Chapter 6 - Principles of Pathophysiology

OBJECTIVES

6.1 Define key terms introduced in this chapter. Slides 11, 15, 17, 26, 27, 31, 33, 37, 40–42, 44, 45, 51, 58

6.2 Describe the basic roles and structures of body cells. Slides 13–20

6.3 Describe the roles of water, glucose, and oxygen in the cell. Slides 14–18

continued

OBJECTIVES

6.4 Describe conditions that can threaten cardiopulmonary function. Slides 26–30, 33–34, 37, 42–44

6.5 Explain how impaired cardiopulmonary function affects the body. Slides 26–30, 33–34, 37, 42–44

6.6 Discuss the mechanisms the body uses to compensate for impaired cardiopulmonary function. Slides 31, 37, 42

continued
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OBJECTIVES

6.7 Explain the pathophysiology of shock. Slide 45

6.8 Identify signs and symptoms that indicate the body is attempting to compensate for impaired cardiopulmonary function. Slide 46

6.9 Describe ways in which the body’s fluid balance can become disrupted. Slide 50

continued

OBJECTIVES

6.10 Recognize indications that the body’s fluid balance has been disrupted. Slide 51

6.11 Describe ways in which the nervous system may be impaired. Slide 52

6.12 Recognize indications that the nervous system may be impaired. Slide 53

continued

OBJECTIVES

6.13 Describe the effects on the body of endocrine dysfunction, digestive system dysfunction, and immune system dysfunction. Slides 55, 57–58

continued
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MULTIMEDIA

• Slide 20  Cell Structure Video
• Slide 47  Transport of Carbon Dioxide Animation

CORE CONCEPTS

• The cell, cellular metabolism, and results of the alteration of cellular metabolism
• The respiratory system and the importance of oxygenation and ventilation
• The cardiovascular system and the movement of blood

CORE CONCEPTS

• The principles of perfusion, hypoperfusion, and shock
• Disrupted physiology of major body systems
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

The Cell
Structure of the Cell

ATP

- Mitochondria convert glucose and other nutrients into adenosine triphosphate (ATP)
- ATP—fuel for cell functions
- Without ATP many of the cell’s specialized structures cannot function

Water and the Cell

- Cells need the correct balance of water inside and outside
  - Too little water: cell dehydrated and dies
  - Too much water: cell systems don’t work properly
- 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.

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
Cell Membrane

- Many diseases alter the permeability of membrane
- Negatively impacts membrane’s ability to transfer fluids, electrolytes, and other substances in and out
- Also allows toxins to enter cell

Cell Structure Video

Click here to view a video on the subject of cell structure.

The Cardiopulmonary System
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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

continued

Airway

continued
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Airway

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

The Lungs

- 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

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

Disruption of Pressure

- If wall of thorax is compromised (punctures, rib fractures), ability to inhale and exhale is impacted and minute volume is reduced
- Air or blood accumulating in chest (pleural space) also compromises respiration

Disruption of Lung Tissue

- Trauma or medical problems can compromise the ability of alveoli to exchange gases
- Less O₂ gets in, less CO₂ gets out
- Can result in low oxygen levels (hypoxia) and high carbon dioxide levels (hypercapnia)
Respiratory Compensation

- Body attempts to compensate for changes
- Chemoreceptors detect changing \( O_2 \) and \( CO_2 \) levels
- Brain stimulates respiratory system to increase rate and/or tidal volume

The Blood

- Four parts
  - Plasma (liquid)
  - Red blood cells (contain oxygen-carrying hemoglobin)
  - White blood cells (fight infection)
  - Platelets (form clots)

The Blood

- Plasma oncotic pressure—proteins in plasma attract water away from cells and into bloodstream
- Hydrostatic pressure—water pushed back out of bloodstream
- Problems with these proteins can cause an imbalance
Blood Dysfunction

- Less blood (hypovolemia), less gas exchange
- Fewer red blood cells (anemia), less gas exchange
- Fewer water-retaining proteins, less volume

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)
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

Blood Vessel Dysfunction

- Loss of tone
  - Vessels lose ability to constrict and dilate
  - Pressure drops
  - Causes: trauma, infection, allergic reaction

Blood Vessel Dysfunction

- Permeability
  - Capillaries leak fluid out their walls
  - Caused by severe infection (sepsis) and certain diseases

continued
### Blood Vessel Dysfunction

- 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

### The Heart

- Pump with stroke volume (output) of about 60 ml blood per contraction
- Stroke volume is based on:
  - Preload—amount of blood returning to heart
  - Contractility—how hard heart squeezes
  - Afterload—pressure in vessels (SVR)

### Cardiac Output

- Stroke volume $\times$ beats per minute = cardiac output
- Slowing heart rate or decreasing stroke volume reduces cardiac output
- Rapid heart rates reduce cardiac output
  - Inadequate time for heart to refill between contractions
Heart Dysfunction

• Mechanical problems
  – Physical trauma
  – Squeezing forces
  – Cell death (heart attack)
• Electrical problems
  – Damage to heart’s ability to regulate rate

V/Q Match

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

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
Recognizing Compensation

- When problems arise, body attempts to compensate
- Signs of compensation:
  - Increased heart rate
  - Increased respiratory rate
  - Dilated pupils
  - Pale, cool, clammy skin

Transport of Carbon Dioxide Animation

Click here to view an animation on the subject of the transport of carbon dioxide.

Pathophysiology of Other Systems
**Fluid Balance**

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

**Fluid Regulation**

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

**Fluid Disruption**

- Fluid loss (dehydration)
  - Decrease in total water volume
- Fluid distribution
  - Water not getting to where it’s needed
- Edema
  - Too much water in some parts of the body
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

Nervous System Dysfunction

- Trauma causes
  - Penetrating trauma to head
  - Damage to spine
  - Swelling tissue has no room
- Medical causes
  - Strokes
  - Infection (meningitis, encephalitis)
  - Disease (Lou Gehrig's disease, MS)
  - Low blood sugar (hypoglycemia)

Endocrine System

- Glands secrete hormones
- Hormones send chemical messages to the body to control body functions
- Major organs of system:
  - Brain
  - Kidney
  - Pancreas
  - Pituitary
  - Thyroid, adrenal glands
Endocrine Dysfunction

- Organ or gland problems
- Present at birth or result of illness
- Too many hormones
  - Hyperthyroidism (too much thyroid hormone)
  - Problems with heart rate and temperature regulation
- Too few hormones
  - Diabetes

Digestive System Dysfunction

- Impacts hydration levels and nutrient transfer
- Gastrointestinal (GI) bleeding
  - Can be slow; chronic bleeding
  - Can be massive, with rectal bleeding and/or vomiting blood

continued

Digestive System Dysfunction

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

- Hypersensitivity
  - Allergic reaction to certain food, drugs, other substances
  - Result of exaggerated immune response
  - Chemicals affect more than just invader
- Edema
- Drop in blood pressure
- Can be life-threatening

Chapter Review

- 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.

continued
Chapter Review

• 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

• 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.

continued

Remember

• 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.

continued
Questions to Consider

• 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?

continued

Questions to Consider

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

continued

Critical Thinking

• 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.

continued
Critical Thinking

• 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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