Anatomy and Physiology Focus: Cardiovascular System
Part 2—Blood Circulatory System and Lymphatic Circulation

Anna Marie Kish, RN, BSN, ARNP, NP-C
Although we have tried to include accurate and comprehensive information in this presentation, please remember it is not intended as legal or other professional advice.
Session Objectives

• Describe structure and function of the blood circulatory system and lymphatic circulation

• Describe diseases and disease processes and how they affect the blood circulatory system and lymphatic circulation
**Blood Circulatory System**

**Structure:**
- Arterial and venous systems
  - Arteries, veins, capillaries

**Function:**
- Movement of blood in controlled, continuous manner
- Nourishment, filtration, and cleansing of cells/tissues
- Prevention of infection
- Thermal regulation
- Circulation of secretions from endocrine glands
Lymphatic Circulation

- Lymphatic circulation
  - Lymphatic fluid (lymph)
  - Lymphatic vessels
- Movement of lymphatic fluid in controlled, continuous manner
- Filtration, and cleansing of cells/tissues
- Prevention of infection
Cells and Tissues of Blood Vessels

- Endothelial cells line inside of blood and lymph vessels and epithelial cells are on outer surface
- Elastic connective tissue cells and branching fibers; function is to stretch
- Smooth (involuntary) muscle forms walls of blood vessels; contract and relax in wave-like manner, impulses spread in organized fashion (pulse); smooth muscle cells form walls of vessels to accommodate blood flow demands, constriction/dilatation

Organs of Blood Circulatory System

- Aorta, arteries, arterioles, capillaries
- Capillaries, venules, veins, superior and inferior vena cava
Structure and Function of Arterial System

Arteries: branch from aorta into smaller arteries to microscopic arterioles to capillaries

Three layers:

- **tunica interna or intima**: innermost layer, squamous epithelium surrounded by connective tissue membrane
- **tunica media**: middle layer, smooth muscle, provides support and ability to regulate blood flow
- **tunica externa or adventitia**: outermost layer, connective tissue, collagenous and elastic fibers; attaches blood vessel to surrounding structures
**Capillaries**: smallest and most numerous; connect arteries and veins; provide $O_2$ and nutrients to tissues, remove waste

**Function of Arterial System**
- Transport of blood from heart through pulmonary arteries and aorta
- Blood flow from heart is dependent on pressure exerted against arterial walls
- Flows from area of higher to lower pressure
- Pressure highest at aorta and large vessels, lowest in capillaries, as blood flow slows blood pressure decreases
- Upon reaching capillaries, blood flow slows to point where essential metabolic functions occur:
  - Exchange of gases and nutrients, removal of metabolic waste
  - Gases pass through capillary wall by diffusion; osmosis and hydrostatic pressure allow liquid substances to enter and leave capillaries
Subdivisions of Systemic Circulation

- Coronary circulation, from ascending aorta to heart (A & B)
- Cerebrovascular circulation, from aortic arch to brain, upper body
- Descending aorta, portal circulation; lower body

![Diagram of the circulatory system showing subdivisions and key arteries](image)
<table>
<thead>
<tr>
<th>Aortic Divisions</th>
<th>First Order Branches</th>
<th>Second Order Branches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascending aorta</td>
<td>Coronary arteries</td>
<td></td>
</tr>
<tr>
<td>Aortic arch</td>
<td>Brachiocephalic (innominate)</td>
<td>Right common carotid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Right subclavian</td>
</tr>
<tr>
<td></td>
<td>Left common carotid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Left subclavian</td>
<td></td>
</tr>
<tr>
<td>Thoracic aorta</td>
<td>Intercostal arteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Superior phrenic arteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bronchial arteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Esophageal arteries</td>
<td></td>
</tr>
<tr>
<td>Thoracic aorta</td>
<td></td>
<td>Inferior phrenic arteries</td>
</tr>
<tr>
<td>Abdominal aorta</td>
<td>Celiac</td>
<td>Hepatic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Left gastric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Splenic</td>
</tr>
<tr>
<td></td>
<td>Superior mesenteric</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suprarenal arteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Renal arteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Testicular/ovarian arteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inferior mesenteric</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Common iliac arteries</td>
<td>External iliac arteries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal iliac arteries</td>
</tr>
</tbody>
</table>
Arteries of Upper Extremity

- Brachiocephalic (innominate) artery branches to subclavian artery, axillary artery, brachial artery, ulnar artery, radial artery, palmar arch, digital branches
Arteries of Lower Extremity

- Arteries continue to branch, becoming femoral artery, branching through leg, popliteal artery, anterior tibial artery, posterior tibial artery, peroneal artery, dorsalis pedis artery
Structure and Function of Venous System

Structure

• Transition from arterial to venous circulation occurs in capillaries; blood enters microscopic venules, flows into veins of increasing size until reaching vena cava and right atrium

• Walls similar to arteries, tunica media has less smooth muscle, is thinner due to lower pressure in venous system; medium/large veins have valves similar to semi-lunar valves in heart; keep blood moving toward heart, prevent backflow and pooling of blood in extremities

Function: Transport blood back to heart

• Venules/veins not dependent on blood pressure

• Return of venous blood to heart is dependent on skeletal muscle contraction, respiratory movements, constriction of smooth muscle in venous walls
Venous Systemic Circulation

**Superior vena cava:** returns deoxygenated blood to right atrium from head, neck and both upper extremities, thorax

- Formed by left and right brachiophepalic veins, which also receive blood from the upper limbs, head, neck via jugular veins

**Inferior vena cava:** receives blood from lower extremities and from pelvic and abdominal organs

- Branches of inferior vena cava: "I Like To Rise So High," Iliac vein (common), Lumbar vein, Testicular (ovarian) vein, Renal vein, Suprarenal vein, and Hepatic vein
Veins of Upper Extremity

Deep veins:
- radial, ulnar, brachial, axillary, subclavian

Superficial veins:
- digital, metacarpal, cephalic, basilic, median
Veins of Lower Extremity

From foot up:
- dorsal venous arch
- short saphenous vein
- popliteal vein
- long saphenous vein
- femoral vein and on up to vena cava
Comparison of Arteries and Veins

**Artery**
- Outer coat (tunica adventitia)
- Muscle coat (tunica media)—thick in arteries and thin in veins
- Elastic and white fibrous tissue

**Vein**
- Lining (tunica intima) of endothelium
- Valve
Diseases, Disorders, Other Conditions of Blood Circulatory System

Neoplasms

• **Malignant /uncertain behavior**
  - Hemangioendothelioma: vascular tumors, commonly present with enlarging mass; head and neck, intestines, lungs, lymph nodes, pleura, retroperitoneum, stomach, other body sites; slow-growing, may begin as hemangioma but become malignant
  
  - Angiosarcoma: aggressive, tend to recur locally, spread widely, have high rate of lymph node and systemic metastases; rate of tumor-related death is high
  
  - Kaposi’s sarcoma: develops from cells that line lymph or blood vessels; different types defined by different populations in which it develops; AIDS related (AIDS defining disease), Mediterranean, African, transplant-associated
• **Benign**
  – Hemangioma: abnormal buildup of blood vessels in skin or internal organs; superficial or deep, most on head or neck; 30% present at birth; usually resolve on own, may need intervention if interferes with vision, breathing, eating, psychological effects; “port-wine” stain, may be permanent, respond to laser
  – Glomus tumor: can invade bony tissue, around ear, grow around jugular veins and carotid arteries, can invade brain tissue

**BENIGN DOES NOT NECESSARILY MEAN NOT DANGEROUS!**
Cerebrovascular Disease

Conditions specific to cerebrovascular system

- **Nontraumatic subarachnoid or intracerebral hemorrhage**: hemorrhagic stroke; difference is site of bleed; subarachnoid occurs outside brain tissue in subarachnoid space; most common cause intracranial aneurysm; other, A-V malformation, tumor, infection

- **Cerebral infarction**: ischemic stroke; blood supply to area of brain interrupted or severely reduced; ischemia, death of brain cells; thrombus or embolus reducing or obstructing blood flow

- **Occlusion/stenosis**: occlusion with or without infarction caused by thrombus or embolism; differentiating factor is whether or not cell and tissue death has occurred
Diseases of Arteries, Arterioles, Capillaries

**Atherosclerosis**: plaque build-up on arterial walls, significant narrowing of lumen, can rupture, sending clots into smaller arteries, obstructing blood flow; can also affect vessels used for bypass grafts and synthetic bypass grafts

**Aneurysm**: ballooning/bulging of artery, weakening or degeneration; aorta, cerebral arteries, mesenteric artery, splenic artery, popliteal artery

- Three types
  - **nonruptured, intact**: asymptomatic; detected with other studies; screening for at-risk individuals
  - **ruptured**: arterial wall bursts, hemorrhage into tissues or body cavity; aortic, high mortality rate if ruptured; 80% mortality rate, 50% before reaching hospital
  - **dissecting**: tear in inner layer of artery causes blood to accumulate between layers; layers separate longitudinally with blood accumulation between; frequently rupture outer layer and result in hemorrhage, most common in aorta; associated with genetic abnormalities, Marfan’s, Turner’s; HTN, connective tissue diseases, lupus, scleroderma
Peripheral Artery Disease (PAD)

Obstruction of large arteries in lower extremities; can result from atherosclerosis, stenosis, embolism, thrombus formation; causes either acute or chronic ischemia; can progress to gangrene

• Symptoms: claudication, “angina”; nonhealing wounds, noticeable difference in color, temperature; diminished hair, nail growth on affected limb; loss of pulse; risks: smoking, diabetes, atherosclerosis, obesity, HTN, dyslipidemia

• Treatment: stop smoking, manage diabetes, lipids; angioplasty in large arteries, PTA, stent; antiplatelet drugs (plavix, ASA); femoral-popliteal bypass, similar to CABG, bypasses blockage, autologous graft, synthetic
Hypertension (Arterial)

"High blood pressure": HTN; chronic medical condition, systemic arterial blood pressure elevated; persistent HTN is risk factor for stroke, myocardial infarction, hypertensive retinopathy, heart failure and arterial aneurysm, leading cause of chronic kidney failure

Blood pressure function of 2 factors, blood volume or amount of blood pumped by heart, and resistance to blood flow in arteries; increased blood volume or narrowing of arterial lumen results in increased blood pressure

HTN is indicator that force required for blood flow is greater than normal; blood pressure is considered elevated when repeated measurement >140/90 of either systolic, diastolic, or both; diagnosis of hypertension made when person has had 2 or more elevated readings after initial assessment

**Essential or primary HTN**: no obvious cause, 90–95% of cases; genetic and certain lifestyle factors such as body weight and salt intake involved; “silent killer”

- Secondary HTN: caused by other medical diagnosis or problem, kidney disease, Cushing's syndrome, pregnancy, oral contraceptive use, chronic alcohol abuse, use of certain medications

- Risk factors: gender, age, heredity and race are factors that cannot be controlled; heredity can be risk factor if one or more parents have been diagnosed with hypertension; African Americans are at greater risk for developing hypertension; chances of developing hypertension increase with age; men generally at greater risk than women, but as women age, risk increases with onset of menopause, then later in life, exceeds that of men; risk factors that can be controlled are lifestyle related: obesity, diet, lack of exercise, stress, the use of certain medications, smoking, and excessive alcohol consumption
The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure has published following chart to classify blood pressure. This applies to patients who are 18 years and older, who have not already been diagnosed with hypertension, are not on any medication for hypertension, and are not seriously ill.
# JNC 7 Blood Pressure Chart

<table>
<thead>
<tr>
<th>Category</th>
<th>Systolic BP (mmHg)</th>
<th>Diastolic BP (mmHg)</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt;120</td>
<td>and &lt; 80</td>
<td>Recheck in 2 years</td>
</tr>
<tr>
<td>Pre-hypertension</td>
<td>120–139</td>
<td>or 85–89</td>
<td>Recheck in 1 year</td>
</tr>
<tr>
<td>Hypertension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage 1</td>
<td>140–159</td>
<td>or 90–99</td>
<td>Confirm within 2 months</td>
</tr>
<tr>
<td>Stage 2</td>
<td>≥160</td>
<td>or ≥100</td>
<td>Evaluate within 1 month or sooner, or treat immediately, depending on clinical situation</td>
</tr>
</tbody>
</table>
Diseases of Veins

**Phlebitis/thrombophlebitis**: inflammation of vein; **superficial** phlebitis affects veins near skin surface, rarely serious, usually resolves rapidly with symptomatic treatment; thrombophlebitis results when blood clot in vein causes inflammation; usually occurs in leg veins, may occur in arm; often causes redness over area of affected vein; vein may also feel hard and thick, ropelike, may have swelling of extremity and heat or pain over vein; causes: local trauma to vein, IV catheters, IV drug use, prolonged immobility

**Venous thrombosis/embolism**: Deep vein thrombosis (DVT), lower extremities most often, can affect portal, hepatic, renal veins; swelling of leg most common symptom of DVT; may also experience pain, particularly when foot is bent upwards (Hohman’s sign); thrombus in **deep** leg veins (femoral, iliac, popliteal, tibial) may break free and cause pulmonary embolism, potentially life-threatening; causes-prolonged immobility (long flights), post-op, major trauma, pregnancy, oral contraceptives, smoking, malignancy, clotting disorder; treated with anticoagulant, Coumadin, IVC filter

**Exercise those leg muscles when sitting for long periods, like on a plane or while attending a stimulating presentation!**
Venous Insufficiency

- Impaired blood flow from extremities due to blocked veins and/or damaged valves in veins
- Symptoms: edema, skin discoloration, prominent varicose veins, aching, burning, throbbing pain, skin ulcers, muscle cramping/weakness; pain worse with standing, better with elevation
- Risks: age, being female (related to progesterone); height; genetics; obesity, pregnancy, prolonged sitting or standing; history of DVT

Varicose veins

- Veins that have become enlarged and tortuous; valves in veins incompetent, allow backflow of fluid, pooling; lower legs most common; pain, swelling, inflammation of veins, ulcers; may occur in rectum (hemorrhoids), esophagus (esophageal varices), stomach, scrotal veins (varicocele)
Other Vascular Diseases and Disorders

Venous hypertension: increased blood pressure in veins, incompetent valves; pooling of blood along length of vein until normal valve reached; arteries continue to pump blood into vein, increasing pressure; prolonged standing

Hypotension: low blood pressure; usually systolic <90, diastolic <60; can cause dizziness and fainting; may lead to hypoxia of brain and vital organs leading to shock; may be indication of other severe heart, endocrine, or neurological problem; reduced blood volume (hypovolemia), most common mechanism producing hypotension; may result from hemorrhage; insufficient fluid intake, dehydration, starvation; excessive fluid loss from diarrhea/vomiting, excessive use of diuretics, medications, fluid loss during exercise

Drink your water!

Gangrene: necrosis or tissue death due to loss of blood supply to body part; may be related to specific disease such as diabetes or vascular disease, or condition such as hernia (entrapped loop of bowel)

- dry: at distal part of limb; due to ischemia, often occurs in toes and feet of elderly patients due to arteriosclerosis; mainly due to arterial occlusion (PAD)
- wet: usually develops rapidly due to blockage of venous (mainly) and/or arterial blood flow; affected part saturated with stagnant blood, promoting rapid growth of bacteria, toxic products formed by bacteria are absorbed causing septicemia and finally death
- gas: bacterial infection producing gas within tissues; usually caused by bacteria, Clostridium perfringens; spreads rapidly as gases produced by bacteria expand and infiltrate nearby healthy tissue
Lymphatic Circulation

- Lymph vessels, lymph nodes, lymphatic fluid (lymph)
Structure and Function of Lymphatic Circulation

**Cells and tissues**

- Simple squamous epithelium lines inside of lymph vessels; few collagenous fiber cells; squamous cells at distal end of capillary overlap, forming one-way valve to allow fluid to flow into capillary and prevent backflow
- Lymphatic tissue is specialized form of netlike connective tissue in lymphatic system that contains large numbers of lymphocytes

**Lymphatic vessels**

- Distributed through most of body, absent from areas without direct blood supply; structure similar to veins, thin-walled, contain valves; differ in having nodes at various intervals
- Begin as open-ended sacs, lymphatic capillaries, located in tissue spaces; when dilated, lymphatic capillaries have greater and more variable diameter than blood capillaries; merge to form small vessels, increase in size to form lymphatic trunks
- Pair of valves at junctions of lymphatic ducts and subclavian veins prevents backflow of lymph
- Pressure gradients moving fluid through lymphatic vessels come from skeletal muscle action, respiratory movement, contraction of smooth muscle in vessel walls
**Lymph Nodes**

- 500–700 bean-shaped structures located along lymph vessels, act as filters or traps for foreign particles.
- Slight depression on side, hilus, where artery and vein enter and leave node; fibrous capsule extends into node, divides into nodules, separated by sinuses; nodules filled with dense masses of lymphatic tissue, packed tightly with lymphocytes and macrophages.
- Lymph moves into node through one or more AFFERENT vessels, circulates through node, is filtered and cleansed, leaves via EFFERENT vessel.
Lymph Node Groups

Lymph nodes concentrated in certain areas of body in groups or chains

- **Superficial**
  - Cervical: neck
  - Axillary: armpits
  - Supraclavicular: along collar bone
  - Inguinal: groin
  - Femoral: upper inner thigh

- **Deep**
  - Mediastinal: upper body behind sternum, between lungs
  - Mesenteric: lower body below rib cage
Functions of Lymphatic System

Three primary functions:

• Returning interstitial fluid to blood
• Absorption of fat and fat-soluble vitamins from digestive tract and transport of those substances to venous circulation
• Defending body against pathogens and toxins by filtering lymph, production of antibodies

Interstitial Fluid

• Extracellular/intracellular fluid: arterial blood moves from larger to smaller vessels to capillary bed, blood flow slows down allowing plasma component to cross walls of arteriole by osmosis and diffusion, and into tissues; interstitial fluid remains outside cells, bathes them, provides nourishment, O₂, hormones, removal of cellular debris and protein cells

Lymph Capillaries and Digestion

• Mucosal lining of small intestine covered with villi (fingerlike projections) containing blood capillaries and lymph capillaries, or lacteals
• Most nutrients are absorbed by blood capillaries, larger fat molecules and fat-soluble vitamins (A, D, E, and K) are absorbed by lacteals, flows through lymphatics, drains into thoracic duct, left subclavian vein, vena cava
Lymph (lymphatic fluid)

- ~90% of interstitial fluid crosses back into blood via venules; remaining 10% left behind becomes lymph; lymph enters lymphatic capillaries and moves into larger lymphatic vessels, into two lymphatic ducts (right lymphatic/thoracic), into right/left subclavian veins, into venous circulation
Diseases of Lymphatic Vessels and Lymph Nodes

- Limited number of conditions directly affect lymph vessels and lymph nodes, many conditions indirectly affect lymph system; common routes for spread of cancer cells

Infections
- **Epstein-Barr virus**: causes infectious mononucleosis, “kissing disease”; most develop immunity in childhood; also associated with particular forms of cancer, Hodgkin’s lymphoma, Burkitt's lymphoma, nasopharyngeal carcinoma and CNS lymphomas associated with HIV
- **Lymphogranuloma venereum**: sexually transmitted disease caused by Chlamydia trachomatis; infection of lymphatics and lymph nodes
- **Lymphangitis**: “blood poisoning”; inflammation of lymphatic vessels and channels: caused by bacterial infections, usually of skin; thin red lines may be observed running along the course of lymphatic vessels in affected area, accompanied by painful enlargement of nearby lymph nodes; cellulitis
Neoplasms

Malignant

• **Lymphoma**: group of cancers originating in lymphatic system; two major categories: Hodgkin’s lymphoma, non-Hodgkin’s lymphoma; begin by malignant transformation of lymphocytes in lymphatic system; generally start in lymph nodes or lymphatic tissue in stomach or intestines; may involve marrow and blood in some cases; metastasis to lungs, heart, central nervous system

Benign

• **Lymphadenopathy/lymphadenitis**
  – Inflammation of lymph node(s); Lymphadenopathy = “disease of the lymph nodes,” used interchangeably; localized or generalized; symptom of infection or malignant disease; autoimmune disease; must be evaluated to r/o malignancy

• **Lymphangioma**
  – Mostly in children; form in lymphatic system, involve skin and mucous membranes; commonly appear in head, neck, buttocks and trunk, usually contain clear lymph; may cause obstructions

*Benign does not necessarily mean not dangerous!*
Other Diseases of Lymphatic Circulation

Lymphedema

• Swelling of extremity due to blockage of lymph vessels: prevents drainage of interstitial fluid from tissues, and prevents immune cells from traveling where they are needed

• Primary: structural abnormality of lymph nodes and/or vessels affecting drainage

• Secondary: damage to lymphatic vessels from surgery or radiation; blockage from cancer or infection

Treatment: combination of manual compression lymphatic massage, compression garments or bandaging; lymphatic vessel grafting, lymphatic liposuction, laser
Injuries, Poisonings, Other External Causes

Injuries

- Lacerations of blood/lymph vessels: traumatic, complication of medical procedure; fractures-Gustilo open fracture classifications IIIc, major arterial injury; self-inflicted
- Contusions; bruises: blunt force trauma; hematoma
- Unspecified: complications of trauma and medical care (post-op)
- Crush injuries
- Poisonings: drugs, chemicals or other substances (therapeutic or non); toxic and adverse effects, overdosing/underdosing (new); identify substance and specific manifestations associated with poisoning

Signs, Symptoms, Abnormal Findings

- Edema: arterial/venous; lymphedema, fluid overload
- Discoloration of skin: arterial, venous insufficiency; infection
- Abnormal labs: clotting, WBC (infections), cytology/histology (malignancies), cultures, lipids
- Abnormal imaging: Doppler studies, ultrasound, CT/MRI
References/Resources

- Advanced Anatomy and Physiology for ICD-10-CM/PCS. Contexo Media. 2010

Internet Resources

- Lymph Node. [http://www.thelymphnodes.com](http://www.thelymphnodes.com)
There is a huge amount of information available on the internet, all just a keystroke away!
Great Website!

HCPro, good resource for all things HIM and more.


Marketplace has extensive list of free newsletters on many topics. ICD-10 trainer is excellent. Daily email presenting cases related to specific diagnosis and coding.
Thank You.

Contact information
Anna Marie Kish, RN, BSN, ARNP, NP-C
flamingo1951@gmail.com