Cardiovascular System

LEARNING OBJECTIVES

Upon completion of this chapter, the student should be able to:

■ Locate and describe the external anatomy of the heart and its great vessels
■ Locate and describe the organization of the coronary blood vessels
■ Locate and describe the internal anatomy of the heart including the chambers and valves
■ Describe the pattern of systemic and pulmonary blood flow through the heart
■ Locate the major blood vessels of the head and neck
■ Identify the vessels that contribute to the Circle of Willis (cerebral arterial circle)
■ Locate the major blood vessels of the upper extremity
■ Locate the major blood vessels of the abdomen and describe hepatic portal circulation
■ Locate the major vessels of the lower extremity

CARDIOVASCULAR SYSTEM OVERVIEW

The cardiovascular system is the main transportation system of the body. The heart is a thick, muscular organ equipped with a series of one-way valves to pump blood throughout the entire body. Dissolved in the blood are respiratory gases (oxygen and carbon dioxide), nutrients (glucose, amino acids, fatty acids, vitamins, etc.), wastes (lactic acid, urea), plasma proteins (antibodies, clotting factors, etc.), electrolytes (sodium, potassium, calcium, etc.), and hormones. This blood gets pumped through a series of blood vessels in order to deliver nutrients to the tissues and pick up wastes to be excreted. Arteries take blood away from the heart while veins transport blood back toward the heart. While most arteries are oxygenated and most veins are deoxygenated, the blood vessels are named for the direction of blood flow (either away from the heart or toward the heart), not the condition of the blood within their walls (oxygenated or deoxygenated). In this chapter, we review heart anatomy and take a look at the many blood vessels that serve the head and neck, torso, and upper and lower extremities.
External Heart Anatomy

The heart is a muscular organ roughly the size of a closed fist located within the mediastinum, sandwiched between the lungs in the center of the thorax. The base of the heart is its superior border where most of the great vessels may be found entering and exiting the heart. The apex is pointed inferiorly and slightly off center to the left, lying just above the diaphragm. The heart is composed of three layers: the outer epicardium (or visceral pericardium), the middle myocardium (responsible for contraction), and the inner endocardium (a continuation of the vessel endothelial lining), which is in contact with the blood.

The heart contains four distinct chambers, which may be seen externally. The two superior chambers are known as atria (singular atrium) and are the receiving chambers. Oxygen-rich blood returning from the lungs enters the left atrium via four pulmonary veins. Deoxygenated blood returning from the rest of the body enters the right atrium via the superior and inferior vena cavae. The two inferior chambers are known as ventricles and act as the ejecting chambers. The right ventricle ejects deoxygenated blood to the lungs via the pulmonary trunk and pulmonary arteries. The left ventricle ejects oxygenated blood to systemic circulation via the aorta, the largest artery in the body. A small connective tissue remnant of fetal circulation known as the ligamentum arteriosum may be seen connecting the aorta to the pulmonary trunk. In fetal circulation, this patent connection was known as the ductus arteriosus and allowed for the shunting of blood between the two vessels. At birth, pressure changes in the thorax reroute blood flow causing this connection to close and become nonfunctional. Smaller blood vessels may also be found surrounding the external surface of the heart. These are the vessels of coronary circulation, which are discussed later.

Identify and label the base and apex of the heart as well as the great vessels associated with each heart chamber in the following figures.

To locate the image (anterior view) in AIA:
2. Click "Search."
3. Find the image titled Heart & Great Vessels (Ant).

To locate the image (posterior view) in AIA:
2. Click "Search."
3. Find the image titled Heart & Great Vessels (Post).
Internal Heart Anatomy

Internally, the hollow chambers, septi, and valves may be visualized. The two atria are separated from each other by the thin interatrial septum. During fetal circulation, the lungs are filled with fluid so blood flows differently than it does after birth. Oxygenated blood comes to the heart via the umbilical cord in-utero rather than from the lungs. A hole in the interatrial septum, the foramen ovale, allows blood to flow between the atria during fetal circulation. Pressure changes within the thorax after birth allow for closure of this opening leaving a shallow depression in the interatrial septum known as the fossa ovalis. The two ventricles are separated by the thicker, more muscular interventricular septum. The thickness of the myocardium is more easily noticed in the internal view. Note the increased thickness of the left ventricular myocardium when compared to the right. The right ventricle only has to pump blood to the nearby lungs but the left ventricle must pump with more than five times the pressure of the right, ensuring adequate perfusion of the entire systemic circulation.

The heart contains four one-way valves, which ensure that blood flow stays unidirectional. The atrioventricular (AV) valves, as the name suggests, separate the superior atria from the inferior ventricles. The right AV valve has three cusps and is referred to as the tricuspid valve. It allows blood to flow from the right atrium into the right ventricle. The left AV valve has two cusps and is referred to as the bicuspid or mitral valve. It allows blood to flow from the left atrium into the left ventricle. With ventricular contraction, the AV valves are forced shut as pressure increases within the ventricles. This snapping shut of the AV valves may be heard (auscultated) as the “lub” sound or first sound of the heartbeat. Because these valves are under high pressure from the strongly contracting ventricles they are supported by small papillary muscles attached to thin, white cords known as chordae tendineae. These strong cords prevent the cusps of the AV valves from inverting back into the atria and ensure that blood exits the ventricles into either the pulmonary trunk or aorta. Because the left ventricle contracts with so much more force than the right, it is often the mitral valve that is damaged as a result of chronic cardiovascular diseases such as hypertension. The other set of valves are known as semilunar valves and may be found separating the ventricles from the great vessels. The pulmonary semilunar valve separates the pulmonary trunk from the right ventricle while the aortic semilunar valve is found between the aorta and the left ventricle. These valves are under lower pressure than the AV valves so they do not require the chordae tendineae reinforcements. With ventricular contraction these valves are at rest to allow blood to exit the ventricles. As blood is forced into the aorta and pulmonary trunk the vessels stretch to accommodate the volume of blood. As the vessels then recoil to their resting state some blood pushes back against the semilunar valves, forcing them shut and allowing for the second heart sound (“dub”). While the heart is made of four independent chambers, the entire heart functions together as a whole to assure blood is continually moved forward through its closed circuit.

To observe an animated overview of the cardiac cycle, including the heartbeat, valves, and blood flow:

1. Click on Clinical Animations; Select “Thorax,” “Cardiovascular,” and “Cardiology” from the associated drop down menus.
2. Click “Search.”
3. Find the animation titled Heartbeat.

Identify and label the internal structures of the heart including the chambers, valves, papillary muscles, and chordae tendineae in the following figure.

To locate the image in AIA:

1. Click on Clinical Illustrations; Select “Thorax,” “Cardiovascular,” “Anterior,” “Illustration,” and “Cardiology” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Heart Valves - Anterior.
The following image allows you to visualize the thickness of the left ventricular myocardium. To locate the image in AIA:
2. Click "Search."
3. Find the image titled Left Atrium & Ventricle (Lat).
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Compare as many structures as you can using the following images of the right side of the heart. To locate the images in AIA:
2. Click "Search."
3. Find the image titled Right Atrium (Lat).

2. Click "Search."
3. Find the image titled Right Atrium & Ventricle (Ant).

For a unique interactive experience, click on the 3D Anatomy icon and then select 3D Heart.

From there you are able to manipulate a three-dimensional heart by rotating it, moving it, and zooming it in and out.

CLINICAL APPLICATIONS

There are several types of pathologies common to the heart. Conditions such as mitral or aortic stenosis involve a narrowing of the corresponding valve. This narrowing causes an increased resistance to blood flow thereby forcing the heart to contract with an increased pressure to overcome this resistance. The extra demand on the heart can lead to further complications such as cardiomyopathy or even heart failure.

To view some images of aortic and mitral stenosis in AIA:
1. Click on Clinical Illustrations; Select "Thorax," "Cardiovascular," "All," "Illustration," and "Cardiology" from the associated drop down menus.
2. Click "Search."
3. Find the corresponding images.

When heart valves become incompetent, that is they cannot close adequately or they invert in the opposite direction we find such conditions as mitral valve prolapse (MVP), aortic insufficiency, and tricuspid regurgitation. These conditions allow for the backflow of blood and reduce the amount of blood moving through the heart correctly. In severe cases, it may be necessary to surgically repair or even replace the incompetent valve.

To view some images of valvular insufficiencies and heart valve replacements in AIA:
1. Click on Clinical Illustrations; Select "Thorax," "Cardiovascular," "All," "Illustration," and "Cardiology" from the associated drop down menus.
2. Click "Search."
3. Find the corresponding images.
Atrial and ventricular septal defects occur when there is an undesired opening in the septum connecting the right and left sides of the heart, allowing for the mixing of oxygenated and deoxygenated blood. When the foramen ovale fails to close properly, it is commonly referred to as a patent foramen ovale (PFO).

To view some images of atrial and ventricular septal defects in AIA:
1. Click on Clinical Illustrations; Select “Thorax,” “Cardiovascular,” “All,” “Illustration,” and “Cardiology” from the associated drop down menus.
2. Click “Search.”
3. Find the corresponding images.

LAB ACTIVITY 6.3

Circulation of Blood Through the Heart
The cardiovascular system is considered a “closed system,” that is, blood is entirely contained within the walls of the heart and blood vessels (plasma, white blood cells, and small nutrients/wastes may enter and leave circulation). Since blood does not leave this system (for our discussion purposes), we can trace a drop of blood through the entire circulatory system and return it to the place where we began. Let’s consider the two types of circulation in this closed system. **Pulmonary circulation** describes the flow of blood from the right side of the heart to the lungs and back to the left side of the heart, whereas **Systemic circulation** describes the flow of blood from the left side of the heart to the rest of the body systems and back to the right side of the heart. Let’s begin our journey in the right atrium. From the right atrium we pass through the tricuspid valve into the right ventricle. Next, pass through the pulmonary semilunar valve into the pulmonary trunk, which then divides into the left and right pulmonary artery en route to the lungs. From the lungs, we enter the four pulmonary veins (two left and two right) and return to the left atrium. Next, pass through the bicuspid (mitral) valve into the left ventricle. From the left ventricle, pass through the aortic semilunar valve into the aorta, from which various systemic branches emerge to supply the body systems. Blood returning from the head, neck, and upper extremities enters the superior vena cava while blood returning from the thorax, abdomen, and lower extremities enters the inferior vena cava. Both the SVC and IVC enter into the right atrium of the heart, which is where we began in this example.

Use the following figure to trace blood flow through systemic and pulmonary circulation.
To locate the image in AIA:
1. Click on Clinical Illustrations; Select “Thorax,” “Cardiovascular,” “Anterior,” “Illustration,” and “Cardiology” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Circulation of Blood through the Heart.

![Circulation of Blood Through the Heart](image_url)
While cardiac physiology is not discussed in detail here, the electrical activity of the heart is commonly analyzed in clinical practice. Electrocardiography is the act of recording the electrical activity of the heart to monitor cardiac function and check for pathology. An electrocardiogram (ECG) may be easily recorded in the hospital setting, in an ambulance, and even in most any physician’s office.

1. Click on Clinical Animations; Select “Thorax,” “Cardiovascular,” and “Cardiology” from the associated drop down menus.
2. Click “Search.”
3. Find the animations titled “Cardiac conduction system” and “Electrocardiogram (ECG)-interactive tool.”

To view several images of ECG tracings in AIA:
1. Click on Clinical Illustrations; Select “Thorax,” “Cardiovascular,” “Non-standard,” “Illustration,” and “Cardiology” from the associated drop down menus.
2. Click “Search.”
3. Find the corresponding images.

LAB ACTIVITY 6.4

Coronary Blood Vessels
While the heart itself is filled with blood, the blood within the chambers does not supply the myocardium. Instead, the myocardium is supplied by a series of vessels that encircle the heart like a “crown,” hence the name “coronary” vessels. The left and right coronary arteries are the two branches of the ascending aorta. When the ventricles contract these coronary arteries are actually compressed shut. Ventricular relaxation and the subsequent recoil of the aorta pushes blood back, closing the aortic valve, and forcing blood into the coronary arteries. Each coronary artery has two main, terminal branches. The right coronary artery gives rise to the marginal artery along the right lateral border of the heart, and then wraps around to the posterior aspect of the heart in the coronary sulcus (AV groove) and terminates in the posterior interventricular artery. The left coronary artery gives rise to the anterior interventricular artery and the circumflex artery. The circumflex artery wraps around the left side of the heart in the coronary sulcus. The anterior interventricular artery, also known as the left anterior descending (LAD) artery supplies the majority of the left ventricular myocardium. This vessel is referred to as the “widowmaker” by many cardiologists because a blood clot in this vessel often leads to left ventricular failure (infarct) followed by death. Drainage of myocardial blood is via cardiac, not coronary, veins. The small cardiac vein parallels the marginal artery and the great cardiac vein follows the reverse course of the anterior interventricular and circumflex arteries. The middle cardiac vein is found on the posterior aspect of the heart beside the posterior interventricular artery. The small, great, and middle cardiac veins drain into a common expanded vessel known as the coronary sinus, which then empties directly into the right atrium. Several anterior cardiac veins also empty directly into the right atrium from the anterior aspect of the heart.

Identify and label the coronary arteries and their branches in the following figures.
To locate the image (anterior view) in AIA:
1. Click on Atlas Anatomy; Select “Thorax,” “Cardiovascular,” “Anterior,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Coronary Arteries (Ant).

To locate the image (posterior view) in AIA:
1. Click on Atlas Anatomy; Select “Thorax,” “Cardiovascular,” “Posterior,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Coronary Arteries (Post).
Identify and label the cardiac veins and the coronary sinus in the following figures.

To locate the image (anterior view) in AIA:
2. Click "Search."
3. Find the image titled Cardiac Veins (Ant).

To locate the image (posterior view) in AIA:
2. Click "Search."
3. Find the image titled Cardiac Veins (Post).

To examine images of the coronary arteries and cardiac veins from the superior view you may go to Coronary Arteries (Sup) and Cardiac Veins (Sup).
Clinical Applications

Cardiac tissue, being aerobic, is very sensitive to oxygen and any interruption of blood flow (ischemia) has the potential to cause damage. Temporary ischemia frequently causes a sensation of pressure or squeezing chest pain known as angina pectoris. The symptoms are often eliminated with rest and there is no residual damage to the myocardial tissue. When muscle cells die from a lack of oxygen, a myocardial infarction (MI) or “heart attack” results. Heart attacks often occur as a result of severe coronary artery disease (CAD) although emboli lodging in the coronary vessels are another cause. While heart attacks do cause permanent damage, they are not always fatal. The amount and location of damaged tissue and the ability of the surrounding tissue to compensate for the lost (dead) tissue dictate the severity. Three common treatments for CAD are coronary artery bypass grafts (CABG), percutaneous transluminal coronary angioplasty (PTCA), and directional coronary atherectomy (DCA).

1. Click on Clinical Animations; Select “Thorax,” “Cardiovascular,” and “Cardiology” from the associated drop down menus.
2. Click “Search.”
3. Find the animations titled “Coronary artery bypass grafts (CABG),” “Percutaneous transluminal coronary angioplasty (PTCA),” and “Directional coronary atherectomy (DCA).”

To view several images of CAD, MI, Angina, Angioplasty, and CABG in AIA:
1. Click on Clinical Illustrations; Select “Thorax,” “Cardiovascular,” “All,” “All,” and “Cardiology” from the associated drop down menus.
2. Click “Search.”
3. Find the corresponding images.

Lab Activity 6.5

Vessels of the Head and Neck

The aortic arch has three major branches that emerge to supply the head, neck, and upper extremities. The first branch of the aortic arch is the **brachiocephalic trunk**. Shortly after emerging from the aorta the brachiocephalic (brachio-“arm”/cephalic-“head”) trunk divides to form the **right subclavian artery** serving the right upper extremity and the **right common carotid artery** serving the right side of the head and neck. The second branch emerging from the arch is the **left common carotid artery**, which serves the left side of the head and neck. The third and final branch of the aortic arch is the **left subclavian artery**, which supplies the left upper extremity. The subclavian arteries give off an additional branch that supplies the brain, the **vertebral artery**. The vertebral artery may be found ascending the neck through the transverse foramina of the cervical spine. The common carotid arteries (commonly used as pulse points) divide into the **internal carotid arteries**, which go on to serve the brain and the **external carotid arteries**, which serve the skin and muscles of the head and neck. Terminal branches of the external carotid arteries include the **occipital**, **superficial temporal**, and **facial arteries**.

Corresponding veins with the same names are found running with most arteries of the head and neck. A noticeable difference is with the carotids themselves since we have no named carotid veins. Instead, we have the **internal jugular vein** and **external jugular vein** that drain the respective areas supplied by the carotid arteries.

Identify and label the arteries of the head and neck in the following figure.

To locate the image in AIA:
1. Click on Atlas Anatomy; Select “Head and Neck,” “Cardiovascular,” “Lateral,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Arteries of Head & Neck.
Identify and label the veins of the head and neck in the following figure.
To locate the image in AIA:
1. Click on Atlas Anatomy; Select "Head and Neck," "Cardiovascular," "Lateral," and "Illustration" from the associated drop down menus.
2. Click "Search."
3. Find the image titled Veins of Head & Neck (Lat).
Since the neural tissue of the brain is perhaps the most oxygen-sensitive tissue in the body, there is a special blood supply to ensure that oxygen delivery to the brain is uninterrupted. The cerebral arterial circle, or circle of Willis, is an anastomosis of four major vessels: the left & right vertebral arteries entering the cranial vault via the foramen magnum and the left and right internal carotid arteries entering via the carotid canal of the temporal bone. These interconnected vessels are then arranged in a circle surrounding the pituitary gland, further dividing to supply the neural tissue of the brain. The internal carotid arteries branch to give us the anterior and middle cerebral arteries, while the vertebral arteries fuse to become the basilar artery. The basilar artery later divides to form the posterior cerebral arteries.

Identify and label the arteries of the cerebral arterial circle in the following figure.

To locate the image in AIA:
1. Click on Atlas Anatomy; Select “Head and Neck,” “Cardiovascular,” “Inferior,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Cerebral Arterial Circle (Inf).

Anterior cerebral artery

Middle cerebral artery

Posterior communicating artery

Anterior communicating artery

Internal carotid artery

Posterior cerebral artery

Basilar artery

Vertebral artery

**CLINICAL APPLICATIONS**

When blood supply to a part of the brain is interrupted causing brain cells to die we call the condition a cerebrovascular accident (CVA), or stroke. Stroke patients often present with unilateral paralysis or loss of strength and difficulty with speech. A stroke is a medical emergency, and permanent disability or death can result if treatment is not initiated rapidly. A transient ischemic attack (TIA) is sometimes referred to as a “mini-stroke” but symptoms typically subside within 24 hours and do not result in permanent damage. TIs are considered a serious warning sign of a stroke and should not be ignored.

1. Click on Clinical Animations; Select “Head and Neck,” “Cardiovascular,” and “Cardiology” from the associated drop down menus.
2. Click “Search.”
3. Find the animations titled Stroke and Stroke - Secondary to Cardiogenic Embolism.

To view several images related to strokes in AIA:
1. Click on Clinical Illustrations; Select “Head and Neck,” “Cardiovascular,” “All,” “All,” and “All” from the associated drop down menus.
2. Click “Search.”
3. Find the corresponding images.

In the following view of the deep veins of the head, specialized veins known as dural venous sinuses may be visualized. These sinuses are sandwiched between two layers of dura mater and collect venous blood from the brain.
as well as cerebrospinal fluid from the subarachnoid space as it gets reabsorbed into circulation. The dural venous sinuses eventually merge into the left and right internal jugular veins and exit the skull through the jugular foramen.

Identify and label the internal jugular vein and a few of the more prominent dural venous sinuses in the following figure.

To locate the image in AIA:
1. Click on Atlas Anatomy; Select “Head and Neck,” “Cardiovascular,” “Lateral,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Deep Veins of Head (Lat).

![Image of Deep Veins of Head (Lat)](image)

**LAB ACTIVITY 6.6**

**Vessels of the Upper Extremity**

The arch of the aorta gives rise to the arteries that supply the upper extremity. The right subclavian artery divides from the brachiocephalic trunk whereas the left subclavian artery is the third and final branch of the aortic arch. The subclavian artery then continues on and becomes the axillary artery, which serves the axilla, shoulder, and part of the lateral chest wall. It continues as the brachial artery, which supplies the musculature of the arm before dividing at the elbow into the radial (commonly used as a pulse point) and ulnar arteries, which serve the forearm. These two vessels then enter the hand as the superficial and deep palmar arches.

The deep veins of the upper extremity run opposite to their arterial counterparts. The superficial and deep palmar arches continue into the forearm as the radial and ulnar veins. These then merge into the brachial vein, which then empties into the axillary vein. The axillary vein continues as the subclavian vein which, after uniting with the internal jugular vein, becomes the brachiocephalic vein. The left and right brachiocephalic veins then merge into the superior vena cava, which enters the heart at the right atrium.

Identify and label the vessels of the upper extremity in the following figures.

To locate the image in AIA:
1. Click on Atlas Anatomy; Select “Upper Limb,” “Cardiovascular,” “Anterior,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Arteries of Upper Limb (Ant).
Superficially, the upper extremity has a network of veins with no arterial partners. The **cephalic vein** may be found running along the lateral forearm and arm before joining into the axillary vein in the area of the shoulder. The **basilic vein** runs along the medial forearm and arm before entering the deeper, brachial vein. The basilic and cephalic veins unite at the antecubital fossa (anterior elbow) to form the **median cubital vein**, which is a common site used for blood removal (phlebotomy) and IV administration.

*Identify and label the superficial veins of the upper extremity in the following figure. Zooming in will allow you to view the extremity in its entirety. To view the image in AIA, go to*
Branches of the Descending Aorta

As the aorta turns downward from the arch it becomes the *descending aorta*. The section of descending aorta superior to the diaphragm is known as the *thoracic aorta*. The branches of the thoracic aorta include intercostal arteries plus branches to the esophagus, lungs, and diaphragm. As the descending aorta passes through the diaphragm its name changes from the thoracic aorta to the *abdominal aorta*.

The first main branch of the abdominal aorta is the *celiac trunk*. Almost immediately the celiac trunk divides into three vessels: the *common hepatic artery* to the liver, the *left gastric artery* to the stomach, and the *splenic artery* to the spleen.

The *superior mesenteric artery* is a singular vessel supplying the majority of the small intestine and the proximal portion of the large intestine (colon).

The paired *renal arteries* supply the left and right kidneys and give off smaller *suprarenal* branches to the adrenal glands sitting atop of each kidney.

The next branches are the paired *gonadal arteries* serving either the testes or ovaries. In a male, these are known as the *testicular arteries* while in the female, they are called the *ovarian arteries*.

Finally, the singular *inferior mesenteric artery* may be found supplying the distal half of the large intestine.

Identify and label the branches of the abdominal aorta in the following figure. To locate the image in AIA:

1. Click on *Atlas Anatomy*; Select “Body Wall and Back,” “Cardiovascular,” “Anterior,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled *Arteries of Trunk (Ant)*.
The following images show close-up views of the branches of the celiac trunk as well as the superior mesenteric artery.

Compare as many structures as you can using the following images of the abdominal viscera. To locate the image in AIA:
1. Click on Atlas Anatomy; Select “Abdomen,” “Cardiovascular,” “Anterior,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Superior Mesenteric Artery 1.

To locate the image in AIA:
1. Click on Atlas Anatomy; Select “Abdomen,” “Cardiovascular,” “Anterior,” and “Cadaver Photograph” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Pancreas & Spleen (Ant).

For a closer look at the distribution of the inferior mesenteric artery:
1. Click on Atlas Anatomy; Select “Abdomen,” “Cardiovascular,” “Anterior,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Inferior Mesenteric Artery 1.
Veins of the Abdomen
The **inferior vena cava** receives blood from the organs of the abdomen as well as the lower extremities. The left and right **hepatic veins**, draining the liver, enter the inferior vena cava just inferior to the diaphragm. The **renal veins** may be seen prominently entering the inferior vena cava, draining the left and right kidneys. The **right suprarenal vein** connects directly to the inferior vena cava while the **left suprarenal vein** joins with the left renal vein. Similarly, the **right gonadal vein** enters the inferior vena cava directly whereas the **left gonadal vein** joins the left renal vein. The remaining organs have their blood collected by the hepatic portal circulation, which is discussed in the next section.

*Identify and label the vessels draining into the inferior vena cava in the following figure. To view the image in AIA, go to*
Hepatic Portal Circulation

The liver is a multifunctional organ with hundreds of different functions. It is a production factory, a storage facility, and a waste removal plant all rolled into one. As such, it is important that the liver has access to ingested nutrients as well as potential ingested toxins. A special circulatory pathway known as hepatic portal circulation is responsible for collecting blood from the digestive organs, pancreas, and spleen, and then delivering the blood to the liver for processing. The inferior mesenteric vein, carrying blood from the colon, joins with the splenic vein, which contains blood from the spleen, pancreas, and stomach. The superior mesenteric vein, with its blood from the small intestine and proximal colon, unites with the splenic vein to form the hepatic portal vein, which then enters the liver from its inferior surface. The liver will store or process the carried nutrients, preparing them for delivery to general circulation. The left and right hepatic veins then exit the liver and join the inferior vena cava.

Identify and label the vessels of hepatic circulation in the following figure. To locate the image in AIA:

1. Click on Atlas Anatomy; Select “Abdomen,” “Cardiovascular,” “Anterior,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Mesenteric Veins.
The following images show close-up views of the hepatic portal vein as well as the mesenteric and splenic veins. Compare as many structures as you can using the following images of the abdominal viscera. To locate the image in AIA:
1. Click on Atlas Anatomy; Select “Abdomen,” “Cardiovascular,” “Anterior,” and “Illustration” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Hepatic Portal Vein.

To locate the image in AIA:
1. Click on Atlas Anatomy; Select “Abdomen,” “Cardiovascular,” “Anterior,” and “Cadaver Photograph” from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Dissection of Portal Vein.

LAB ACTIVITY 6.10
Vessels of the Lower Extremity
Once the abdominal aorta reaches the level of approximately L4 it terminates and divides into the left and right common iliac arteries. The common iliac arteries soon divide into the internal iliac artery, which supplies the organs of the pelvis (bladder, rectum, prostate in males, and vagina in females), gluteal muscles, and the adductor muscles of the thigh. The external iliac artery supplies blood to the skin and muscles of the lower abdomen before exiting the pelvis to supply the lower limb. In the thigh, its name changes to the femoral artery where it supplies the femur and muscles of the thigh. Branching from the proximal portion of the femoral artery is the deep femoral artery, which supplies the majority of the thigh musculature. Branching from this vessel are the lateral and medial circumflex femoral arteries, supplying the areas around the head and neck of the femur. At the knee, the femoral artery continues on as the popliteal artery, which then divides into the anterior and posterior tibial arteries, which supply the leg. The anterior tibial artery crosses the ankle joint as the dorsalis pedis artery (terminating as the dorsal arcuate artery) while the posterior tibial artery wraps around the posterior aspect of the medial malleolus, terminating as the medial and lateral plantar arteries. Both the dorsalis pedis and posterior tibial arteries are common pulse points in the lower extremity.

Blood from the plantar aspect of the foot enters the posterior tibial vein while that of the dorsum of the foot enters the anterior tibial vein. The anterior and posterior tibial veins join to form the popliteal vein at the knee, which then continues up the thigh as the femoral vein. Once in the pelvic, the femoral vein becomes the external iliac vein, which will then join with the internal iliac vein to become the common iliac vein. The left and right common iliac veins unite to form the inferior vena cava, which ascends the abdomen to enter the heart via the right atrium.
Identify and label the vessels of the thigh in the following figures. To locate the image in AIA:
1. Click on Atlas Anatomy; Select "Lower Limb," "Cardiovascular," "Anterior," and "Illustration" from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Arteries of Lower Limb (Ant).

To locate the image in AIA:
1. Click on Atlas Anatomy; Select "Lower Limb," "Cardiovascular," "Anterior," and "Illustration" from the associated drop down menus.
2. Click “Search.”
3. Find the image titled Deep Veins of Lower Limb (Ant).

Using the same two previous illustrations, scroll down to the level of the leg and identify the vessels of the leg and foot.
For a better view of the posterior leg vasculature, use the following figures to identify and label the vessels of the posterior leg. To locate the image in AIA:
1. Click on Atlas Anatomy; Select "Lower Limb," "Cardiovascular," "Posterior," and "Illustration" from the associated drop down menus.
2. Click "Search."
3. Find the image titled Arteries of Lower Limb (Post).

To locate the image in AIA:
1. Click on Atlas Anatomy; Select "Lower Limb," "Cardiovascular," "Posterior," and "Illustration" from the associated drop down menus.
2. Click "Search."
3. Find the image titled Deep Veins of Lower Limb (Post).

Superficially, the lower extremity has a network of veins with no arterial partners. The small saphenous vein may be found coursing from lateral aspect of the foot and up the posterior leg before joining with the popliteal vein behind the knee. The great saphenous vein is the longest vein in the human body and takes a long, tortuous route along the entire lower extremity. It originates from the medial side of the dorsum of the foot, and then progresses along the medial leg and thigh before joining the deeper, femoral vein just below the inguinal ligament. The great saphenous vein is a common site for harvesting grafts to be used for CABG procedures.

To view the superficial veins of the lower extremity in AIA go to DA P3 or DA P3 to visualize the small saphenous vein and go to DA A5 or DA A8 to get a good view of the great saphenous vein. Zooming in and out and scrolling up and down will allow you to view the extremity and its vessels in their entirety.
CARDIOVASCULAR SYSTEM REVIEW EXERCISES

Matching

1. Right AV valve  
2. CVA  
3. Vessel used when taking blood pressure  
4. Commonly used in CABG procedures  
5. Angina pectoris  
6. Common site for pulse  
7. LAD  
8. Left AV valve

Labeling

Draw your own lines and then label following features on the diagram.

a. Right coronary artery  
b. Left pulmonary artery  
c. Left common carotid artery  
d. Brachiocephalic trunk  
e. Inferior vena cava  
f. Left brachiocephalic vein  
g. Anterior interventricular artery  
h. Superior vena cava  
i. Pulmonary trunk  
j. Left subclavian vein  
k. Ligamentum arteriosum  
l. Right pulmonary veins  
m. Aortic arch  
n. Great cardiac vein
Draw your own lines and then label following features on the diagram.

a. Left common carotid artery
b. Right common iliac artery
c. Celiac trunk
d. Brachiocephalic trunk
e. Right renal artery
f. Inferior mesenteric artery
g. Right vertebral artery
h. Left axillary artery
i. Left internal iliac artery
j. Thoracic aorta
k. Superior mesenteric artery
l. Left gonadal artery
m. Right external iliac artery
Draw your own lines and then label following features on the diagram.

a. Inferior mesenteric vein  
b. Right external iliac vein  
c. Splenic vein  
d. Inferior vena cava  
e. Superior mesenteric vein  
f. Left common iliac vein  
g. Hepatic portal vein  
h. Left femoral vein

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**Fill in the Blank/Short Answer**

1. The gonadal artery in the female is better known as the ______ ovarian a. ______ artery.
2. The radial and ulnar vein merge to form the ______ brachial v. ______ vein.
3. The two major arteries supplying the brain are the ______ vertebral a. ______ and ______ internal carotid a. ______
4. The middle and great cardiac veins drain into the ______ coronary sinus ______, which then enters the right atrium.
5. The longest vein in the body is the ______ great saphenous v. ______
6. The inner lining of the heart in contact with the blood is the ______ endocardium ______
7. The second branch of the aortic arch is the ______ common carotid a. ______
8. The most common site for venipuncture is the ______ median cubital v. ______ vein.
9. The pulse of the ______ dorsalis pedis a. ______ artery may easily be palpated on the dorsum of the foot.
10. The **bicuspid/mitral** valve separates the left atrium from the left ventricle.

11. The opening in the interatrial septum normally found during fetal circulation is the __**foramen ovale**__.

12. The veins draining the digestive organs, pancreas, and spleen collectively enter the liver via the __**hepatic portal v.**__

13. The interconnected network of vessels supplying the brain with oxygenated blood is known as the **cerebral arterial circle (circle of Willis)**.

14. The role of the chordae tendineae is to __**prevent inversion of AV valves/backflow of blood**__.

15. Incomplete closure of the tricuspid valve would cause blood to back up into __**right atrium → IVC → systemic circulation/lower extremities**__.

**Essay**

1. Beginning with the left ventricle, trace a drop of blood through the entire cardiovascular system, returning to the left ventricle. (Be sure to include valves, chambers, and great vessels).

   - **Left ventricle → aortic valve → aorta → body systems → SVC/IVC → right atrium → tricuspid valve → right ventricle → pulmonary valve → pulmonary trunk → pulmonary arteries → lungs → pulmonary veins → left atrium → bicuspid/mitral valve → left ventricle.**

2. Beginning with the large intestine, trace a drop of blood back to the right atrium. (Be sure to include vessels and organs encountered along the way).

   - **Large intestine → inferior mesenteric vein → splenic vein → hepatic portal vein → liver → hepatic vein → IVC → right atrium.**

3. Compare and contrast a TIA with a CVA.

   - **TIA-transient ischemic attack; “mini-stroke;” temporary reduction on blood flow; symptoms usually unilateral; symptoms usually subside within a few hours; no permanent damage; may eventually lead to CVA.**

   - **CVA-cerebrovascular accident; “stroke;” complete blockage of blood flow; symptoms typically unilateral; symptoms do not subside; permanent damage results; may lead to death if severe.**