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Cardiovascular and Lymphatic Physiology

Anatomy & Physiology

Cardiac cycle, heart rate, cardiac output, blood pressure, circulation, pulse, ECG and lymphatic functions.

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Circulation and the cardiac pump

Cardiovascular physiology explains how the heart generates pressure and how vessels distribute blood to support tissue exchange. The right ventricle pumps through the pulmonary circulation; the left ventricle pumps through the systemic circulation. These circuits are arranged in series, so their average outputs must match over time. Arteries carry blood away from the heart and veins return it; oxygen content does not define the vessel type.

Blood moves down pressure gradients, and valves open or close passively when pressure relationships reverse. Coronary vessels provide the myocardium with its own supply. Arterioles are major resistance vessels, capillaries provide thin exchange surfaces, and veins serve as a substantial blood reservoir. Venous valves, skeletal-muscle contractions and respiratory pressure changes assist return toward the heart.

Electrical activity, heart rate and ECG

The sinoatrial node normally initiates impulses. Excitation spreads through atrial tissue, slows at the atrioventricular node, then travels through the atrioventricular bundle, bundle branches and Purkinje network. The delay allows ventricular filling before coordinated ventricular contraction. Autonomic nerves modify this intrinsic rhythm: sympathetic activity generally increases rate and contractility, whereas vagal parasympathetic activity slows nodal rate and conduction.

An electrocardiogram records surface voltage differences caused by cardiac electrical activity. The P wave represents atrial depolarization. The QRS complex represents ventricular depolarization, with atrial repolarization usually obscured. The T wave represents ventricular repolarization. Electrical excitation precedes mechanical contraction. A trace must therefore be interpreted with pulse, symptoms and perfusion; a visible rhythm alone does not prove effective circulation.

Cardiac cycle and heart sounds

Ventricular phase	Valve state	Main event
Filling	Atrioventricular open; semilunar closed	Most filling is passive; atrial systole adds blood
Isovolumetric contraction	All valves closed	Ventricular pressure rises without volume change
Ejection	Semilunar open; atrioventricular closed	Blood enters the pulmonary trunk and aorta
Isovolumetric relaxation	All valves closed	Pressure falls before atrioventricular valves reopen

The first heart sound, S1, is associated with atrioventricular valve closure at the start of ventricular systole. S2 is associated with aortic and pulmonary valve closure at the end of ejection. End-diastolic volume is the ventricular volume before contraction, and end-systolic volume is the remainder after ejection. Stroke volume equals

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end-diastolic volume minus end-systolic volume. Faster heart rates shorten diastole particularly, potentially reducing filling and coronary perfusion time.

Cardiac output and arterial pressure

Cardiac output equals heart rate multiplied by stroke volume. For example, 70 beats/min multiplied by 70 mL/beat gives 4.9 L/min from each ventricle. This is an illustrative resting-adult calculation, not a target for every patient. Preload relates to myocardial stretch before contraction; afterload is the load opposing ejection; contractility is intrinsic force generation at a given loading condition.

Within physiological limits, increased filling can increase force and stroke volume through the Frank-Starling mechanism. Increased afterload can reduce stroke volume, whereas increased contractility can improve ejection. Flow depends on pressure difference divided by resistance. Vessel radius strongly affects resistance. Mean arterial pressure is related to cardiac output and systemic vascular resistance; the common estimate, diastolic pressure plus one-third of pulse pressure, is most useful at usual resting rates. Pulse pressure equals systolic minus diastolic pressure.

Regulation, capillary exchange and lymph

Stretch-sensitive baroreceptors in the carotid sinus and aortic arch signal cardiovascular centres in the medulla. A fall in arterial pressure can reduce receptor firing and promote sympathetic responses that raise rate, contractility and vascular tone. Local metabolites adjust tissue flow, while renal fluid regulation and hormones contribute to longer-term pressure control. Compensation may temporarily preserve blood pressure despite reduced tissue perfusion.

Capillary hydrostatic pressure promotes outward filtration, and plasma-protein oncotic pressure opposes that movement. Permeability and interstitial forces also matter. Lymphatics return filtered fluid and proteins to the venous circulation, transport absorbed dietary lipids and support immune surveillance through lymph nodes. Lymph propulsion depends on valves, vessel contraction and surrounding movement. Impaired lymph drainage can cause protein-rich tissue swelling.

Nursing applications and exam organization

Assess pulse rate, rhythm, amplitude and symmetry alongside blood pressure, skin findings, mental state and urine-output trend. Use an appropriate cuff and consistent positioning, because technique can distort pressure readings. Compare peripheral pulse with an apical rate when indicated; an electrical or apical beat may not produce a palpable peripheral pulse. New chest discomfort, syncope or poor perfusion requires prompt clinical escalation.

For exam answers, separate electrical initiation from mechanical pumping. Draw the conduction route, then describe cycle phases with pressures, valve states and sounds. Show units in cardiac-output calculations and explain how preload, afterload or contractility changes the result. For oedema questions, consider hydrostatic pressure, plasma proteins, capillary permeability and lymph drainage rather than attributing all swelling to excess total body water.

Quick Revision

- Pulmonary and systemic circulations operate in series.
- The sinoatrial node normally initiates cardiac excitation.
- P, QRS and T represent atrial depolarization, ventricular depolarization and ventricular repolarization.
- Pressure differences determine valve movement and blood flow.

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- Cardiac output depends on heart rate and stroke volume.
- Lymphatics return filtered fluid and proteins and support immunity.

Important Examination Questions

1. Trace the cardiac conduction pathway and correlate it with ECG waves.
2. Explain the cardiac cycle using a valve-state table.
3. Calculate cardiac output and discuss preload, afterload and contractility.
4. Explain neural and renal contributions to blood-pressure regulation.
5. Describe pulse formation, capillary exchange and lymphatic functions.

References and further reading

Newly written physiology study notes. Read the supporting textbook sections for diagrams, mechanisms and further explanation.

- OpenStax Anatomy and Physiology 2e: Cardiac Muscle and Electrical Activity (https://openstax.org/books/anatomy-and-physiology-2e/pages/19-2-cardiac-muscle-and-electrical-activity)
- OpenStax Anatomy and Physiology 2e: Cardiac Cycle (https://openstax.org/books/anatomy-and-physiology-2e/pages/19-3-cardiac-cycle)
- OpenStax Anatomy and Physiology 2e: Cardiac Physiology (https://openstax.org/books/anatomy-and-physiology-2e/pages/19-4-cardiac-physiology)
- OpenStax Anatomy and Physiology 2e: Blood Flow, Blood Pressure, and Resistance (https://openstax.org/books/anatomy-and-physiology-2e/pages/20-2-blood-flow-blood-pressure-and-resistance)
- OpenStax Anatomy and Physiology 2e: Capillary Exchange (https://openstax.org/books/anatomy-and-physiology-2e/pages/20-3-capillary-exchange)
- OpenStax Anatomy and Physiology 2e: Homeostatic Regulation of the Vascular System (https://openstax.org/books/anatomy-and-physiology-2e/pages/20-4-homeostatic-regulation-of-the-vascular-system)
- OpenStax Anatomy and Physiology 2e: Anatomy of the Lymphatic and Immune Systems (https://openstax.org/books/anatomy-and-physiology-2e/pages/21-1-anatomy-of-the-lymphatic-and-immune-systems)

Practice questions

Choose one best answer. The answer key and explanations follow the questions.

1. What does the QRS complex primarily represent?

A. Atrial repolarization alone
B. Ventricular depolarization
C. Ventricular filling
D. Aortic valve closure

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2. What is cardiac output at 80 beats/min and 60 mL/beat?

A. 0.75 L/min

B. 140 L/min

C. 4.8 L/min

D. 8.0 L/min

3. Which valves are open during ventricular ejection?

A. Atrioventricular valves

B. All four valves

C. No valves

D. Semilunar valves

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Answer key and explanations

1. B - Ventricular depolarization

The QRS complex is an electrical event that precedes ventricular contraction.

2. C - 4.8 L/min

80 x 60 = 4800 mL/min, or 4.8 L/min.

3. D - Semilunar valves

Ejection begins when ventricular pressure exceeds arterial pressure and opens the semilunar valves.

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