Control of Blood Pressure
• **Short-term neural and hormonal controls**
  • Counteract fluctuations in blood pressure by altering peripheral resistance
• **Long-term renal regulation**
  • Counteracts fluctuations in blood pressure by altering blood volume

Short-Term Mechanisms: Neural Controls
• **Neural controls of peripheral resistance**
  • Maintain MAP by altering blood vessel diameter
  • Alter blood distribution in response to specific demands
• **Neural controls operate via reflex arcs that involve**
  • Baroreceptors
  • Vasomotor centers and vasomotor fibers
  • Vascular smooth muscle

The Vasomotor Center
• **A cluster of sympathetic neurons in the medulla that oversee changes in blood vessel diameter**
• **Part of the cardiovascular center, along with the cardiac centers**
• **Maintains vasomotor tone (moderate constriction of arterioles)**
• **Receives inputs from baroreceptors, chemoreceptors, and higher brain centers**

Short-Term Mechanisms: Baroreceptor-Initiated Reflexes
• **Baroreceptors are located in**
  • Carotid sinuses
  • Aortic arch
  • Walls of large arteries of the neck and thorax
• **Increased blood pressure stimulates baroreceptors to increase input to the vasomotor center**
  • Inhibits the vasomotor center, causing arteriole dilation and venodilation
  • Stimulates the cardioinhibitory center
• **Baroreceptors taking part in the carotid sinus reflex protect the blood supply to the brain**
• **Baroreceptors taking part in the aortic reflex help maintain adequate blood pressure in the systemic circuit**

Short-Term Mechanisms:  
Chemoreceptor-Initiated Reflexes  
• **Chemoreceptors are located in the**  
  • Carotid sinus  
  • Aortic arch  
  • Large arteries of the neck  
  • Chemoreceptors respond to rise in CO₂, drop in pH or O₂  
  • Increase blood pressure via the vasomotor center and the cardioacceleratory center  
• **Are more important in the regulation of respiratory rate (Chapter 22)**

Influence of Higher Brain Centers  
• **Reflexes that regulate BP are integrated in the medulla**  
• **Higher brain centers (cortex and hypothalamus) can modify BP via relays to medullary centers**

Short-Term Mechanisms: Hormonal Controls  
• **Adrenal medulla hormones norepinephrine (NE) and epinephrine cause generalized vasoconstriction and increase cardiac output**  
• **Angiotensin II, generated by kidney release of renin, causes vasoconstriction**  
• **Atrial natriuretic peptide causes blood volume and blood pressure to decline, causes generalized vasodilation**  
• **Antidiuretic hormone (ADH)(vasopressin) causes intense vasoconstriction in cases of extremely low BP**

Long-Term Mechanisms: Renal Regulation  
• **Baroreceptors quickly adapt to chronic high or low BP**  
• **Long-term mechanisms step in to control BP by altering blood volume**  
• **Kidneys act directly and indirectly to regulate arterial blood pressure**  
  1. Direct renal mechanism  
  2. Indirect renal (renin-angiotensin) mechanism  
Direct Renal Mechanism  
• **Alters blood volume independently of hormones**  
  • Increased BP or blood volume causes the kidneys to eliminate more urine, thus reducing BP  
  • Decreased BP or blood volume causes the kidneys to conserve water, and BP rises
Indirect Mechanism

- The renin-angiotensin mechanism
  - Arrow down \(\downarrow\) Arterial blood pressure \(\rightarrow\) release of renin
  - Renin \(\rightarrow\) production of angiotensin II
  - Angiotensin II is a potent vasoconstrictor
  - Angiotensin II \(\rightarrow\) aldosterone secretion
    - Aldosterone \(\rightarrow\) renal reabsorption of Na\(^+\) and \(\downarrow\) urine formation
  - Angiotensin II stimulates ADH release

Monitoring Circulatory Efficiency

- Vital signs: pulse and blood pressure, along with respiratory rate and body temperature
- Pulse: pressure wave caused by the expansion and recoil of arteries
- Radial pulse (taken at the wrist) routinely used

Measuring Blood Pressure

- Systemic arterial BP
  - Measured indirectly by the auscultatory method using a sphygmomanometer
  - Pressure is increased in the cuff until it exceeds systolic pressure in the brachial artery

Measuring Blood Pressure

- Pressure is released slowly and the examiner listens for sounds of Korotkoff with a stethoscope
- Sounds first occur as blood starts to spurt through the artery (systolic pressure, normally 110–140 mm Hg)
- Sounds disappear when the artery is no longer constricted and blood is flowing freely (diastolic pressure, normally 70–80 mm Hg)

Variations in Blood Pressure

- Blood pressure cycles over a 24-hour period
- BP peaks in the morning due to levels of hormones
- Age, sex, weight, race, mood, and posture may vary BP

Alterations in Blood Pressure

- Hypotension: low blood pressure
  - Systolic pressure below 100 mm Hg
  - Often associated with long life and lack of cardiovascular illness

Homeostatic Imbalance: Hypotension

- Orthostatic hypotension: temporary low BP and dizziness when suddenly rising from a sitting or reclining position
- Chronic hypotension: hint of poor nutrition and warning sign for Addison’s disease or hypothyroidism
• **Acute hypotension:** important sign of circulatory shock

Alterations in Blood Pressure

• **Hypertension:** high blood pressure
  • Sustained elevated arterial pressure of 140/90 or higher
    • May be transient adaptations during fever, physical exertion, and emotional upset
  • Often persistent in obese people

Homeostatic Imbalance: Hypertension

• *Prolonged hypertension is a major cause of heart failure, vascular disease, renal failure, and stroke*

• **Primary or essential hypertension**
  • 90% of hypertensive conditions
  • Due to several risk factors including heredity, diet, obesity, age, stress, diabetes mellitus, and smoking

Homeostatic Imbalance: Hypertension

• **Secondary hypertension is less common**
  • Due to identifiable disorders, including kidney disease, arteriosclerosis, and endocrine disorders such as hyperthyroidism and Cushing’s syndrome

Blood Flow Through Body Tissues

• **Blood flow (tissue perfusion) is involved in**
  • Delivery of \( \text{O}_2 \) and nutrients to, and removal of wastes from, tissue cells
  • Gas exchange (lungs)
  • Absorption of nutrients (digestive tract)
  • Urine formation (kidneys)

• **Rate of flow is precisely the right amount to provide for proper function**

Velocity of Blood Flow

• **Changes as it travels through the systemic circulation**

• **Is inversely related to the total cross-sectional area**

• **Is fastest in the aorta, slowest in the capillaries, increases again in veins**

• **Slow capillary flow allows adequate time for exchange between blood and tissues**

Autoregulation

• **Automatic adjustment of blood flow to each tissue in proportion to its requirements at any given point in time**

• **Is controlled intrinsically by modifying the diameter of local arterioles feeding the capillaries**

• **Is independent of MAP, which is controlled as needed to maintain constant pressure**

Autoregulation

• **Two types of autoregulation**
  1. Metabolic
2. Myogenic Metabolic Controls

- Vasodilation of arterioles and relaxation of precapillary sphincters occur in response to
  - Declining tissue $O_2$
  - Substances from metabolically active tissues ($H^+$, $K^+$, adenosine, and prostaglandins) and inflammatory chemicals

Myogenic Controls

- Myogenic responses of vascular smooth muscle keep tissue perfusion constant despite most fluctuations in systemic pressure
- Passive stretch (increased intravascular pressure) promotes increased tone and vasoconstriction
- Reduced stretch promotes vasodilation and increases blood flow to the tissue

Long-Term Autoregulation

- Angiogenesis
  - Occurs when short-term autoregulation cannot meet tissue nutrient requirements
  - The number of vessels to a region increases and existing vessels enlarge
  - Common in the heart when a coronary vessel is occluded, or throughout the body in people in high-altitude areas

Read: Blood Flow in Special Areas p 715-717

Blood Flow Through Capillaries

- Vasomotion
  - Slow and intermittent flow
  - Reflects the on/off opening and closing of precapillary sphincters

Capillary Exchange of Respiratory Gases and Nutrients

- Diffusion of
  - $O_2$ and nutrients from the blood to tissues
  - $CO_2$ and metabolic wastes from tissues to the blood
- Lipid-soluble molecules diffuse directly through endothelial membranes
- Water-soluble solutes pass through clefts and fenestrations
- Larger molecules, such as proteins, are actively transported in pinocytotic vesicles or caveolae
Fluid Movements: Bulk Flow
- Extremely important in determining relative fluid volumes in the blood and interstitial space
- Direction and amount of fluid flow depends on two opposing forces: hydrostatic and colloid osmotic pressures

Hydrostatic Pressures
- Capillary hydrostatic pressure ($HP_c$) (capillary blood pressure)
  - Tends to force fluids through the capillary walls
  - Is greater at the arterial end (35 mm Hg) of a bed than at the venule end (17 mm Hg)
- Interstitial fluid hydrostatic pressure ($HP_{if}$)
  - Usually assumed to be zero because of lymphatic vessels

Colloid Osmotic Pressures
- Capillary colloid osmotic pressure (oncotic pressure) ($OP_c$)
  - Created by nondiffusible plasma proteins, which draw water toward themselves
  - ~26 mm Hg
- Interstitial fluid osmotic pressure ($OP_{if}$)
  - Low (~1 mm Hg) due to low protein content

Net Filtration Pressure (NFP)
- NFP—comprises all the forces acting on a capillary bed
- $NFP = (HP_c - HP_{if}) - (OP_c - OP_{if})$
- At the arterial end of a bed, hydrostatic forces dominate
- At the venous end, osmotic forces dominate
- Excess fluid is returned to the blood via the lymphatic system

Circulatory Shock
- Any condition in which
  - Blood vessels are inadequately filled
  - Blood cannot circulate normally
- Results in inadequate blood flow to meet tissue needs

Circulatory Shock
- Hypovolemic shock: results from large-scale blood loss
- Vascular shock: results from extreme vasodilation and decreased peripheral resistance
- Cardiogenic shock results when an inefficient heart cannot sustain adequate circulation

END OF OUTLINE

References