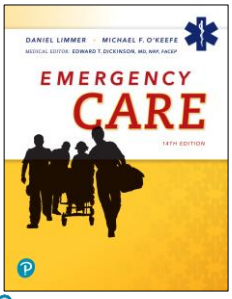
Emergency Care

Fourteenth Edition



Chapter 7

Principles of Pathophysiology

Topics

Introduction to Pathophysiology

- Study of how disease processes affect function of body
- Understanding helps you recognize changes patient is going through due to illness or injury
- Understanding helps you recognize the needs of the body in its most vulnerable state

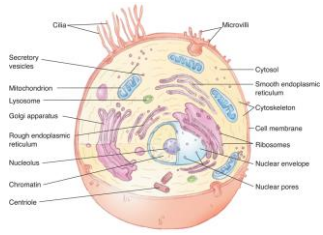
The Cell

Back to Topics

The Cell (1 of 2)

- 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.

The Cell (2 of 2)



For long description, see slide 80: Appendix 1

The cell.

Water and the Cell

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

Think About It

- Draw an analogy between cell metabolism and how a refinery turns crude oil into gasoline for use in automobiles.

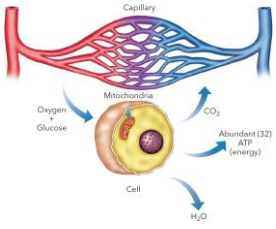
Glucose and the Cell

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

Oxygen and the Cell (1 of 3)

- 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.

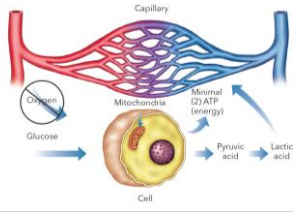
Oxygen and the Cell (2 of 3)



For long description, see slide 81: Appendix 2

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

Oxygen and the Cell (3 of 3)



For long description, see slide 82: Appendix 3

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 the membrane.
- Ineffective cell membrane can allow substances into the cell that should not be there.
- These substances can interfere with the regulation of water.

The Regulation of Homeostasis

Back to Topics

Homeostasis

- Regulated in the brain
- Maintained through nervous system feedback and messaging
- Key structures are the hypothalamus and medulla oblongata

The Fight or Flight Response (1 of 2)

- Parasympathetic nervous system
  - "Feed or breed" functions
  - Neurotransmitters regulate digestion and reproduction
  - Reduces heart rate and blood pressure

The Fight or Flight Response (2 of 2)

- Sympathetic nervous system
  - "Fight or flight" situations
  - Epinephrine and norepinephrine
  - Enhances body's ability to protect itself
  - Increases heart rate and blood pressure

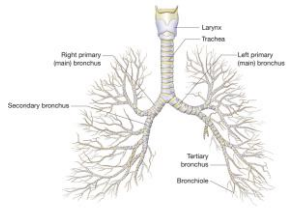
The Cardiopulmonary System

Back to Topics

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.

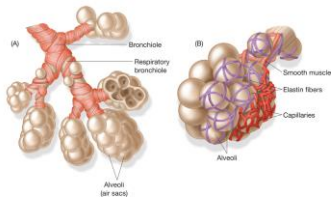
The Airway (1 of 3)



For long description, see slide 83: Appendix 4

The bronchial tree. Each mainstem bronchus enters a lung, then branches into smaller and smaller bronchi, ending in the smallest bronchioles.

The Airway (2 of 3)



For long description, see slide 84: Appendix 5

(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 (3 of 3)

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

The Lungs (1 of 2)

- Part of lower airway
- 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

The Lungs (2 of 2)

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

Respiratory Dysfunction (1 of 3)

- Disruption of respiratory control
  - Respirations controlled in brain by the medulla oblongata
  - Any event impacting function of the medulla oblongata can affect minute volume
    - Infection, drugs, toxins, trauma

Respiratory Dysfunction (2 of 3)

- Disruption of pressure
  - If a hole is created in the chest wall (thorax), pressures needed for breathing are disrupted.
  - Air or blood accumulating in chest (pleural space) also compromises respiration.

Respiratory Dysfunction (3 of 3)

- Disruption of lung tissue
  - Trauma or medical problems can compromise the ability of alveoli to exchange gases.
  - Less oxygen gets in; less carbon dioxide gets out.
  - Can result in low oxygen levels (hypoxia) and high carbon dioxide levels (hypercapnia)

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.

The Blood (1 of 2)

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

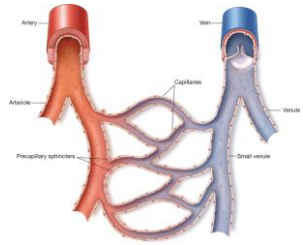
The Blood (2 of 2)

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

Blood Dysfunction

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

The Blood Vessels (1 of 3)



For long description, see slide 85: Appendix 6

The network of arteries, veins, and capillaries.

The Blood Vessels (2 of 3)

- 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

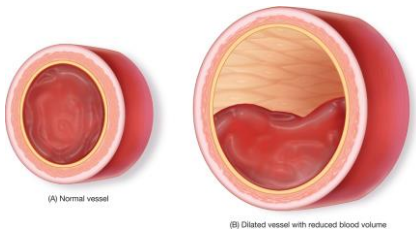
The Blood Vessels (3 of 3)

- 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.

Blood Vessel Dysfunction (1 of 6)

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

Blood Vessel Dysfunction (2 of 6)



For long description, see slide 86: Appendix 7

Dilated blood vessel.

Blood Vessel Dysfunction (3 of 6)

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

Blood Vessel Dysfunction (4 of 6)

Permeable capillaries

Increased permeability allows too much fluid to escape through capillary walls.

Blood Vessel Dysfunction (5 of 6)

- Hypertension
  - Systemic vascular resistance (SVR)
    - Pressure inside vessels
  - Various conditions lead to abnormal constriction of vessels, leading to an unhealthy, high pressure level
  - Major risk factor in stroke and heart disease

Blood Vessel Dysfunction (6 of 6)

- Loss of regulation
  - Chemical messengers tell blood vessels when to dilate and constrict
  - If signals are blocked, problems arise
  - Lack of sympathetic response can cause shock

The Heart (1 of 2)

- Pump with average stroke volume (output) of about 70 mL blood per contraction

The Heart (2 of 2)

- 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

Cardiac Output

- Stroke volume × beats per minute = cardiac output
- 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

Pediatric Compensation

- Infants and young children
  - Rely on heart rate to compensate for poor perfusion
  - Lack contractile muscles
  - Cannot regulate the force of contraction
  - Fast heart rate indicates compensation

Heart Dysfunction

- Mechanical problems
  - Physical trauma
  - Squeezing forces
  - Cell death (heart attack)
- Electrical problems
  - Damage to heart's electrical system
  - Cause unorganized rhythms and rate problems

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
- V/Q ratio can be disrupted by any challenge to the cardiopulmonary system

Shock

Back to Topics

Shock

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

Four Categories of Shock

- Hypovolemic – low blood volume
- Distributive – low blood vessel tone
- Cardiogenic – heart fails to pump
- Obstructive – blood cannot flow

Recognizing Compensation (1 of 2)

- 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

Recognizing Compensation (2 of 2)

- Decompensated shock occurs when compensatory measures fail
  - Characterized by decreased blood pressure and altered mental status
- Irreversible shock occurs when inadequately perfused organ systems begin to die
  - Patient death commonly follows

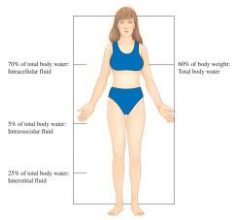
Pathophysiology of Other Systems

Back to Topics

Fluid Balance (1 of 3)

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

Fluid Balance (2 of 3)



For long description, see slide 87: Appendix 8

Water comprises approximately 60 percent of body weight. The water is distributed into three spaces: intracellular, intravascular, and interstitial.

Fluid Balance (3 of 3)

- 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

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
    - Swelling associated with the movement of water

The Nervous System

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

Nervous System Dysfunction (1 of 2)

- Trauma
  - Motor-vehicle crashes
  - Falls
  - Diving accidents

Nervous System Dysfunction (2 of 2)

- Medical dysfunction
  - Strokes
  - Infection (meningitis, encephalitis)
  - Disease (Lou Gehrig disease, MS)
  - Low blood sugar (hypoglycemia)

The Endocrine System (1 of 2)

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

The Endocrine System (2 of 2)

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

Endocrine System Dysfunction (1 of 2)

- 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
  - Type 1 diabetes

Endocrine System Dysfunction (2 of 2)

- Adrenal insufficiency
  - Affect steroid hormones
    - Cortisol
    - Aldosterone
  - Medications that suppress the immune system suppress adrenal function
  - Can result if patients stop taking prescribed steroids

The Digestive System

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

Digestive Dysfunction (1 of 2)

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

Digestive Dysfunction (2 of 2)

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

The Immune System

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

Hypersensitivity (Allergic Reaction) (1 of 2)

- Allergic reaction to certain food, drugs, other substances
- Result of exaggerated immune response
- Chemicals affect more than just invader.

Hypersensitivity (Allergic Reaction) (2 of 2)

- Produces edema
- Results in a rapid drop in blood pressure
- Can be life threatening

Chapter Review

Chapter Review (1 of 2)

- Pathophysiology allows us to understand how negative forces impact the normal function of the body.
- Pathophysiology helps us understand how common disorders cause changes in the body.

Chapter Review (2 of 2)

- Understanding how the body compensates for insults sheds light on the signs and symptoms we may see during assessment.
- Understanding what compensation looks like helps us rapidly identify potentially life-threatening problems.

Remember (1 of 2)

- 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.

Remember (2 of 2)

- Shock occurs when the cardiopulmonary system fails and cells become hypoperfused.
- The body is composed primarily of water, and this fluid is distributed throughout the body systems.

Questions to Consider (1 of 2)

- When evaluating a patient with a cardiac problem, consider the impact on the respiratory system. When evaluating a patient with a respiratory problem, consider the impact on the cardiovascular system. What impacts do problems in these systems have on each other?

Questions to Consider (2 of 2)

- Shock must be recognized immediately. What is the pathophysiology of shock?

Critical Thinking (1 of 2)

- You are treating a patient who was recently released from the intensive care unit with a massive infection (sepsis). This has impaired the patient's ability to regulate the size of the blood vessels.

Critical Thinking (2 of 2)

- 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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Appendix 1

Illustration of a cell with its many parts labeled. The cell is surrounded by the cell membrane with cilia and microvilli branching off at the top. The cell is filled with cytosol, which contains organelles such as the secretory vesicles, mitochondria, lysosomes, Golgi apparatus, rough endoplasmic reticulum, smooth endoplasmic reticulum, cytoskeleton, and ribosomes. Toward the center of the cell is the nucleus, which is surrounded by the nuclear envelope with nuclear pores and contains chromatin and the nucleolus.

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Appendix 2

A cell with a nucleus in the center and a large mitochondrion in the cytoplasm is present. A capillary is present above the cell. Glucose and oxygen enter the cell toward the mitochondrion from the capillary, which produces energy in the form of ATP, abundant 32, during aerobic metabolism. The carbon dioxide produced is given to the capillary. Water is also produced.

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Appendix 3

A cell with a nucleus in the center and a large mitochondrion in the cytoplasm is present. A capillary is present above the cell. Glucose enters the cell toward the mitochondrion, but no oxygen is given from the capillary. A small amount of energy in the form of ATP, minimal 2, is produced during anaerobic metabolism, which is given to the capillary. The waste product pyruvic acid from the metabolism leads to the creation of lactic acid, which is again given to the capillary.

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Appendix 4

Diagram of the bronchial tree of the lungs. Image shows an illustration of the airway and bronchial tubes of the lungs. At the top of the tree is the larynx in the throat, which leads into the trachea. The trachea leads down into the lungs and branches into two large primary bronchi. Each bronchus branches into smaller secondary bronchi, which branch into even smaller tertiary bronchi and end in bronchioles.

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Appendix 5

The first image shows an illustration of a bronchiole, which branches into several respiratory bronchioles that each end in alveoli. The alveoli, or air sacs, resemble bubbles at the end of each bronchiole. The second image shows an illustration of a bunch of alveoli, which are air sacs, covered by capillaries. Elastin fibers and smooth muscle surround the air sacs.

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Appendix 6

Illustration shows an artery on the left connected to a network of capillaries in the center, which connect to a vein on the right. Other components are labeled including the arteriole, which is connected to the artery, the precapillary sphincters, which are located where the artery and capillaries meet, and the venule and small venule, which are connected to the vein.

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Appendix 7

The first diagram shows a cross sectional view of a small blood vessel that is filled with blood. The second diagram shows a cross sectional view of an enlarged blood vessel that is filled halfway with blood.

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Appendix 8

An illustration of a woman is used to explain that 60% of body weight is comprised of water, 70% of total body water is intracellular fluid, 5% of total body water is intravascular fluid, and 25% of total body water is interstitial fluid.

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