

CARDIOVASCULAR PHYSIOLOGY

ANSWER KEY

Section 2 – Electrophysiology

1) Which ion(s) is/are responsible for connecting the electrical – and mechanical activity of the heart?

- a) Na⁺
- b) K⁺
- c) Ca²⁺**
- d) Cl⁻
- e) All of the above

2) Which ion(s) is/are responsible for the resting membrane potential of the cardiomyocyte?

- a) Na⁺
- b) K⁺**
- c) Ca²⁺
- d) None of the above
- e) All of the above

3) Which phase of the action potential in the SA-node is responsible for the heart rate?

- a) Phase 3
- b) Phase 0
- c) Phase 4**
- d) Phase 1
- e) Phase 2

4) What is correct regarding contractility of the heart?

- a) The contractility of the heart is directly proportional to the concentration of Ca²⁺**
- b) The contractility of the heart is unaffected by Ca²⁺
- c) The contractility of the heart is inversely proportional to the concentration of Ca²⁺
- d) Contractility is the only factor affecting stroke volume
- e) A and D are correct

5) What is the correct sequence of conduction of electrical activity in the heart?

- a) SA-node → His bundle → internodal tracts → AV-node → bundle branches → Purkinje fibers
- b) SA-node → internodal tracts → AV-node → His bundle → Purkinje fibers → bundle branches
- c) SA-node → internodal tracts → AV-node → His bundle → bundle branches → Purkinje fibers**
- d) SA-node → bundle branches → AV-node → internodal tracts → His bundle → Purkinje fibers
- e) None of the above

6) During normal conduction of electrical activity in the heart - how long is the physiological delay in the AV-node?

- a) 50 ms
- b) 70 ms
- c) 100 ms**
- d) 110 ms
- e) None of the above

7) Select the correct statement regarding making waves in ECG.

- a) A wave of depolarization moving away from an electrode gives a positive deflection
- b) A wave of repolarization moving towards an electrode gives a negative deflection
- c) A wave of depolarization moving away from an electrode gives a negative deflection
- d) A wave of repolarization moving towards an electrode gives a positive deflection
- e) **B and C are correct**

8) Pair the correct electrical event and phase of the cardiac cycle.

- a) Atrial depolarization – late diastole
- b) Ventricular depolarization – early systole
- c) Atrial repolarization – early diastole
- d) **A and B are correct**
- e) All of the above

9) ECG is an important tool in clinical medicine. What does the ECG record?

- a) Cardiac output
- b) Action potentials
- c) Depolarization and repolarization
- d) **B and C are correct**
- e) All of the above

10) What is the correct sequence of electrical events in the heart?

- a) **Atrial depolarization → conduction through the AV-node → ventricular depolarization + atrial repolarization → ventricular repolarization**
- b) Conduction through the AV-node → atrial depolarization → ventricular depolarization → atrial repolarization → ventricular repolarization
- c) Atrial depolarization → conduction through the AV-node → ventricular depolarization → ventricular repolarization → atrial repolarization
- d) A and C are correct
- e) None of the above

Section 3 – Cardiac Muscle Mechanics

1) What are the three most important variables affecting the stroke volume of the heart?

- a) **Contractility, preload and afterload**
- b) Contractility, heart rate and stroke volume
- c) Contractility, preload and heart rate
- d) Preload, venous return and cardiac output

2) Choose the correct statement regarding the definition of cardiac output.

- a) It is the volume of blood ejected by the right ventricle per minute
- b) It is the volume of blood ejected by the right ventricle per beat
- c) It is the volume of blood ejected by the left ventricle per beat
- d) **It is the volume of blood ejected by the left ventricle per minute**

3) The trigger Ca^{2+} enters the myocardial cell during which phase of the cardiac action potential?

- a) The upstroke phase
- b) **The plateau phase**
- c) During the relative refractory period
- d) During repolarization

4) During excitation-contraction coupling, a wave of depolarization spreads to the interior of the cell membrane via **t-tubules. During the plateau phase of the cardiac action potential, **trigger** Ca^{2+} enters the myocardial cell via L-type Ca^{2+} channels, also known as **dihydropyridine** receptors. The calcium which enters the myocardial cell activates **ryanodine** receptors on the sarcoplasmic reticulum. This process is also known as **Ca^{2+} -induced Ca^{2+} -release**. Tropomyosin inhibition on myosin will be removed when Ca^{2+} binds to **troponin C**. Myosin and actin can now bind and form cross-bridges, leading to contraction.**

5) Select the correct statement(s) regarding contractility.

- a) **It is also known as inotropism**
- b) It is inversely proportional to the intracellular calcium concentration
- c) Changes in contractility does not necessarily affect the ejection fraction
- d) Increased contractility leads to increased rate of pressure development, increased peak left ventricular pressure and decreased rate of relaxation
- e) All of the above
- f) A, C and D are correct

6) Select the correct statement(s) regarding preload.

- a) It is affected by the tone of capacitance vessels
- b) It is determined by the amount of blood in the left ventricle after diastole
- c) Dilation of veins will decrease preload
- d) Blood volume and venous tone are variables which may affect the level of preload
- e) **All of the above**

7) Select the correct statement(s) regarding the Frank-Starling law.

- a) Describes the relationship between the end-diastolic volume and stroke volume
- b) Increased EDV will lead to stretch of the sarcomere towards optimum actin-myosin overlap and therefore increased stroke volume
- c) Increased EDV will lead to increased sympathetic stimulation and therefore increased stroke volume**
- d) A and B

8) Compare the systolic performance of heart A and heart B. What is the explanation for the decreased cardiac output in heart B, when the preload of both hearts is the same?

Heart A:

Cardiac output: 5 L/min

Preload: 120mL

Heart B:

Cardiac output: 3L/min

Preload: 120mL

- a) This is a normal variation between the heart of a woman and the heart of a man
- b) The contractility of heart A is better than the contractility of heart B
- c) The contractility of heart B is poor and the Frank-Starling curve of heart B will be shifted to the right
- d) The contractility of heart B is poor and the Frank-Starling curve of heart B will be shifted to the left
- e) A,B and C is correct
- f) B and C is correct**

9) The workload on the heart during contraction will increase with which of the following?

- a) Afterload
- b) Aortic pressure
- c) The total peripheral resistance
- d) A and B
- d) All of the above**

Section 4 – The Cardiac Cycle

1) Starting from systole, place the different phases of the cardiac cycle into the correct order.

1. Isovolumetric ventricular relaxation, 2. Isovolumetric ventricular contraction, 3. Ventricular filling (*passive phase*), 4. Ventricular Ejection, 5. Ventricular filling (*active phase*):

- a) 2 – 4 – 1 – 5 – 3
- b) 1 – 3 – 5 – 2 – 4
- c) 2 – 4 – 1 – 3 – 5**
- d) 1 – 2 – 3 – 4 – 5

2) The mitral valve closes:

- a) During ventricular ejection
- b) During isovolumetric ventricular relaxation
- c) Immediately after the passive phase of ventricular filling
- d) During isovolumetric ventricular contraction**

3) Choose the correct statement regarding the opening of the aortic valve.

- a) The aortic valve opens because the aortic pressure is higher than the left ventricular pressure
- b) The aortic valve opens during isovolumetric ventricular relaxation
- c) The aortic valve opens during the ejection phase of the cardiac cycle, because the pressure generated by the left ventricle exceeds the pressure in the aorta
- d) The aortic valve opens during isovolumetric contraction at the point where the pressure generated by the left ventricle exceeds the pressure in the aorta**

4) Choose the correct statement(s) regarding the closure of the mitral valve.

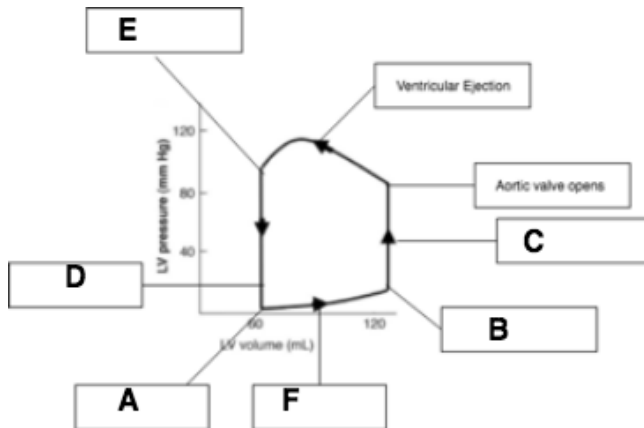
- a) The mitral valve closes because the pressure in the left ventricle is higher than the pressure in the left atrium
- b) It produces the first heart sound
- c) In order for the mitral valve to close, the pressure in the left atrium has to be higher than the pressure in the left ventricle
- d) A and B are correct**

5) Physiologic splitting of the 2nd heart sound can be explained by which of the following?

- a) Delayed closure of the tricuspid valve
- b) During inspiration, there is an increase in cardiac output which causes a more forceful contraction of the left ventricle and the aortic valve will close before the pulmonary valve
- c) During inspiration, there is an increase in blood volume returning to the right ventricle. The resulting increase in blood volume will prolong the ejection time of the right ventricle and the closure of the pulmonary valve will be delayed**
- D) It occurs as a result of expiration

6) Place the missing events of the cardiac cycle on the pressure-volume loop.

- a) Mitral valve opens
- b) Mitral valve closes
- c) Isovolumetric ventricular contraction
- d) Isovolumetric ventricular relaxation
- e) Aortic valve closes
- f) Ventricular filling



7) The QRS complex represents:

- a) Atrial contraction
- b) Ventricular repolarization
- c) Ventricular ejection
- d) Isovolumetric ventricular contraction**

8) The first heart sound is produced by?

- a) Opening of the mitral valve
- b) Closure of the aortic valve
- c) Closure of the mitral valve
- d) Closure of the tricuspid valve
- e) C and D are correct**

Section 5 – Hemodynamics

1) Select the correct statement(s) regarding normal blood flow.

- a) Arteries always contain more O₂ than veins
- b) Superior vena cava returns the blood from the head, neck, upper extremities and abdomen
- c) Mixed venous blood is a collection of blood from the superior vena cava and the inferior vena cava**
- d) A and C are correct
- e) All of the above

2) Select the correct sequence(s) of blood flow in the systemic – and pulmonary circulations.

- a) Pulmonary capillaries → pulmonary arteries → left atrium → left ventricle → aorta
- b) Arterioles → systemic capillaries → venules → veins → vena cava**
- c) Right atrium → right ventricle → pulmonary veins → pulmonary capillaries → pulmonary arteries
- d) All of the above
- e) None of the above

3) Why is the blood flow equal in the pulmonary – and systemic circulation?

- a) The pulmonary – and systemic circulation are coupled in series**
- b) The resistance is higher in the pulmonary circulation, compared with the systemic circulation
- c) The pulmonary – and systemic circulation are coupled in parallel
- d) A and B are correct
- e) None of the above

4) Why does right ventricular failure lead to peripheral edema?

- a) Increased pressure in the right atrium
- b) Pooling of blood in the veins
- c) Increased hydrostatic pressure in the arteries
- d) A and B are correct**
- e) All of the above

5) Select the correct statement(s) regarding vessels.

- a) The speed of blood flow in the veins is the lowest, because they contain the smallest pressure
- b) Vasoconstriction of veins leads to increased blood flow
- c) The degree of elastic tissue and smooth muscle affects the compliance of arteries and veins
- d) B and C are correct**
- e) All of the above

6) Select the correct statement(s) regarding hemodynamic concepts.

- a) Cross-sectional area depends indirectly on the size of the vessels
- b) Increased viscosity leads to decreased risk of thrombosis
- c) Arterioles are the vessels with the highest resistance
- d) A and C are correct**
- e) None of the above

7) Select the false statement(s) regarding hemodynamic concepts.

- a) The major factor determining resistance is the radius
- b) Laminar flow does not occur in the heart
- c) Turbulent flow may create bruits in the heart and murmurs in the vessels
- d) Atherosclerosis increases the Reynolds number of a given vessel
- e) C and D are false**

8) A man presents with symptoms and signs of myocardial infarction. Imaging reveals 50 % obstruction of the left coronary artery. Based on the degree of obstruction – what would be the increase in resistance of the same artery?

- a) 6-fold increase
- b) 8-fold increase
- c) 16-fold increase**
- d) Impossible to calculate
- e) None of the above

9) Select the correct statement(s) regarding series – and parallel circulations.

- a) Since the heart and the lungs are two separate organs, the systemic – and pulmonary circulations are coupled in parallel
- b) Flow is independent in a series circulation
- c) If a woman donated a kidney to her brother, the total peripheral resistance would decrease accordingly
- d) All of the above
- e) None of the above**

10) Select the correct statement(s) regarding compliance and elasticity.

- a) Elasticity is determined by the amount of smooth muscle
- b) The fundamental characteristic of a compliant vessel is to expand with a large increase in pressure
- c) Elasticity decreases with age**
- d) Compliance decreases with age
- e) B and C are correct

11) Select the correct statement(s) regarding distribution of blood volume.

- a) Systemic veins contain the largest amount of blood, because they have the highest elasticity
- b) Around 40 % of the blood volume, at any given moment, is present in the systemic veins
- c) The systemic veins, along with the pulmonary system, constitute the biggest reservoir of blood**
- d) All of the above
- e) None of the above

12) Select the correct statement(s) regarding distribution of vascular resistance.

- a) The arterioles have the highest pressure drop in the systemic circulation, because they have the highest resistance
- b) Abundance of smooth muscle is characteristic of resistance vessels
- c) Besides the arterioles, the capillaries are the most important factor contributing to vascular resistance
- d) A and C are correct
- e) All of the above**

13) Select the correct statement(s) regarding regulation of flow.

- a) Extrinsic regulation involves the nervous system
- b) During exercise, there is no change in the cerebral circulation
- c) In a resting individual, the α_1 -receptors are more activated than the β_2 -receptors in the arteries of skeletal muscle
- d) B and C are correct
- e) ~~None of the above~~ correction: **all of the above**

14) Select the false statement regarding regulation of flow.

- a) Hyperventilation leads to decreased levels of CO₂, which causes vasoconstriction
- b) Adenosine is a vasodilatory metabolite
- c) The partial pressure of CO₂ in the alveoli is proportional to the partial pressure of CO₂ in the pulmonary veins**
- d) The left ventricle compresses the left coronary artery during the systolic phase of the cardiac cycle
- e) The greatest flow in the right coronary artery is during the diastolic phase of the cardiac cycle

15) Select the correct statement(s) regarding cutaneous circulation.

- a) β_2 -receptors respond to epinephrine and norepinephrine released from nerve terminals
- b) α_1 -receptors are of greater physiological importance than the β_2 -receptors
- c) Vasodilation is a result of relaxation of smooth muscle in the vessels
- d) B and C are correct**
- e) All of the above

Section 6 – Regulation of Blood Pressure

1) Which of the following will increase the amount of blood pumped by the left ventricle per beat?

- a) Increased HR
- b) Increased afterload
- c) Increased TPR
- d) Increased venous tone**

2) β_1 -stimulation results in?

- a) Increased sodium and water retention by the kidney
- b) Increased stroke volume
- c) Increased cardiac output
- d) All of the above**

3) The autonomic nervous system elicits an _____ (immediate/delayed) effect on blood pressure and is responsible for _____ (short-term/long-term) regulation of blood pressure. Hormones, especially the Renin-Angiotensin-Aldosterone system, elicits a _____ (delayed/immediate) effect on blood pressure and is responsible for _____ (short-term/long-term) regulation of blood pressure.

4) The parasympathetic nervous system aims to _____ (decrease/increase) the blood pressure via the stimulation of _____ receptors (muscarinic/adrenergic). The sympathetic nervous system aims to _____ (decrease/increase) the blood pressure via the stimulation of _____ receptors (muscarinic/adrenergic).

5) Concerning the baroreceptors, which cranial nerve is responsible for carrying information from the carotid sinus to the brain?

- a) Glossopharyngeal**
- b) Vagus
- c) Hypoglossal
- d) Trigeminal

6) What are the effect(s) of increased baroreceptor discharge rate?

- a) Inhibition of the parasympathetic nervous system and stimulation of the sympathetic nervous system
- b) Inhibition of the sympathetic nervous system and stimulation of the parasympathetic nervous system**
- c) Increased contractility, increased total peripheral resistance and increased venous return
- d) Increased contractility, increased preload and increased total peripheral resistance
- e) A, D, C
- f) A and D

7) Select the correct statement(s) regarding carotid massage

- a) It can slow the rate of conduction through the AV node and subsequently decrease the heart rate
- b) Pressure is applied on the carotid sinus for 10 seconds. The firing rate from the glossopharyngeal nerve will increase, and the sympathetic nervous system will be stimulated in order to increase blood pressure
- c) Pressure is applied on the carotid sinus for 10 seconds. The firing rate from the glossopharyngeal nerve will increase, and the parasympathetic nervous system will be stimulated in order to decrease blood pressure
- d) A and B
- e) **A and C**

8) α_1 stimulation results in:

- a) Increased TPR
- b) Increased cardiac output
- c) Increased preload
- d) A and C
- e) **All of the above**