Anatomy Review: Blood Vessel Structure & Function

Page 1. Introduction

- The blood vessels of the body form a closed delivery system that begins and ends at the heart.

Page 2. Goals

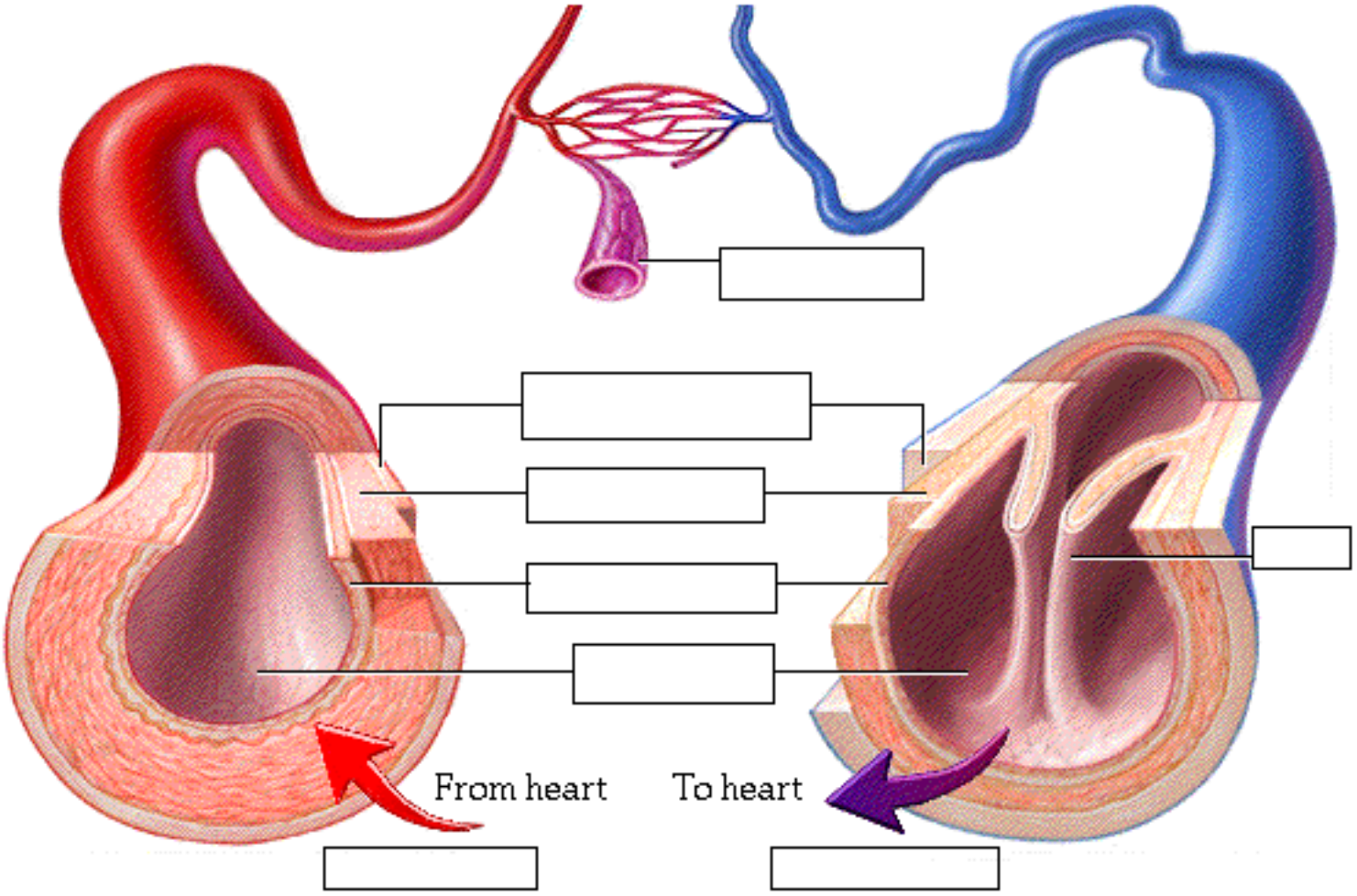
- To describe the general structure of blood vessel walls.
- To compare and contrast the types of blood vessels.
- To relate the blood pressure in the various parts of the vascular system to differences in blood vessel structure.

Page 3. General Structure of Blood Vessel Walls

- All blood vessels, except the very smallest, have three distinct layers or tunics. The tunics surround the central blood-containing space - the lumen.
  1. Tunica Intima (Tunica Interna) - The innermost tunic. It is in intimate contact with the blood in the lumen. It includes the endothelium that lines the lumen of all vessels, forming a smooth, friction reducing lining.
  2. Tunica Media - The middle layer. Consists mostly of circularly-arranged smooth muscle cells and sheets of elastin. The muscle cells contract and relax, whereas the elastin allows vessels to stretch and recoil.
  3. Tunica Adventitia (Tunica Externa) - The outermost layer. Composed of loosely woven collagen fibers that protect the blood vessel and anchor it to surrounding structures.

Page 4. Comparison of Arteries, Capillaries, and Veins

- Let's compare and contrast the three types of blood vessels: arteries, capillaries, and veins.
- Label the artery, capillary and vein. Also label the layers of each.



- Arteries are vessels that transport blood away from the heart. Because they are exposed to the highest pressures of any vessels, they have the thickest tunica media. The elastin allows them to stretch and recoil and the smooth muscle allows them to constrict and dilate.
- Capillaries are the smallest vessels, the link between arteries and veins in the pathway of blood. Capillary walls consist of just a thin tunica intima, making them ideally suited for their role: the exchange of materials between the blood and the interstitial fluid.
- Veins are farthest from the heart so they experience the least pressure. Their walls are thinner than arterial walls and their lumens are larger, allowing them to accommodate a large volume of blood. The tunica adventitia is the heaviest wall layer in veins.

Page 5. Cross-Section of Artery and Vein

- When you compare an artery and a vein side by side, you observe a thick tunica media in the artery and thin walls in the vein.

Page 6. Systemic Pathway of Blood Through Vessels

- This graphic will remind you that in the systemic circulation blood travels from the heart to elastic arteries, muscular arteries, arterioles, capillaries, venules, veins, then back to the heart

Page 7. Three Groups of Arteries

- In terms of relative size and function, arteries can be divided into three groups:
  1. Elastic Arteries
  2. Muscular Arteries

3. Arterioles

Page 8. Elastic Arteries (Aorta and Branches)

- Elastic arteries are closest to the heart and experience the greatest pressure as the heart forces blood into them. They have the greatest amount of elastin, enabling them to expand. When the heart relaxes, the recoil propels blood onward.
- A cross section reveals abundant elastin, which can be seen as wavy fibers in the thick tunica media.

Page 9. Blood Pressure in Aorta

- The graph shows blood pressure variation in the various vessels of the systemic circulation. Note that the aorta experiences the widest variation in pressure of any vessel type. Its thick tunica media with elastin allows it to stretch and recoil to accommodate this pressure change as the heart pumps blood into it and then relaxes.

Page 10. Muscular Arteries

- In the elastic artery, elastin forms most of the wall of the tunica media. In the muscular artery, the tunica media is composed mainly of smooth muscle.
- Muscular arteries deliver blood to specific body organs.
- They have relatively more smooth muscle and less elastin than elastic arteries in the tunica media. This enables them to actively constrict and relax.
- Vasomotor fibers of the sympathetic nervous system regulate the activity of the smooth muscle in muscular arteries. Depending on the needs of the body, the vasomotor fibers can cause vasoconstriction (reduction in lumen diameter due to smooth muscle contraction) or vasodilation (widening of the lumen diameter due to smooth muscle relaxation).
- Small changes in blood vessel diameter greatly influence blood flow and blood pressure, making the muscular arteries crucial in regulating circulatory dynamics.
- When sympathetic nerves to the smooth muscle of muscular arteries fire, vasoconstriction occurs which narrows the lumen of the artery. Lack of sympathetic stimulation causes vasodilation which widens the lumen of the artery.

Page 11. Blood Pressure in Muscular Arteries

- In muscular arteries, the pressure begins to decline.

Page 12. Arterioles

- Arterioles are the smallest arteries.
- The larger arterioles have all three layers, but their tunica media is mainly smooth muscle

Page 13. Enlargement of Arterioles

- Feeder arterioles bring blood directly to capillary beds. These smaller arterioles consist only of smooth muscle cells surrounding tunica intima.
- A widened feeder arteriole will allow blood flow to a capillary bed, whereas when the feeder arteriole narrows, less blood will flow to a capillary bed.

Page 14. Blood Pressure in Arterioles

- The steepest drop in blood pressure occurs in arterioles.
- Arterioles offer the greatest resistance to blood flow.
- Blood flow no longer pulses by the time it gets through the arterioles.

Page 15. Review: Three Groups of Arteries

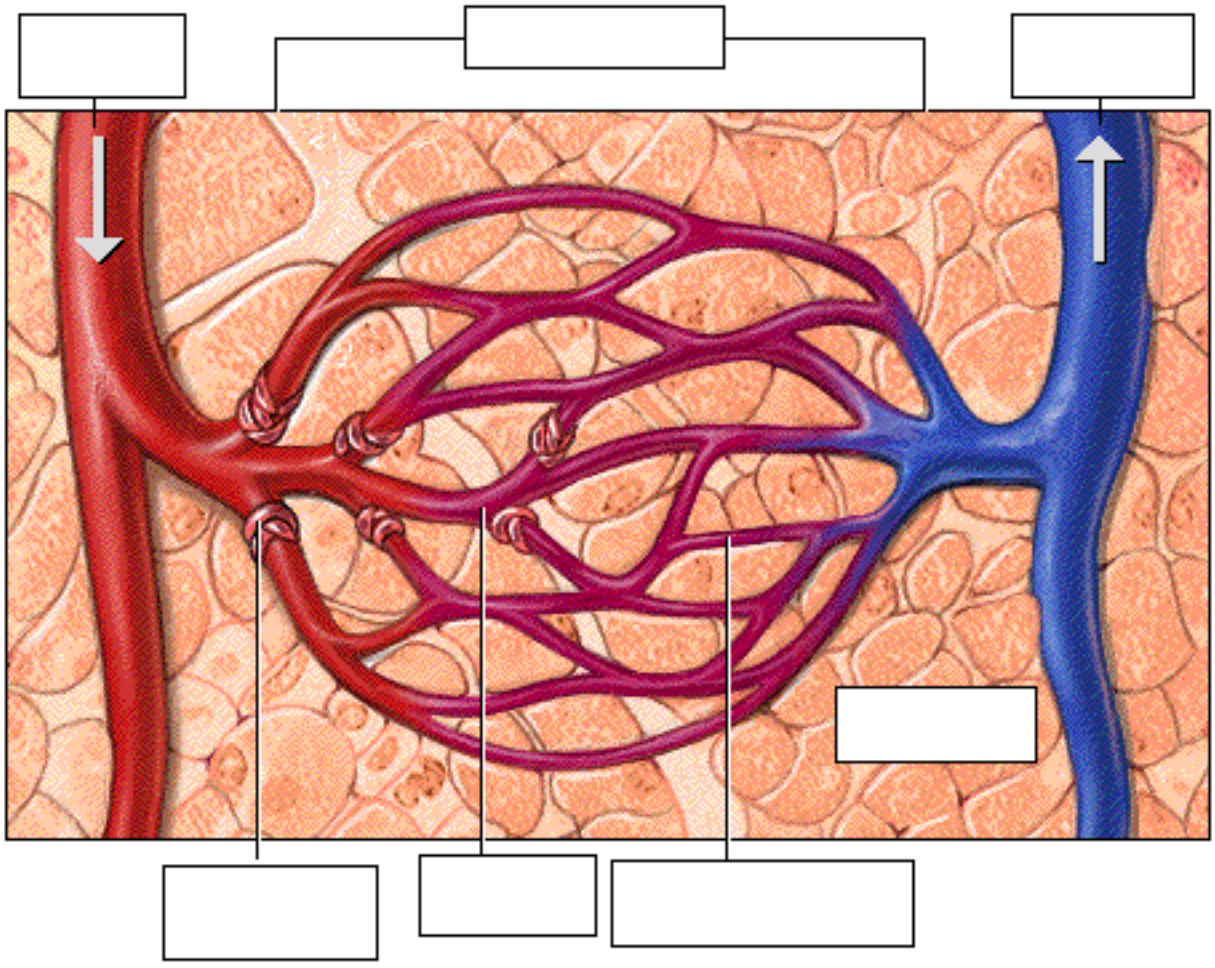
- Blood vessel function follows blood vessel structure. The more elastic tissue in an artery, the greater its ability to expand and recoil (pulsate). Elastic arteries, such as the aorta, have the most elastin so they are able to expand and recoil dramatically. Muscular arteries have less elastic tissue, so they have a reduced ability to expand and recoil. Arterioles have virtually no elastin so the pulsation smooths out.

Page 16. Capillaries

- Capillaries consist of only a thin tunica intima or endothelium.
- Most capillaries are arranged in capillary beds.
- Thinness allows exchange of materials between blood and tissues.

Page 17. Capillary Beds

- Label the following in this diagram:
  feeder arteriole, shunt, true capillaries, precapillary sphincter, drainage venule, capillary bed, tissue cells



- Blood flow regulation occurs at the capillary beds. The feeder arteriole brings blood to the capillary bed. The shunt is a short vessel that directly connects the feeder arteriole and the drainage venule at the opposite end of the bed. Exchange of materials take place between the tissue cells and the blood in the true capillaries. The precapillary sphincter is a cuff of smooth muscle fibers that surround the root

of each true capillary, acting as a valve to regulate the flow of blood into the true capillaries.

Page 18. Exchange of Materials Between Blood & Tissues

- When the precapillary sphincters constrict, blood is diverted away from the true capillaries. Materials do not exchange between blood and tissues.

Page 19. Blood Pressure in the Capillaries

- Blood pressure is relatively low in the capillaries.
- High pressures would rupture the fragile capillaries.
- High pressures would also force excessive amounts of solute-containing fluids out of the blood stream into the interstitial space.

Page 20. Venules

- Venules are formed when capillaries unite.
- In larger venules both a sparse tunica media and a thin tunica adventitia are present.

Page 21. Venules

- Smallest venules drain the capillaries.
- Consist of endothelium around which a few fibroblasts congregate.

Page 22. Blood Pressure in the Venules

- Blood pressure continues to drop as blood flows though the venules, encountering further resistance.

Page 23. Veins

- Venules join to form veins.
- Veins have three distinct tunics, but their walls are thinner and lumens are larger than arteries.
- The tunica adventitia is the heaviest wall layer.

Page 24. Blood Pressure in the Veins

- Low blood pressure in the veins.
- Because blood pressure within veins is low, they can have thinner walls than arteries without danger of bursting.
- The low pressure in the veins requires special adaptations to help return blood to the heart. Venous valves, the muscular pump, and the respiratory pump all assist in returning blood to the heart.

Page 25. Venous Valves

- Venous valves are hinge-like flaps formed from folds of the tunica intima.
- Venous valves are most abundant in the veins of the limbs, where upward flow of blood is opposed by gravity.
- The one-way valves prevent backflow as blood travels toward the heart.

Page 26. Muscular Pump

- In the muscular pump, contracting skeletal muscles press against veins, forcing blood through one-way valves.

Page 27. Respiratory Pump

- Pressure changes occurring in the ventral body cavity during breathing create the respiratory pump that sucks blood upward towards the heart.
- As we inhale, pressure in the thoracic cavity decreases. Meanwhile pressure increases in the abdominal cavity, squeezing abdominal veins. These create an sucking effect that pulls blood toward the heart.

Page 28. Summary

- Of the three types of vessels, arteries have the thickest tunica media (allowing stretch/recoil and vasoconstriction), veins have relatively thick tunica adventitia, and capillaries are the thinnest (allowing exchange of materials.)
- Blood pressure varies in different parts of the vascular system. At least part of this variation reflects vessel structure. Structural adaptations of veins assist in returning blood to the heart.

Study Questions on Anatomy Review: Blood Vessel Structure & Function:

1. (Page 3.) What is the central blood-containing space of a blood vessel called?

2. (Page 3.) What are the names of the three distinct layers of a blood vessel from innermost to outermost?

3. (Page 3.) What is the tunica intima composed of?

4. (Page 3.) What is the function of endothelium?

5. (Page 3.) What two structures is the tunica media composed of? What is the purpose of each?

6. (Page 3.) What is the tunica adventitia composed of? What is its function?

7. (Page 4.) Tell if the following are characteristic of arteries, capillaries or veins:
   a. Presence of smooth muscle allows them to constrict and dilate.
   b. Lumens are largest.
   c. Have the thickest tunica media.
   d. Are able to accommodate a large volume of blood.
   e. Exposed to the highest pressures of any vessels.
   f. The link between arteries and veins in the pathway of blood.
   g. Experience the least pressure.
   h. The smallest vessels.
   i. Vessels that transport blood away from the heart.
   j. The tunica adventitia is the heaviest wall layer.
   k. Presence of elastin allows them to stretch and recoil.
   l. Walls consist of just a thin tunica intima.
   m. Role: the exchange of materials between the blood and the interstitial fluid.

8. (Page 7.) What are the three types of arteries classified by relative size and function? List from largest to smallest.

9. (Page 8.) What layer of elastic arteries allows them to stretch and recoil?

10. (Page 8.) What is the aorta?

11. (Page 8-10.) Tell if the following are characteristic of elastic arteries or muscular arteries:
    a. Have the greatest amount of elastin, enabling them to expand when blood is forced into them.

b. More smooth muscle and less elastin enables them to actively constrict and relax.
c. Deliver blood to specific body organs.
d. Closest to the heart.
e. When the heart relaxes, they recoil.
f. The tunica media is composed mainly of smooth muscle.
g. Vasomotor fibers of the sympathetic nervous system regulate the size of the lumen.
h. Experience the greatest pressure.

12. (Page 10.) Define vasodilation and vasoconstriction.

13. (Page 10.) What causes vasoconstriction?

14. (Page 13.) What are the smaller arterioles that allow blood to flow to capillary beds called?

15. (Page 12,13.) Contrast the difference in the layers of a large arteriole compared to a smaller arteriole.

16. (Page 14.) Does the blood pulsate in arterioles?

17. (Page 14.) Which of the three types of arteries offers the greatest resistance to blood flow?

18. (Page 16.) What are capillaries made of? How does that affect their function?

19. (Page 17.) Match the following to their function or characteristic:

1. feeder arteriole	a. exchange of materials take place here
2. shunt	b. short vessel that directly connects the feeder arteriole and the drainage venule
3. true capillaries	c. accepts the blood coming from the true capillaries
4. precapillary sphincter	d. acts as a valve to regulate the flow of blood into the true capillaries
5. drainage venule	e. brings blood to the capillary bed

20. (Page 18.) What happens to blood flow through a capillary bed when precapillary sphincters constrict?

21. (Page 19.) What would happen if blood pressures were high in the capillaries?

22. (Page 20.) What layers are found on larger venules?

23. (Page 21.) What layers are found on smaller venules?

24. (Page 23.) How does the structure of veins differ from arteries?

25. (Page 23.) What is the heaviest wall layer in veins?

26. (Page 24.) List the three factors which assist in returning blood to the heart.

27. (Page 25.) What is the structure and function of venous valves?

28. (Page 25.) Where are venous valves the most abundant?

29. (Page 26). How does the muscular pump work?

30. (Page 27.) Explain how the respiratory pump works.

31. (Pages 9, 11, 14) Match the artery type to its characteristic blood pressure:

1. Aorta & other elastic arteries
2. Muscular arteries
3. Arterioles

a. The steepest drop in blood pressure occurs here.
b. The pressure begins to decline
c. Experiences the greatest pressure.