mitral regurgitation will cause a leftward shift of the QRS axis. Mitral stenosis will not affect the left ventricle, but in severe enough circumstances it could cause an increase in pulmonary artery pressure, which would cause an increase in pulmonary capillary pressure at the same time. Tricuspid stenosis will not affect the right ventricle. Therefore, pulmonary valve stenosis is the only condition that fits this set of symptoms.
TMP13 pp. 285-286

119. A) The fourth heart sound occurs at the end of diastole and is caused by inrushing of blood into the ventricles due to atrial contraction. The first heart sound is caused by closing of the A-V valves. The closing of the aortic and pulmonary valves at the end of systole causes the second heart sound. This initiates a vibration throughout the ventricles, aorta, and pulmonary artery. The third heart sound is caused by inrushing of blood into the ventricles in the early to middle part of diastole.
TMP13 p. 284

120. B) Blowing murmurs of relatively high pitch are usually murmurs associated with valvular insufficiency. The key pieces of data to identify this murmur are the systolic and diastolic pressures. Aortic valve regurgitation typically has a high pulse pressure, which is the systolic - the diastolic pressure, and in this case is 100 mm Hg. Also notice that the diastolic pressure decreases to very low values of 40 mm Hg as the blood leaks back into the left ventricle.
TMP13 pp. 285-286

121. E) Left ventricular hypertrophy occurs when the left ventricle either has to produce high pressure or when it pumps extra volume with each stroke. During aortic regurgitation, extra blood leaks back into the ventricle during the diastolic period. This extra volume must be expelled during the next heartbeat. During mitral regurgitation, some blood gets pumped out into the aorta, while at the same time blood leaks back into the left atrium. Therefore, the left ventricle is pumping extra volume with each heartbeat. During aortic stenosis, the left ventricle must contract very strongly, producing high wall tension to increase the aortic pressure to the values high enough to expel blood into the aorta. During mitral stenosis the ventricle is normal because the atrium produces the extra pressure to get blood through the stenotic mitral valve.
TMP13 pp. 285-286

122. E) Several diastolic murmurs can be heard easily with a stethoscope. During diastole, aortic and pulmonary valve regurgitation occur through the insufficient valves causing the heart murmur at this time. Tricuspid and mitral stenosis are diastolic murmurs because blood flows through the restricted valves during the diastolic period. Patent ductus arteriosus is heard in both systole and diastole.
TMP13 pp. 285-286

123. C) Aortic stenosis has a very high ventricular systolic pressure. Diastolic filling of the ventricle requires a much higher left atrial pressure. However, tricuspid stenosis and regurgitation, pulmonary valve regurgitation, and pulmonary stenosis are associated with an increase in right atrial pressure and should not affect pressure in the left atrium.
TMP13 pp. 285-286

124. B) This patient has a QRS axis of −45 degrees, indicating a leftward axis shift. In other words, the left side of the heart is enlarged. In aortic valve stenosis the left side of the heart is enlarged because of the extra tension the left ventricular walls must exert to expel blood out the aorta. Therefore, these symptoms fit with a patient with aortic stenosis. In pulmonary valve stenosis, the right side of the heart hypertrophies, and in mitral valve stenosis there is no left ventricular hypertrophy. In tricuspid valve regurgitation, the right side of the heart enlarges, and in tricuspid valve stenosis, no ventricular hypertrophy occurs.
TMP13 pp. 285-286

125. C) This patient has a heart murmur heard maximally in the "pulmonary area of cardiac auscultation." The high pitch indicates regurgitation. The rightward axis shift indicates that the right side of the heart has hypertrophied. The two choices that have a rightward axis shift are pulmonary valve regurgitation and tetralogy of Fallot. In tetralogy of Fallot, the arterial blood oxygen content is low, which is not the case with this patient. Therefore, pulmonary valve regurgitation is the correct answer.
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126. A) Right ventricular hypertrophy occurs when the right heart has to pump a higher volume of blood or pump it against a higher pressure. Tetralogy of Fallot is associated with right ventricular hypertrophy because of the increased pulmonary valvular resistance, and this also occurs during pulmonary artery stenosis. Tricuspid insufficiency causes an increased stroke volume by the right heart, which causes hypertrophy. However, tricuspid stenosis does not affect the right ventricle.
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127. E) Mitral stenosis is heard during diastole only. Aortic stenosis, tricuspid valve regurgitation, interventricular septal effect, and patent ductus arteriosis are clearly heard during systole. However, patent ductus arteriosus is also heard during diastole.
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128. A) In tetralogy of Fallot, there is an interventricular septal defect as well as stenosis of either the pulmonary artery or the pulmonary valve. Therefore, it is very difficult for blood to pass into the pulmonary artery and into the lungs to be oxygenated. Instead the blood partially shunts to the left side of the heart, thus bypassing the lungs. This situation results in low arterial oxygen content.
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129. B) The first heart sound by definition is always associated with the closing of the A-V valves. The heart sounds are usually not associated with opening of any of the valves but with the closing of the valves and

the associated vibration of the blood and the walls of the heart. One exception is an opening snap in some mitral valves.
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130. B) In tetralogy of Fallot, an interventricular septal defect and increased resistance in the pulmonary valve or pulmonary artery cause partial blood shunting toward the left side of the heart without going through the lungs. This situation results in a severely decreased arterial oxygen content. The interventricular septal defect causes equal systolic pressures in both cardiac ventricles, which causes right ventricular hypertrophy and a wall thickness very similar to that of the left ventricle.
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131. C) Mitral regurgitation and aortic stenosis are murmurs heard during the systolic period. A ventricular septal defect murmur is normally heard only during the systolic phase. Tricuspid valve stenosis and patent ductus arteriosus murmurs are heard during diastole. However, a patent ductus arteriosus murmur is also heard during systole.
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132. E) The third heart sound is associated with inrushing of blood into the ventricles in the early to middle part of diastole. The next heart sound, the fourth heart sound, is caused by inrushing of blood in the ventricles caused by atrial contraction. The first heart sound is caused by the closing of the A-V valves, and the second heart sound is caused by the closing of the pulmonary and aortic valves.
TMP13 pp. 283-284

133. A) A number of things occur in progressive shock, including increased capillary permeability, which allows fluid to leak out of the vasculature, thus decreasing the blood volume. Other deteriorating factors include vasomotor center failure, peripheral circulatory failure, decreased cellular mitochondrial activity, and acidosis throughout the body. Usually, urine output strikingly decreases; therefore, the increased urinary output answer is incorrect. Tissue pH decreases and reverse stress relaxation of the veins occurs.
TMP13 pp. 296-297

134. A) Sympathomimetic drugs are given to counteract hypotension during a number of conditions. These conditions include spinal cord injury in which the sympathetic output is interrupted. Sympathomimetic drugs are also given during very deep anesthesia, which decreases the sympathetic output, and during anaphylactic shock that results from histamine release and the accompanying vasodilatation. Sympathomimetic drugs, such as norepinephrine, increase blood pressure by causing a vasoconstriction. Shock caused by excess vomiting, hemorrhage, or excessive administration of diuretics results in fluid volume depletion, resulting in decreased blood volume and decreased mean systemic filling pressure. Administering a balanced electrolyte solution best counteracts this condition.
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135. D) Too deep a level of anesthesia can decrease sympathetic tone and reduce arterial pressure enough to induce shock. To replace the sympathetic tone that was lost, the optimal therapy is infusion of a sympathomimetic drug. Infusion of red blood cells, plasma, or electrolytes would be of little benefit.
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136. D) The patient received an influenza inoculation and quickly went into shock, which leads one to believe that he may be in anaphylactic shock. Anaphylactic shock is a state of extreme vasodilation because of histamine release. Antihistamines would be somewhat helpful, but they are very slow acting, and the patient could die in the meantime. Therefore, a very rapid-acting agent must be used, such as a sympathomimetic drug.
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137. E) In compensated hemorrhagic shock, a number of factors prevent the progression of the shock, including increased heart rate. Also occurring is reverse stress relaxation in which the vasculature, particularly the veins, constrict around the available blood volume. Increased ADH release also occurs, which causes water retention from the kidney but also vasoconstriction of the arterioles. A CNS ischemic response also occurs if the blood pressure drops to very low values, causing an increase in sympathetic output. Increased absorption of interstitial fluid through the capillaries also occurs, which increases the volume in the vasculature.
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138. E) Spinal anesthesia, especially when the anesthesia extends all the way up the spinal cord, can block the sympathetic nervous outflow from the spinal cord. This can be a very potent cause of neurogenic shock. The therapy of choice is to replace the sympathetic tone that was lost in the body. The best way to increase the sympathetic tone is by infusing a sympathomimetic drug.
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139. A) This patient has obviously lost a lot of blood because of the motorcycle wreck. The most advantageous therapy is to replace what was lost in the accident. This would be whole blood, which is much superior to a plasma infusion, because the patient is also receiving red blood cells that have a much superior oxygen-carrying capacity than the plasma component of blood. Sympathetic nerves are firing very

rapidly in this condition, and an infusion of a sympathomimetic agent would be of little advantage.
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140. C) In hemorrhagic shock, anaphylactic shock, and neurogenic shock, the venous return of blood to the heart markedly decreases. However, in septic shock the cardiac output increases in many patients because of vasodilation in affected tissues and a high metabolic rate causing vasodilation in other parts of the body.
TMP13 p. 300

141. E) This patient has been hemorrhaging, and the optimal therapy is to replace the blood he has lost. Unfortunately, no blood is available, and therefore we must choose next best therapy, which is increasing the volume of his blood. Thus, plasma infusion is the next best therapy because its high colloid osmotic pressure will help the infused fluid stay in the circulation much longer than would a balanced electrolyte solution.
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142. B) Intestinal obstruction often causes severe reduction in plasma volume. Obstruction causes a distention of the intestine and partially blocks the venous blood flow in the intestines. This partial blockage results in an increased intestinal capillary pressure, which causes fluid to leak from the capillary into the walls of the intestines and also into the intestinal lumen. The leaking fluid has a high protein content very similar to that of the plasma, which reduces the total plasma protein and the plasma volume. Therefore, the therapy of choice would be to replace the fluid lost by infusing plasma.
TMP13 pp. 300-301

143. A) In progressive shock, because of the poor blood flow, the pH in the tissues throughout the body decreases. Many vessels become blocked because of local blood agglutination, which is called "sludged blood." Patchy areas of necrosis also occur in the liver. Mitochondrial activity decreases and capillary permeability increases. There is also an increased release of hydrolases by the lysosomes and a decrease in cellular metabolism of glucose.
TMP13 p. 297

144. A) Anaphylaxis is an allergic condition that results from an antigen-antibody reaction that takes place after exposure of an individual to an antigenic substance. The basophils and mast cells in the pericapillary tissues release histamine or histamine-like substances. The histamine causes venous dilation, dilation of arterioles, and greatly increased capillary permeability with rapid loss of fluid and protein into the tissue spaces. This response reduces venous return and often results in anaphylactic shock.
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