

CHAPTER 5

Introduction to Pathophysiology

EDUCATION STANDARDS:

COMPETENCIES:

CHAPTER OVERVIEW:

- Pathophysiology

- Uses simple knowledge of shock and respiratory compromise to respond to life threats.

Chapter 4 presented basic anatomy (structure) and physiology (function) of the human body. This chapter provides a very basic description of how the body responds when things do not function properly. A basic understanding of anatomy and physiology is the baseline for how the body *should* behave when all things are functioning properly. Understanding pathophysiology helps you recognize when things are not working so well. Being able to recognize abnormal signs and having even a basic understanding of what these signs mean, will help you provide the best possible care for your patient.

While it is possible to dedicate an entire lifetime to the study of pathophysiology, this chapter can provide only a very brief overview of some of the major concepts. Anatomy, physiology, and pathophysiology all provide extensive opportunities to continue your quest for knowledge even after your Emergency Medical Responder course ends. There are many additional, informative resources on this topic, and learning more will only make you a better provider.

Upon successful completion of this chapter, the student should be able to:

COGNITIVE

1. Define key terms introduced in this chapter
 - a. aerobic metabolism (p. 88)
 - b. anaerobic metabolism (p. 88)
 - c. cardiac output (CO) (p. 93)
 - d. cell membrane (p. 88)
 - e. cell nucleus (p. 88)
 - f. dead air space (p. 91)
 - g. dehydration (p. 89)
 - h. DNA (p. 88)
 - i. edema (p. 89)
 - j. electrolytes (p. 88)
 - k. metabolism (p. 88)
 - l. patent (p. 90)
 - m. pathophysiology (p. 88)
 - n. perfusion (p. 94)
 - o. stroke volume (SV) (p. 93)
 - p. tidal volume (p. 90)
2. Explain the importance of understanding basic pathophysiology. (p. 88)

3. Differentiate between the processes of aerobic and anaerobic cellular metabolism. (p. 88)
4. Explain the concept of perfusion, including the components necessary to maintain perfusion. (p. 94)
5. Describe the composition of ambient air. (p. 89)
6. Explain how changes in respiratory system function can affect ventilation. (p. 90)
7. Describe the transport of oxygen and carbon dioxide in the blood. (p. 89)
8. Discuss factors that affect cardiac output. (p. 93)
9. Describe the two ways the heart can fail resulting in decreased cardiac output. (p. 94)
10. List the responses by the body when the sympathetic nervous system is stimulated. (p. 94)

AFFECTIVE

11. Value the importance of developing a basic understanding of pathophysiology.

OBJECTIVES



FIRST ON SCENE

EMS dispatcher Brooke Barrton stretched her back, glanced at her watch, and sat forward to scan the night's call log. "It's been pretty quiet tonight," she said to her partner Jordan. "I thought that it was definitely going to be busier."

Chris looked around the side of his computer monitor and frowned. "You realize that you just jinxed us, right? And with only an hour to go before shift change!"

Brooke's laugh was cut short by a ringing on the emergency line, and she shrugged at her partner before answering. "911. What is your emergency?" Brooke had to strain to hear the gasping voice on the other end of the line and initially could make out only the words "Can't breathe." She

muted her phone and leaned over to Chris. "I need you to send the rescue to this address for difficulty breathing, code three!"

As Brooke returned to the caller, Chris keyed the radio. "Six fifty-three, six five three, control, respond code three to 4512 Berry Lane in Jefferson Township for a difficulty breathing. Showing you dispatched at 0612 hours."

In a back corner of a deserted gas station parking lot across town, firefighters Case Bloomfield and Darin Small secure their seat belts, and as Darin shifts the idling truck into drive, Case acknowledges the dispatch and punches the address into the GPS unit.

OBJECTIVE

- 2. Explain the importance of understanding basic pathophysiology.

pathophysiology ► the study of how disease processes affect the function of the body.

cell membrane ► outer covering of the cell that protects and selectively allows water and other substances into and out of the cell.

cell nucleus ► the control center of a cell.

DNA ► deoxyribonucleic acid; a molecule that contains the body's genetic code for reproduction.

metabolism ► the conversion of glucose into energy.

electrolytes ► substances that when dissolved in water separate into charged particles.

aerobic metabolism ► the cellular process by which oxygen is used to metabolize glucose and energy is produced in an efficient manner with minimal waste products.

OBJECTIVE

- 3. Differentiate between the processes of aerobic and anaerobic cellular metabolism.

anaerobic metabolism ► the cellular process by which glucose is metabolized without oxygen and energy is produced in an inefficient manner with many waste products.

Understanding Pathophysiology

The term **pathophysiology** refers to the study of how disease processes affect the functions of the body. As an Emergency Medical Responder, you will be encountering many people whose bodies are functioning abnormally due to illness or injury. The knowledge you have of how the body responds and the signs and symptoms it displays when things are wrong will help you identify issues and provide the indicated care more promptly. In other words, you may be able to anticipate what the body needs sooner rather than later.

Cell Function and Fluid Balance

Understanding basic cell function will provide a foundation for how the body responds when cells begin to fail.

The Cell

The most basic unit of the human body is the cell. Many cells have specific functions. When joined together, they create the organs and systems that allow the body to function.

The **cell membrane** is the outer, protective layer of the cell. It controls the movement of water and other substances into and out of the cell. The **cell nucleus** contains **DNA**, the genetic blueprint for reproduction. All cells have basic needs that must be met to accomplish such important functions. Those needs include glucose, water, and oxygen.

Glucose is a simple sugar converted from food and is the basic nutrient of the cell. During normal **metabolism**, the cell converts glucose into energy to power its basic functions. Without glucose, energy is not created and cell functions stop.

Water is also required for cells to function. Cells need a correct balance of water between the inside and outside of the cell membrane. Cells dry out and die without enough water. Too much water, and cellular function will be interrupted. The cell membrane is an important component of the cell. Many disease processes can alter its ability to effectively transfer fluids and other substances in and out of the cell. An ineffective cell membrane can interfere with the balance of fluid (water) inside and outside the cell. Water also influences the concentrations of important chemicals called **electrolytes**.

Oxygen fuels the fire of metabolism. It is a necessary component used by the cell to metabolize glucose into energy. Ordinarily, glucose is converted into energy when there is an adequate supply of oxygen. This process is called **aerobic metabolism** (Figure 5.1A). One of the byproducts of aerobic metabolism is carbon dioxide.

When there is not enough oxygen to metabolize glucose, **anaerobic metabolism** (Figure 5.1B) occurs. During anaerobic metabolism, energy is produced inefficiently and with a great many more byproducts, including carbon dioxide and lactic acid. Anaerobic metabolism is not healthy for the body because the accumulation of waste products makes the body more acidic and creates a toxic environment for the cells.

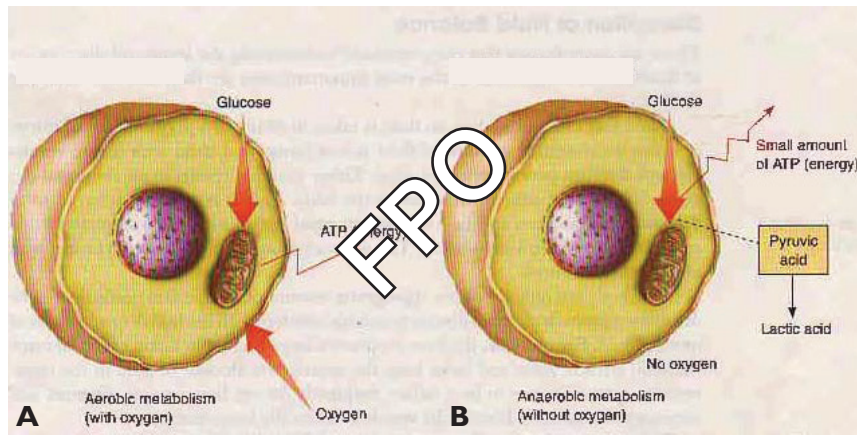


Figure 5.1 (A) Aerobic metabolism requires an adequate supply of glucose and oxygen. (B) Anaerobic metabolism occurs when there is not enough oxygen.

Fluid Balance

Human cells require a constant supply of water. In fact, about 60% of the body is made of water. Balancing the distribution of water is an important part of maintaining normal cell function. Without an appropriate balance of water, both inside and outside of cells, the basic functions of the cells would cease.

Water is introduced into the body by drinking fluids. It is eliminated from the body by sweating, breathing, and making urine. These processes allow the body to constantly adjust fluid levels.

Disruption of Fluid Balance

Many factors contribute to disrupting the balance of fluids in the body. Some of the most important are fluid loss and improper fluid distribution.

Fluid loss can occur when no fluid is taken in (think of a person dying of thirst) or when an abnormal amount of fluid is lost (imagine a child with severe vomiting and diarrhea over a period of several days). Such an abnormal decrease in the total amount of water in the body is commonly referred to as **dehydration**.

The body needs both the appropriate amount of fluid and the fluid to be distributed properly. Fluids are located in one of three places within the body: inside the cell, outside the cell, and inside the vessels. The movement of fluids may be associated with **edema**, or swelling.

Edema can be seen best in those parts of the body most subject to gravity such as the hands, feet, and legs. Edema also can occur because of an injury. For example, edema may occur after hitting your thumb with a hammer. In that case, the injury damaged and altered the permeability of local capillaries, resulting in the leakage of blood and a shift in fluid. The larger the injury, the more the fluid shifts.

dehydration ► an abnormally low amount of water in the body.

edema ► swelling associated with the movement of water into the space surrounding the tissues.

The Cardiopulmonary System

Aerobic metabolism requires a constant supply of oxygen. The body obtains this oxygen primarily from the air we breathe. The air we breathe contains approximately 21% oxygen. The respiratory system transfers oxygen into the bloodstream, and the cardiovascular

OBJECTIVES

- Describe the composition of ambient air.
- Describe the transport of oxygen and carbon dioxide in the blood.

From the Medical Director **Fluid Balance**

A patient's fluid balance can be assessed externally. Dehydration can be seen through dry mucous membranes, sunken eyes, and even through the body's responses, such as tachycardia and low blood pressure. Poor fluid distribution can be recognized through fluid accumulation (edema) in areas such as the ankles and feet.

system transports it out to the body cells. The blood also picks up carbon dioxide from the cells and transports it back to the lungs, where it can be eliminated through exhalation.

It is important to remember that both the respiratory and cardiovascular systems must work together. The lungs, heart, blood vessels, and the blood itself must all work in concert to successfully deliver oxygen and nutrients to the cells and remove waste products. Interruption of any part of this balance results in a failure of the cardiopulmonary system.

The Respiratory System

The respiratory system includes the structures of the airway, the lungs, and the muscles of respiration. Movement of air in and out of the chest requires an open and clear pathway referred to as a **patent** airway. There are a number of potential challenges to maintaining a patent airway due to disease and trauma. They include:

OBJECTIVE

6. Explain how changes in respiratory system function can affect ventilation.

patent ► open and clear; free from obstruction.

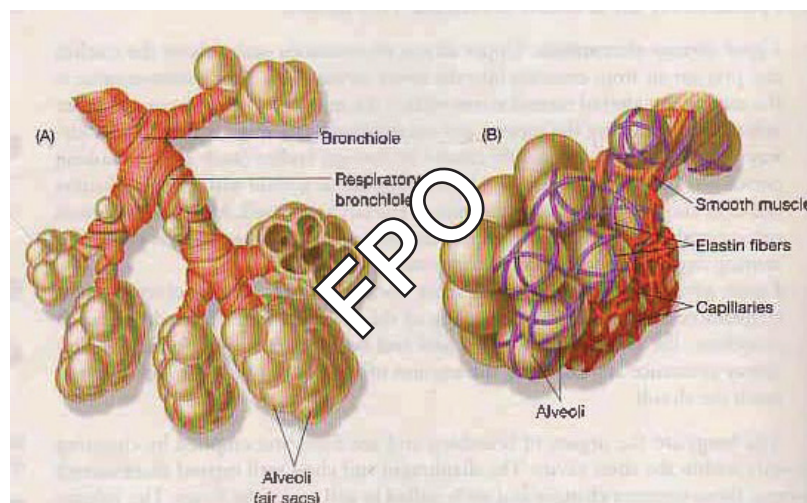
- *Upper airway obstructions.* Upper airway obstructions occur above the trachea and prevent air from entering the lower airway. The most common cause is a loss of control of the muscles in the airway. An altered mental status relaxes the muscles of the pharynx and the soft tissues, including the tongue and epiglottis, obstructing airflow. Upper airway obstructions are frequently caused by foreign bodies (such as in a choking person) or by swelling. Trauma or burns also can cause the soft tissues of the larynx to swell. Any of those obstructions can seriously and significantly impact the flow of air and interrupt the process of moving oxygen in and carbon dioxide out.
- *Lower airway obstructions.* The most common lower airway obstruction is bronchoconstriction, or the narrowing of the lower airways. In conditions such as asthma, the small bronchioles spasm and become narrower, causing greater airway resistance and reducing the amount of oxygen-rich air that can flow through them to reach the alveoli (Figure 5.2).

The lungs are the organs of breathing and are filled and emptied by changing pressure within the chest cavity. The diaphragm and chest wall expand and contract to cause those pressure changes, and air is pulled in and out of the lungs.

The volume of air moved in and out with each breath is called **tidal volume**. Changes in breathing rate or tidal volume can greatly affect the adequacy of ventilations. A patient must have a good balance between volume and rate to ensure good oxygen intake and removal of carbon dioxide. Breathing that is too slow will allow for an excess buildup of carbon dioxide. Breathing that is too fast may lead to abnormally low levels of carbon dioxide. Neither situation is good for the patient long term.

tidal volume ► the volume of air moved in one breathing cycle, which consists of one inhalation and one exhalation.

Figure 5.2 (A) In the alveoli is where the exchange of oxygen and carbon dioxide take place. (B) The alveoli are surrounded by capillaries that bring in oxygen and venules that carry away carbon dioxide.



During your primary assessment, you will assess a patient's breathing rate by counting the number of ventilations per minute. Then you must do your best to assess the adequacy of tidal volume, which is a bit more subjective. The best way to assess tidal volume is by observing chest rise and fall.

Not all of the volume that a person breathes in gets down to the level of the alveoli, where gas exchange occurs. In adults, about 150 mL of normal tidal volume stays in the space between the mouth and alveoli. That space is referred to as **dead air space**. Gas exchange occurs only with the air that actually reaches the alveoli.

dead air space ► the space between the mouth and alveoli, which is occupied by air that does not actually reach the area of gas exchange.

Respiratory System Dysfunction

There are many causes of respiratory system dysfunction. In general, normal function is interrupted any time rate or volume becomes inadequate. Examples of common causes of respiratory dysfunction include disruption of respiratory control, disruption of pressure, and disruption of lung tissue.

Disruption of Respiratory Control Breathing is controlled by an area of the brain called the *medulla oblongata*. Disorders that affect this area of the brain can interfere with respiratory function. Medical reasons such as stroke, brain tumors, and infection can disrupt the medulla's function and alter the stimulus to breathe. Toxins and drugs also can affect the medulla's ability to regulate breathing by slowing respirations. Brain trauma can physically harm the medulla and impair its function. Spinal-cord injuries and diseases such as multiple sclerosis can significantly impair the respiratory system.

Disruption of Pressure The chest cavity is a closed container. A large muscle called the *diaphragm* forms the lower boundary and combines with the ribs and intercostal muscles to change the container's size. The lungs are adhered to the chest wall by contact between two membranes known as the *parietal* (chest wall) *pleura* and *visceral* (lung) *pleura*. Even though the two membranes are stuck tightly together, there is a potential space between them called the *pleural space*. A small amount of fluid exists there to lubricate the pleura and help the lungs to adhere. It is important to remember that the pleural space is a potential space where blood and air can accumulate under the right circumstances.

When the chest expands, a negative pressure is created inside the chest, which pulls air into the lungs. When the container relaxes and becomes smaller, positive pressure is created inside the chest, and air is pushed out. The act of changing pressures within the chest cavity relies on an intact chest compartment. If a hole is created in the chest wall and air is allowed to escape or be drawn in, the pressure necessary to breathe can be disrupted. Furthermore, if bleeding develops within the chest, blood can accumulate in the pleural space (hemothorax) and force a lung to collapse away from the chest wall. This also can occur if a hole in either a lung or the chest wall (or both) allows air to accumulate in this space (pneumothorax).

Disruption of Lung Tissue Besides changing the actual amount of air moved per minute, lung function can be interfered with by disrupting the lung tissue itself. Trauma is the chief cause. When lung tissue is destroyed by mechanical force, it cannot exchange gas. Keep in mind, however, that medical problems also disrupt the function of lung tissue. For example, pneumonia or infection can reduce the ability of the alveoli to transfer gases. The result of any such challenges is low oxygen (hypoxia) and high carbon dioxide.

Respiratory System Compensation

The respiratory system is very good at responding to challenges. When a problem occurs, the body takes steps to attempt to correct it. In the normal patient, the brain regulates

breathing by monitoring the levels of carbon dioxide in the blood. When special sensors in the brain and vascular system register changes in carbon dioxide and oxygen levels, they send messages to the brain that action is necessary. The response is a change (increase or decrease) in respiratory rate and/or tidal volume. By doing so, the brain is attempting to regulate the levels of carbon dioxide and oxygen. These changes are predictable and should be recognized as a sign of respiratory dysfunction.

The Cardiovascular System

Proper gas exchange occurs only when the respiratory system is paired with appropriate cardiovascular function. But just as there can be many challenges to normal respiratory functions, there can be many threats to normal circulation in the cardiovascular system.

The Blood

Blood is the means of transport in the cardiovascular system. The most common dysfunction related to blood is not having enough. Circulation requires a sufficient quantity of blood, and when that quantity is not available, circulation fails. Major bleeding is the most likely cause of this type of problem, but volume can also be lost from the bloodstream by losing water from the plasma as in dehydration.

Blood Vessels

The blood vessels are the pathways in which blood travels. Arteries, veins, and capillaries form this distribution network. Arteries carry oxygenated blood away from the heart (with the exception of the pulmonary artery). They are composed of a series of layers and can change diameter by contracting their middle layer of smooth muscle. Veins (with the exception of the pulmonary vein) carry deoxygenated blood back to the heart and also can change diameter with a layer of smooth muscle. As blood leaves the heart, it first travels through arteries, which decrease in size as they approach the cellular level and turn into arterioles. Arterioles then feed the oxygenated blood to tiny vessels called *capillaries*.

Capillaries have thin walls that, like cell membranes, allow for movement of substances into and out of the bloodstream. It is through those thin walls that oxygen is off-loaded and carbon dioxide is picked up from the cells of the body. Capillaries then connect to the smallest veins, called *venules*. As they grow larger, venules turn into veins and transport blood back to the heart. It is a similar, but reversed, process in the lungs.

Deoxygenated blood that has been returned to the right side of the heart is transferred to the lungs by way of the pulmonary arteries and arterioles. The pulmonary arterioles connect with pulmonary capillaries that surround the alveoli. Oxygen is transferred from the air in the alveoli across the alveolar membrane to the surrounding capillaries. Carbon dioxide is off-loaded across the alveolar membrane from the bloodstream to the air in the alveoli. The newly oxygenated blood then continues on its way from the pulmonary capillaries to the pulmonary venules and into the pulmonary veins. The pulmonary veins then return the oxygenated blood to the left side of the heart to be pumped to the body.

Blood is moved through the blood vessels by the pressure created by the beating heart. Pressure is an essential element to circulation. Without pressure in the circulatory system, blood will not move and gas exchange cannot occur. For a blood cell to get where it is going, it must have other cells behind it pushing it along (normal pressure). If the cells are too spread out, no one pushes that lead cell and it does not move (low pressure).

One very important factor that helps determine pressure within the cardiovascular system is the relative internal diameter of the blood vessels. Arteries and arterioles can change their diameter using a layer of smooth muscle and will frequently change size to adjust for changes in pressure.

Pressure may need to be adjusted for a variety of reasons including loss of volume (blood) or too much volume in the system. For example, imagine an 18-year-old patient who has lacerated his femoral artery. As a result of severe bleeding, the volume of blood in his blood vessels significantly decreases, therefore causing the pressure in the system to decrease and the existing blood to have a difficult time moving. Special sensors in his aorta

notice the falling pressures. Messages are transmitted to the central nervous system, and the blood vessels are stimulated to contract. This decreases the size of the vessels, and the pressure within the system normalizes (for a while).

The autonomic nervous system plays a major role in controlling vessel diameter. In particular, the sympathetic nervous system in its fight-or-flight response stimulates blood vessels to constrict. The parasympathetic nervous system stimulates blood vessels to relax or dilate.

A variety of dysfunctions can interfere with the normal operation of blood vessels. The following are common examples:

- *Loss of blood vessel tone.* A major problem related to blood vessels is the inability of a vessel to control its own size (or more specifically its own internal diameter). If blood vessels are unable to constrict when necessary or they are allowed to dilate without control, blood pressure can drop significantly. Many conditions can cause this loss of tone. Injuries to the brain and spinal cord, uncontrolled infections that cause sepsis, and severe allergic reactions all can cause uncontrolled dilation of the vessels.
- *Permeability problems.* Certain conditions cause capillaries to leak fluid. In this case, fluid passes through the capillary walls too easily, and the fluid portion of blood leaves the intravascular space too readily. Severe infection (sepsis) and certain diseases are frequently responsible for these problems.
- *Hypertension.* Also called *high blood pressure*, hypertension can cause pressure-related problems such as stroke and kidney failure. Chronic smoking, certain drugs, and even genetics can cause abnormal constriction of the peripheral blood vessels resulting in an unhealthy high level of pressure. This increased pressure can be a major risk factor in heart disease and stroke.

The Heart

The heart often is described as a simple four-chambered pump. Although its role is fairly simple, the pressure it creates by pumping is critical to the success of the cardiovascular system. The movement of blood and subsequently the transportation of oxygen and carbon dioxide are all dependent on the heart's working properly.

The job of the heart is very straightforward: move blood. To do this, it mechanically contracts and ejects blood. The volume of blood ejected in one squeeze is known as **stroke volume (SV)**.

Cardiac output (CO) is the amount of blood ejected from the heart in one minute. Cardiac output is a function of both stroke volume and heart rate. Cardiac output can be changed by altering either heart rate or stroke volume.

Cardiac output can also be impacted by heart rates that are too fast. Normally, increasing heart rate would increase cardiac output. However, very fast rates (usually >180 in adults) limit the filling time of the heart and can *decrease* stroke volume. Some examples of impaired cardiac output include:

- A 33-year-old woman has tachycardia (fast heart rate) at a rate of 220. Her tachycardia is not giving her ventricles enough time to fill between contractions. As a result, her stroke volume (and overall cardiac output) has dropped.
- A 67-year-old man has bradycardia (slow heart rate) at a rate of 40. His heart rate has decreased and because of this, so has his cardiac output.
- A 19-year-old has been stabbed in the abdomen. Because he has severe internal bleeding, not as much blood is returning to his heart, and stroke volume is therefore decreased. Cardiac output would drop as a result.
- A 90-year-old woman is having her fourth heart attack. In this case, the wall of the left ventricle is no longer working. Because her heart has difficulty squeezing out blood, her cardiac output drops.

The autonomic nervous system also plays a large role in adjusting cardiac output. The sympathetic, fight-or-flight response increases heart rate and the strength of contractions. The parasympathetic nervous system slows the heart down and decreases contractility.

OBJECTIVE

8. Discuss factors that affect cardiac output.

stroke volume (SV) ► the volume of blood ejected from the heart in one contraction.

cardiac output (CO) ► the amount of blood ejected from the heart in one minute.

OBJECTIVE

- Describe the two ways the heart can fail resulting in decreased cardiac output.

The heart can fail in two different ways—mechanically or electrically. That is, failure can be a result of a muscle (structural) problem or the result of a problem with electrical stimulation of that muscle. Mechanical failure can be caused by a number of factors, including trauma, such as bullet holes and stab wounds; squeezing forces, such as bleeding inside the heart’s protective sac; or loss of function of cardiac muscle due to cell death as in a heart attack. Electrical failure can result from problems in the heart’s conduction system, which include excessively fast rates (tachycardia), excessively slow rates (bradycardia), and disorganized conduction such as ventricular fibrillation. More information on cardiac dysfunction is discussed in later chapters.



FIRST ON SCENE

continued

Pulling up to the address, Case and Darin are met at the curb by a man who identifies himself as the building landlord. “Please hurry,” the man says in a very winded voice. “He’s up on the second floor, and he looks real bad. He is having a hard time breathing.” Case and Darin grab their jump bag, oxygen, and AED, and follow the man up two flights of stairs. As they enter the cluttered apartment, they find a thin, frail, elderly gentleman gasping for each breath.

“We are with the fire department, sir, and we are here to help. Can you tell me when you started having trouble breathing?” Darin asks the man. Darin notes that the man is very pale and is able to speak in only three- and four-word sentences. “Quick, give me a nonrebreather at 15 liters,” Darin directs Case.

OBJECTIVE

- Explain the concept of perfusion, including the components necessary to maintain perfusion.

perfusion ► the constant supply of oxygen and nutrients to the cells by the flow of blood.

Cardiopulmonary System and Perfusion

Every cell and every organ system require regular delivery of oxygen and nutrients and the removal of waste products. This is a function of a constant supply of blood and is referred to as **perfusion**. Perfusion absolutely relies on the interrelated function of the respiratory and cardiovascular systems.

For oxygen to be delivered and for waste products to be removed, all components of the cardiopulmonary system must be functioning together. In the respiratory system, air movement must bring oxygen all the way to the alveoli and move carbon dioxide back all the way out. There must be a significant quantity of air moving, and the alveoli must be capable of exchanging gas. In the cardiovascular system, there must be enough blood, the heart must pump that blood, and there must be enough pressure in the system to move the blood between the body cells and the alveoli. The blood also must be capable of carrying oxygen and carbon dioxide.

Hypoperfusion and Shock

Shock occurs when perfusion fails. In other words, shock occurs when the regular delivery of oxygen and nutrients to cells and the removal of their waste products are interrupted. This failure is referred to as *hypoperfusion*. Without a regular supply of oxygen, cells become hypoxic and must rely on anaerobic metabolism. When this type of metabolism occurs, lactic acid and other waste products accumulate and harm the cells. Without the removal of carbon dioxide, the buildup of harmful waste products is accelerated. Unless reversed, shock will kill cells, organs, and eventually the patient.

Just as the respiratory system predictably responds to a gas-exchange problem, the cardiopulmonary system causes predictable changes to compensate for poor perfusion. In most cases of hypoperfusion, the sympathetic nervous system causes blood vessels to constrict and the heart to beat faster and stronger. It also causes pupils to dilate and the skin to sweat. Receptors in the brain and blood vessels sense an increase in carbon dioxide and low levels of oxygen and stimulate the respiratory system to breathe faster and deeper.

Those signs of compensation can be seen during patient assessment. A patient in shock will have an increased pulse and respiratory rate. He also can have delayed capillary refill and pale skin secondary to constriction of the peripheral vessels. Pupils may be dilated, and the patient may be sweaty even in cool environments.

OBJECTIVE

- List the responses by the body when the sympathetic nervous system is stimulated.

Recognizing compensation (as seen by an elevated heart rate) is an important element of trauma patient assessment because it can rapidly identify the patient in shock. Always be on the lookout during your assessment for the telltale signs of hypoperfusion (shock).

As an Emergency Medical Responder, you should learn to recognize these findings as a signal that shock is present. Understanding compensation is a critical component in predicting more serious potential changes to come.

Pediatric Compensation

Children compensate differently than adults do. Children rely more on heart rate to overcome problems with cardiac output. Because of this, fast heart rates in children should always be considered shock until proven otherwise. Children also rely heavily on vasoconstriction to compensate for volume loss. As a result, they can maintain pressure in the cardiovascular system with relatively less blood than an adult. For this reason, blood pressure is a fairly unreliable indicator of shock in children. Children also have a higher metabolic rate than adults do. That means they burn more oxygen and require a more regular supply of perfusion to sustain normal function.

Shock is among the leading killers of pediatric patients. As an Emergency Medical Responder, you must learn to recognize the specific signs of hypoperfusion and compensation in the younger age groups.



FIRST ON SCENE *Wrap-up*

Later that day, Case and Darin ran into the ambulance crew at the hospital. "Nice job, guys," one of the medics commented as they passed in the ambulance bay. "Your guy was just minutes away from going into respiratory arrest,

and the oxygen really helped. He has a long history of emphysema and had run out of oxygen in his home tank."

"Thanks for the follow-up, guys," Case stated. "It's good to hear the outcome of a patient once in a while."

CHAPTER 5 REVIEW

Summary

- Understanding pathophysiology helps you understand the basic and most important functions of the body and their critical dysfunctions.
- There is a delicate balance of fluid in the body. Levels must be appropriate in the major spaces and balanced constantly to maintain life.
- Aerobic metabolism is the normal way the body converts glucose into energy. Anaerobic metabolism can be used, but is not as efficient, and it creates significantly more waste product.
- Perfusion requires the combined function of the respiratory and cardiovascular systems. All functions must be operating correctly to deliver oxygenated blood to the cells.
- Oxygen is introduced into the body from the ambient air. This process requires a functioning respiratory system and the ability to move air in and out of the lungs.
- Inspired air must be paired with circulating blood for perfusion to occur. Furthermore, appropriate quantities must be matched to ensure adequate delivery of oxygen to the cells.
- The cardiovascular system is the transport mechanism for oxygen, carbon dioxide, and nutrients for the cells. Proper transport requires the presence of appropriate elements of blood, pressure within the system, and a functioning pump.
- Cellular metabolism relies on a constant supply of glucose and oxygen. Therefore, normal metabolism relies on perfusion and the successful operation of the cardiopulmonary system.

Take Action

ASK ABOUT DIABETES

Diabetes is a disease that results when the pancreas will not produce the hormone insulin, or when the body does not use insulin properly. As of 2010, more than 25 million people in the United States have diabetes. With so many diabetics, there is a good chance you know someone who suffers from this disease. When you discover someone you know has diabetes, let him know you are in an Emergency Medical Responder class and ask if he would be willing to share his experiences being a diabetic. Use the following suggested questions to guide your exploration:

1. How long have you been living with diabetes?
2. Are you a type 1 or type 2 diabetic?

3. Do you take medication to control the disease? If so, what do you take and how often?
4. Do you have limitations because of the disease?
5. How do you know when your blood sugar is out of balance? How does it make you feel?
6. How do you monitor your blood sugar level?

First on Scene Run Review

Recall the events of the “First on Scene” scenario in this chapter, and answer the following questions, which are related to the call. Rationales are offered in the Answer Key at the back of the book.

1. How would you describe the patient’s level of distress related to his difficulty breathing (mild, moderate, severe) and why?

2. Why is this man presenting with pale skin?
3. What is supplemental oxygen going to do for this man?

Quick Quiz

To check your understanding of the chapter, answer the following questions. Then compare your answers to those in the Answer Key at the back of the book.

1. The most basic unit of the human body is the:

- | | |
|------------------|--------------|
| a. cell. | b. organ. |
| c. organ system. | d. quadrant. |

2. All cells require a constant supply of glucose, water, and:

- | | |
|--------------------|------------|
| a. carbon dioxide. | b. ATC. |
| c. glycogen. | d. oxygen. |

3. Anaerobic metabolism in a cell produces carbon dioxide and:

- | | |
|-----------------|---------------------|
| a. lactic acid. | b. carbon monoxide. |
| c. insulin. | d. hemoglobin. |

4. Fluid within the body is found in each of the following areas EXCEPT:

- | | |
|-----------------------|------------------------|
| a. inside the cells. | b. inside the lungs. |
| c. outside the cells. | d. inside the vessels. |

5. A breathing rate that is too slow will result in an excess buildup of _____ in the blood.
- electrolytes
 - carbon dioxide
 - oxygen
 - carbon monoxide
6. Which one of the following would be a predictable bodily response to hypoperfusion (shock)?
- Decreased respiratory rate
 - Increased heart rate
 - Vasodilation
 - Pupil constriction
7. A four-year-old male shock patient has delayed capillary refill time. This is most likely caused by:
- vasodilation.
 - cold ambient temperature.
 - medicine he has been given.
 - vasoconstriction.
8. During normal metabolism, what does the cell convert into energy?
- Glucose
 - Water
 - Oxygen
 - Lactic acid
9. The process of using oxygen to fuel the creation of energy is called _____ metabolism.
- aerobic
 - anaerobic
 - inaerobic
 - lactic
10. The regulation of breathing is controlled by the:
- lungs.
 - diaphragm.
 - medulla.
 - peripheral nervous system.
11. A reduction of total body fluid volume below normal levels is also known as:
- edema.
 - dehydration.
 - hypervolemia.
 - devolumation.
12. The problem that can result when a patient does not get an adequate supply of oxygen is called:
- hypoxia.
 - pneumothorax.
 - stroke.
 - anoxia.
13. The *smallest* vessel that carries deoxygenated blood is called a(n):
- artery.
 - arteriole.
 - venule.
 - vein.
14. Stimulation of the sympathetic nervous system will result in all of the following EXCEPT:
- increased heart rate.
 - increased respiratory rate.
 - constriction of vessels.
 - decreased heart rate.
15. The volume of blood that is ejected from the left ventricle with each contraction is known as:
- cardiac output.
 - respiratory volume.
 - stroke volume.
 - minute volume.