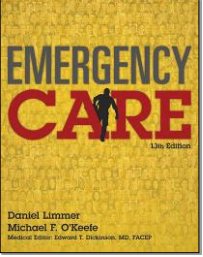


Emergency Care

THIRTEENTH EDITION



CHAPTER 7

Ventilation, Perfusion,
and Shock:
Understanding
Pathophysiology

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The Cell

- Cell membrane protects and selectively allows water and other substances in and out of the cell
- Mitochondria convert glucose and other nutrients into adenosine triphosphate (ATP).
 - Fuel for cell functions
 - Without ATP, many of the cell's specialized structures cannot function.

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The Cell

- Body's cells require:
 - Oxygen
 - Brought by respiratory and circulatory systems
 - Nutrients
 - Food broken down by digestive system into glucose
 - Brought by circulatory system
 - Removal of wastes
 - Removed by circulatory system

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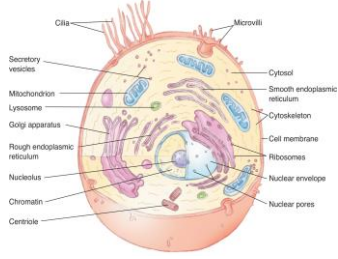
Water and the Cell

- Cells need the correct balance of water inside and outside.
 - Too little water
 - Cell dehydrated and dies
 - Too much water
 - Basic cellular function interrupted
- Water also affects levels of electrolytes.
 - Impacts electrical functions

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Glucose and the Cell

- Building block for energy
- Supply of insulin must match the body's glucose requirement.



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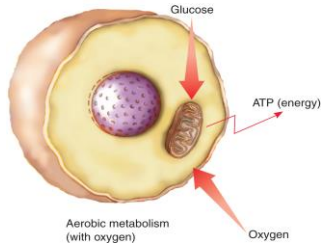
Oxygen and the Cell

- Aerobic metabolism
 - Cellular functions using oxygen
- Anaerobic metabolism
 - Cellular functions not using oxygen
 - Creates much less energy and much more waste
 - Body becomes acidic, impairing many body functions.

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Aerobic Metabolism

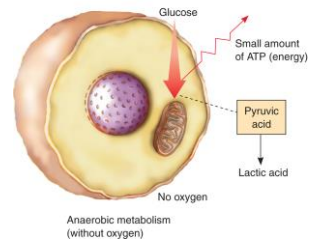
(A) Aerobic metabolism



Glucose broken down in the presence of oxygen produces a large amount of energy (ATP).

Anaerobic Metabolism

(B) Anaerobic metabolism



Glucose broken down without the presence of oxygen produces acidic by-products and only a small amount of energy (ATP).

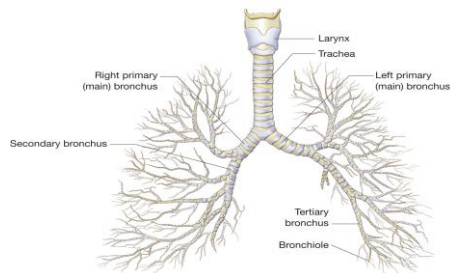
The Vulnerability of Cells, Organs, and Organ Systems

- Many diseases alter the permeability of membrane. **What diseases?**
- Ineffective cell membrane can allow substances into the cell that should not be there.
- These substances can interfere with the regulation of water.

The Cardiopulmonary System

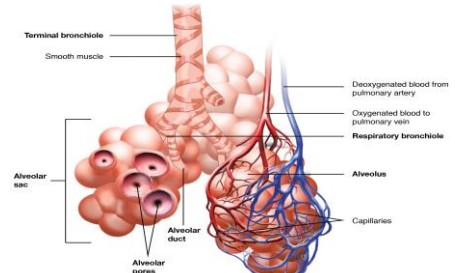
- Respiratory and cardiovascular systems work together.
 - Bring oxygen into body
 - Distribute to cells
 - Remove waste products
- Any breakdown can result in system failure.

Airway Structure



- Bronchial Tree – Smaller Bronchi – Smallest Bronchioles

Lower Airway



- (A) Each bronchiole terminates in a tiny air pocket called an alveolar sac. (B) The alveoli are encased by networks of capillaries; oxygen and carbon dioxide are exchanged between the air in the alveoli and the blood in the capillaries.

The Airway

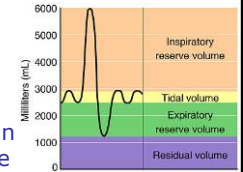
- Must have an open (patent) airway for system to function
- Upper airway obstructions are common.
 - Caused by foreign bodies, infection, or trauma



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The Lungs

- Tidal volume
 - Volume of air moving in and out during each breath cycle
- Tidal Volume × Respiratory Rate = Minute Volume
 - Amount of air moved in and out of lungs in one minute



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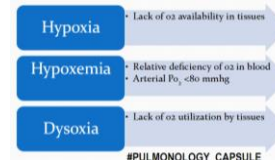
The Lungs

- Any change in tidal volume or respiratory rate reduces minute volume.
- Respiratory dysfunction occurs any time something interferes with minute volume.

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Respiratory Compromise

- Inability to move gas effectively
 - Can lead to:
 - Hypoxia: decreased level of oxygen
 - Hypercarbia: elevated carbon dioxide



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Respiratory Dysfunction

- Factors that impair ventilation:
 - Blocked airway
 - Impairment of the muscles of breathing
 - Lower airway compromise
- Factors that impair respiration:
 - Change in atmosphere
 - High altitudes
 - Impaired movement of the gas across cell membranes

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Respiratory Compensation

- Body attempts to compensate for gas exchange deficits.
- Chemoreceptors detect changing oxygen and carbon dioxide levels.
- Brain stimulates respiratory system to increase rate and/or tidal volume.

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Acid-Base Regulation

- Respiratory Acidosis = $\text{pH} < 7.35$
 - Body fails to eliminate CO_2
- Respiratory Alkalosis = $\text{pH} > 7.45$
 - Body releases too much CO_2
- Metabolic Acidosis and Alkalosis

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The Blood

- Four parts
 - Plasma (liquid)
 - Red blood cells
 - Contain oxygen-carrying hemoglobin
 - White blood cells
 - Fight infection
 - Platelets
 - Form clots

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Blood Dysfunction

- Without enough blood, oxygen and carbon dioxide cannot be properly moved around.
 - Bleeding
 - Dehydration
 - Anemia
 - Liver failure

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The Blood

- Plasma oncotic pressure
 - Proteins in plasma attract water away from are around cells and pulls it into bloodstream.
- Hydrostatic pressure
 - Water pushed back out of blood vessels towards cells.
- Problems with these proteins can cause an imbalance.

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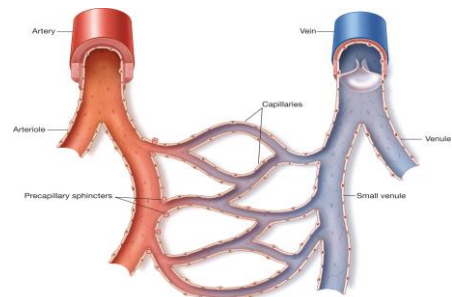
The Blood Vessels

- Take oxygenated blood from lungs via heart to capillaries
- Where gas exchange takes place
 - Between cells and capillaries
- Return blood to lungs via heart for gas exchange
 - Between capillaries and alveoli

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Network of Blood Vessels



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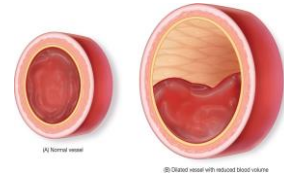
The Blood Vessels

- Need adequate pressure to make cycle work
- Pressure controlled by changing diameter of blood vessels
- Stretch receptors monitor pressure.
- Pressure can be increased or decreased depending on situation.

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Blood Vessel Dysfunction

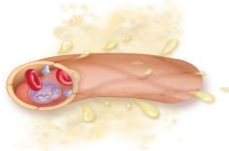
- Loss of Tone
 - Vessels lose ability to constrict and dilate.
 - Pressure drops
 - Causes
 - Trauma
 - Infection
 - Allergic reaction



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Blood Vessel Dysfunction

- Excessive permeability
 - Capillaries leak fluid out their walls.
 - Caused by severe infection (sepsis), high altitude, and certain diseases



Permeable capillaries

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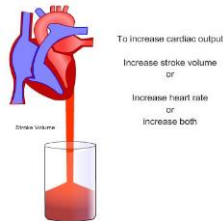
Blood Vessel Dysfunction

- Hypertension
 - Systemic vascular resistance (SVR)
 - Pressure inside vessels
 - Various conditions lead to abnormal constriction of vessels, leading to dangerously high pressures (hypertension).
 - Major risk factor in stroke and heart disease

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The Heart

- Pump with average stroke volume (output) of about 70 mL blood per contraction
- Average adult has about 5 L of blood
 - Infants 300 mL, children 2 to 3 L
- Central and peripheral pulses
- $BP = CO \times SVR$



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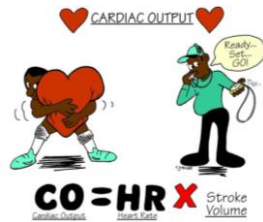
The Heart

- Stroke volume is based on:
 - Preload
 - Amount of blood returning to heart
 - Contractility
 - How hard heart squeezes
 - Afterload
 - Pressure the heart has to pump against to force blood out into the system

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Cardiac Output (CO)

- Stroke volume \times beats per minute = CO
- Slowing heart rate or decreasing stroke volume reduces cardiac output.
- Very fast heart rates reduce cardiac output.
 - Inadequate time for heart to refill between contractions



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Heart Dysfunction

- Mechanical problems
 - Physical trauma
 - Squeezing forces
 - Cell death (heart attack)
- Electrical problems
 - Damage to heart's ability to regulate rate

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The Cardiopulmonary System: Putting It All Together

- Entire cardiopulmonary system must work together to maintain life.
- Must be a balance between ventilation (V) and perfusion (Q) for system to work properly
 - V/Q match
- Any breakdown in system impacts ratio causing possible life-threatening situation.

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Shock

- Perfusion
 - Regular delivery of oxygen and nutrients to cells and removal of waste products
- Hypoperfusion
 - Breakdown in system
 - Can result in death of patient

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TYPES OF SHOCK - Four Categories

Type of Shock	Insult	Physiologic Effect	Compensation
Cardiogenic	Heart fails to pump blood out *MI, arrhythmia, aortic stenosis, mitral regurg.	↓ CO	BaroRc ↑ SVR
Obstructive	Heart pumps well, but the outflow is obstructed *Extracardiac obstructive causes such as PE, tension pneumothorax, tamponade	↓ CO	BaroRc ↑ SVR
Hypovolemic	Heart pumps well, but not enough blood volume to pump *Hemorrhage *Fluid Loss (Vomiting, Diarrhea, Burns)	↓ CO	BaroRc ↑ SVR
Distributive	Heart pumps well, but there is peripheral vasodilation *Septic, anaphylactic, and neurogenic shock *Pancreatitis, burns, multi-trauma via activation of the inflammatory response	↓ SVR	↑ CO

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Recognizing Compensation

- When problems arise, body attempts to compensate.
- Signs of compensated shock
 - Slight mental status changes
 - Increased heart rate
 - Increased respiratory rate
 - Delayed capillary refill time
 - Pale, cool, clammy skin
 - Sweating
 - Nausea and vomiting

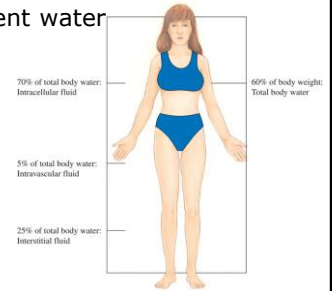
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Pathophysiology of Other Systems

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Fluid Balance

- Body is 60 percent water
 - Intracellular (70 percent)
 - Intravascular (5 percent)
 - Interstitial (25 percent)



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Fluid Balance

- Brain and kidneys regulate thirst and elimination of excess fluid
- Blood plasma proteins pull fluid into the bloodstream
- Cell membrane and capillary permeability regulate flow in and out

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Disruptions of Fluid Balance

- Fluid loss (dehydration)
 - Decrease in total water volume
- Poor fluid distribution
 - Water not getting to where it needs to go
 - Edema
 - Too much water in some parts of the body

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The Nervous System

- Brain and spinal cord are well-protected by skull and spine.
 - Covered by several protective layers (meninges) and a layer of shock-absorbing fluid (cerebrospinal fluid)
 - Still subject to damage from trauma or disease

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Nervous System Dysfunction

- Trauma
 - Motor-vehicle crashes
 - Falls
 - Diving accidents
- Medical Causes
 - Strokes
 - Infection (meningitis, encephalitis)
 - Disease (Lou Gehrig disease, MS)
 - Low blood sugar (hypoglycemia)

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The Endocrine System

- Glands secrete hormones.
- Hormones send chemical messages to the body to control body functions.

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The Endocrine System

- Major organs of system
 - Brain
 - Kidneys
 - Pancreas
 - Pituitary gland
 - Thyroid gland
 - Adrenal glands

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Endocrine System Dysfunction

- Organ or gland problems
- Present at birth or result of illness
- Too many hormones
 - Graves' disease (too much thyroid hormone)
 - Problems with heart rate and temperature regulation
- Not enough hormones
 - Diabetes

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The Digestive System

- Allows food, water, and other nutrients to enter the body
- Major organs of system
 - Esophagus
 - Stomach
 - Intestines

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Digestive Dysfunction

- Impacts hydration levels and nutrient transfer
- Gastrointestinal bleeding
 - Can be slow
 - Chronic bleeding
 - Can be massive, with rectal bleeding and/or vomiting blood

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Digestive Dysfunction

- Vomiting and diarrhea
 - Most common disorders
 - Variety of causes
 - May result in malnutrition and dehydration



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The Immune System

- Responsible for fighting infection
- Responds to specific body invaders by identifying them, marking them, and destroying them

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Hypersensitivity (Allergic Reaction)

- Results in a rapid drop in blood pressure
- Can be life threatening
- Result of exaggerated immune response
- Chemicals affect more than just invader
- Produces edema



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Remember

- Cellular metabolism requires a constant supply of oxygen and glucose. Absence of either component disrupts normal metabolism.
- Cardiopulmonary system combines the functions of respiratory and cardiovascular systems to provide oxygen at the cellular level.

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Critical Thinking

- You have a patient with a massive infection (sepsis). This has impaired the patient's ability to regulate the size of the blood vessels.
- How might this affect the patient's ability to compensate for any additional illnesses? What steps should you take to help this patient compensate?

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