The Cardiovascular System

Part 2: Circulatory Systems

Objectives:
The circulatory systems
1. Describe the general features of vessel walls.
2. Describe the coronary arterial circulation and its venous return.
3. Describe the major components of the pulmonary circulation and the systemic circulation.
4. List the structural changes that occur at birth in changing from a fetal to an adult circulatory pattern.
5. Find the major pulse points in the neck, upper extremities, and the lower extremities.
6. Describe the role of the autonomic nervous system in regulation of heart rate and peripheral resistance.
7. Describe the components of the lymphatic system.

Components of the cardiovascular system

- Heart
- Blood vessels
  - Arteries
  - Veins
  - Capillaries
- Coronary circulation
- Pulmonary circulation
- Systemic circulation

Review of heart anatomy:
- Pair of muscular pumps:
  - The “right heart” feeding the pulmonary circulation
  - The “left heart” feeding the systemic circulation
- Four chambers
  - Two atria, separated by an interatrial septum
  - Two ventricles, separated by an interventricular septum
- Atrioventricular valves (tricuspid and bicuspid) prevent backflow of blood into atria during ventricular contraction

- From the center to the periphery the arterial tree undergoes modifications:
  - The arteries increase in number by repeated bifurcations and branching.
  - The arteries also decrease in diameter.
  - Smaller arteries become arterioles and are more muscular.
  - Blood from the arterioles enters into a capillary bed within the tissues, where exchange of gases and nutrients takes place.
  - Blood from the capillaries is carried by post capillary venules, then muscular venules, to larger veins back toward the right heart.
  - Arteries, arterioles and veins have 3 "coats" while capillaries and post capillary venules have only 2.

The 3 coats of the arteries, arterioles and veins:
- Tunica intima – inside, next to lumen. Endothelium and connective tissue.
- Tunica media – middle layer. Smooth muscle, elastin, collagen.
- Tunica adventitia – outer layer. Collagen, elastin. Houses vasa vasorum (blood vessels to the blood vessels) and nervi vasorum.
Gross anatomy

- Arteries and veins are named primarily for their anatomical location or target tissue or organ.
  - For example, the brachiocephalic trunk will branch to supply the arm (brachium), and head (cephalic)
  - The femoral artery is in the thigh (as is the femur)
  - The coronary arteries supply the heart

Vascular supply to the heart:
The coronary circulation

- The first 2 branches off of the aorta are the right and left coronary arteries.

The right coronary artery

1. Originates posterior to the right anterior aortic valve cusp.
2. Travels in the AV groove (coronary sulcus).
3. Gives off right marginal branch.
4. Travels to the posterior interventricular groove where it descends as the posterior interventricular branch.
5. Also supplies the SA node.

The left coronary artery

1. Originates behind the left anterior aortic valve.
2. Divides into the anterior interventricular branch (also called the left anterior descending or LAD), and the circumflex artery.

Coronary artery disease (CAD)

- Generally used to refer to the pathologic process affecting the coronary arteries (usually atherosclerosis).
- Coronary heart disease (CHD) is a result of CAD, and includes myocardial infarction and angina pectoris (pain in the chest related to cardiac ischemia).
- The American Heart Association reported that 17.6 million persons in the United States have CHD (AHA, 2010)
- CHD is responsible for about 1/3 of all deaths in adults > 35 years old

Venous return from the heart
To the right atrium
Review of the great vessels

- Superior vena cava (cut) Carrying de-oxygenated blood
- Inferior vena cava (cut) Carrying de-oxygenated blood
- Aorta (cut) Carrying oxygenated blood
- Right pulmonary veins from right lung to the left atrium Carrying oxygenated blood
- Pulmonary trunk To right and left pulmonary arteries to right and left lungs Carrying de-oxygenated blood
- Left pulmonary veins from left lung to left atrium Carrying de-oxygenated blood

Intrapulmonary circulation

- Pulmonary artery from right heart
- Pulmonary vein to left heart
- Capillary bed within alveolar wall, gas exchange
- Visceral pleura covering lung
- Capillary bed within alveolar wall

Prenatal circulation

- Ductus arteriosus
- Ductus venosus
- Foramen ovale
- Inferior vena cava

Postnatal circulation

- Ligamentum arteriosum
- Ligamentum venosum
- Fossa ovalis

The systemic circulation

- Blood from the left ventricle exits the heart through the aortic valve to the aorta. Arterial branches from the aorta branch to smaller arteries, arterioles, and then to capillaries on their journey.
- Waste and carbon dioxide move out of the cell into the blood, and oxygen in the blood moves into the cell. Blood then travels to post capillary venules, veins, through the IVC or SVC and enters the heart at the right atrium.
Posterior tibial artery
Dorsalis pedis

Medial view

Posterior tibial artery
Tibial nerve
Posterior to the medial malleolus

Dorsalis pedis artery
On the dorsum of the foot

Venous drainage of the head and neck

External jugular v.
Internal jugular v.
Common carotid a.

Sternocleidomastoid muscle

Venous drainage of the thoracic cavity

SVC
Esophagus
Azygos vein
(Hepatic portal vein)

Venous drainage of the GI system

Hepatic portal vein
Superior mesenteric vein

Inferior mesenteric vein

Venous drainage from lower body

Inferior vena cava (IVC)
Right renal vein
Common iliac vein
External iliac vein

Femoral vein

Venous return via the SVC

Right IJV
Left IJV
Right subclavian vein
Left subclavian vein

Right brachiocephalic vein
Left brachiocephalic vein

Superior vena cava

The internal jugular veins (IJV) and subclavian veins form brachiocephalic veins. These veins then join to form the SVC.
Conducting system: revisited

1. Specialized cardiac muscle cells have the inherent ability to contract & relax spontaneously, acting as a conducting system.
2. An area of the right atrium contains cells that generate the fastest contract/relax rhythm, and are thus the "pacemaker" of the heart. This is the sinoatrial (SA) node.
3. This sets the rate of contraction for the rest of the heart.

Conducting system

4. The impulses from the SA node are transmitted to both atria and to the atrioventricular (AV) node, located in the inter-atrial septum, above the opening for the coronary sinus.
5. The AV bundle of His extends from the AV node, through the fibrous skeleton, and branches in the interventricular septum into the right and left bundles.
6. Purkinje fibers extend from the end of the bundle branches throughout the heart muscles to carry impulses to the cardiac cells of the ventricles to produce contraction of the ventricles.

Take your pulse

• Palpate an arterial pulse and determine your heart rate.
• Take your pulse for 30 seconds (multiply by 2) or for one full minute if your heart rate is irregular.
• Now breathe slowly and rhythmically for 1 minute and retake your pulse while you continue to do this slow deep breathing.
• Is your heart rate any slower?
• Can you feel your pulse change with each inhalation and exhalation?

Innervation: Autonomic influence

• The cardiac cycle is initiated by the SA node.
• But regulated and harmonized by the autonomic nervous system.
1. "Sympathetic nervous system"
   • Fight or flight
   • Accelerates heart rate and increases the strength of the cardiac contraction
   • Dilates (opens) the coronary arteries
2. Parasympathetic nervous system
   • Rest and digest
   • Slows heart rate
   • Causes constriction (narrowing) of the coronary arteries

REVIEW

Stress and cardiovascular disease

"Evidence is accumulating from population and clinical studies that stress might contribute to risk of cardiovascular disease at a number of stages, including the long-term development of atherosclerosis and the acute triggering of cardiac events."


Lymph circulatory system

Moore, 6th Ed., Fig. 1.27