

# Diving First Aid for Professional Divers



## Student Handbook



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This program meets the current (as of December 2020) consensus on Guidelines for Resuscitation from the International Liaison Council on Resuscitation (ILCOR) and as issued by its member organizations including the American Heart Association (AHA), the European Council on Resuscitation (ERC), the Heart and Stroke Foundation of Canada (including the course requirements for CPR-C in Canada), Australia New Zealand Council on Resuscitation (ANZCOR), the Resuscitation Council of South Africa, the InterAmerican Heart Foundation, and the Resuscitation Council of Asia.

4th Edition, Rev 3.0 February 2023  
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3rd Edition published 2017; 2nd edition published September 2013; 1st edition published 2006.

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Diving First Aid  
for Professional Divers

Chapter 1: Course Overview

Divers Alert Network® (DAN®) developed this Diving First Aid for Professional Divers (DFA Pro) course specifically for individuals who dive as part of their job duties or volunteer activities. This includes people who are employed as commercial divers, scientific divers and public safety divers as well as divers who are employed by or volunteer at aquariums. Since much of the content draws from DAN’s core diving first aid courses, this program is also well suited for dive professionals such as divemasters and dive instructors.

Dive accidents are rare, but they may require prompt, specific action. However, one does not have to be a diver to render aid to someone who has had a diving accident or to someone who is in need of other assistance from a non-diving incident. This course addresses topics required by OSHA guidelines, including bloodborne pathogens. Other topics include scene safety, oxygen administration, neurological assessment, CPR — including use of automated external defibrillators (AEDs), and first aid for injuries from marine life.

This course assumes that the injured diver has been removed from the water and all scuba gear or other equipment has been removed; that training is available from other agencies. The sequencing of topics follows from a “most likely” scenario to a more “urgent care” one. Secondary care is covered in the latter part of the book.

Successful completion of the Diving First Aid for Professional Divers course includes demonstration of skill competency and passing a knowledge assessment. Upon completion, you will receive a provider card indicating that you have been trained in basic life support (including CPR) and first aid measures.

Reading this handbook without instruction and skill practice will not make someone competent to provide CPR or first aid assistance.

First Responder Roles and Responsibility

First aid is providing initial care for an injury or illness. The three key aims of first aid are to (1) preserve life, (2) prevent the condition from worsening and (3) promote recovery.

Emergency response skills deteriorate with time, so retraining is required every two years to maintain DFA Pro provider credential, although some local/institutional protocols and regulations may require more frequent retraining. In addition, regular practice is encouraged to retain skill proficiency. All skills performed in an emergency should be within the scope of your training and experience.

Course Prerequisites

There are no prerequisites, including scuba certification, for participation in the DFA Pro course.

Anyone who provides surface support for divers and/or serves as first responders to divers and others in and around water will benefit from this course. Familiarity with diving equipment and diving terminology will make understanding the material easier, but interested and informed nondivers should be able to master the material. There is no minimum age requirement to participate in this course. Some countries, states and local municipalities may have minimum age stipulations for the use of emergency oxygen.

Retraining

Emergency-response skills deteriorate with time. Retraining is required every two years to maintain Diving First Aid for Professional Divers provider certification, and regular practice is encouraged to retain proficiency. All skills performed in an emergency should be within the scope of one's training.

How To Use this Handbook

Each chapter in this student handbook contains three distinct features.

- The beginning of each chapter has a list of questions to assist with learning. This is the information you should look for as you read the material, complete the knowledge review questions, and participate in class discussions.
- Boxes labeled “Note” provide explanations that are important for understanding the material just presented.
- Boxes labeled “Advanced Concepts” contain additional information beyond what is required for this course. It is enrichment for students who want to know more.

Terminology

This student handbook introduces medical terms that may be unfamiliar to some readers. Familiarity with basic medical terminology will enhance the quality of communication with emergency and health care workers. A glossary of terms is provided in the back of this handbook.



Diving First Aid  
for Professional Divers

Chapter 2: Introduction

Objectives

1. What is duty of care, and how does it apply to the first aid provider?
2. Why is it important to ask permission before rendering care?
3. How can a rescuer deal with emotional stress?

Duty of Care

Duty of care is an obligation imposed on an individual or organization to provide assistance to someone in an effort to prevent unreasonable loss or harm. The care provided should not exceed one's level of training.

As a bystander, you have no legal obligation to provide first aid. Some locations, however, may have jurisdictional laws that require a response, even if it is just to notify authorities there is an emergency and assistance is required. Your DFA Pro Instructor can provide information relevant to the area where they teach.

You may have an organizational duty of care if you are part of an organizational response team. Internal oversight for organizational responsibilities is typically the responsibility of designated compliance officers or dive safety officers. This obligation does not extend to circumstances outside the organization.

In circumstances outside your organization, you may have an obligation to notify authorities that someone is in need of medical assistance. If you engage in basic life support and/or first aid, the care you provide must be within the scope of your training.

In support of bystander first aid, most countries have laws broadly classified as Good Samaritan laws. They are designed to protect rescuers in certain situations. Rescuers need only use their best rescue efforts in good faith based on their own training when attempting to provide care.

These laws may not apply, however, if you are required to provide care or people perceive you to have a responsibility to provide care. Consult your local laws for additional information.

Two cautions warrant mention here. You may not be protected by these laws if you provide care outside the scope of first aid training you have completed OR once you have initiated care, you fail to continue care or turn care over to medically trained professionals.

Always ask an injured person for permission before you provide care. This can be done by saying: “My name is \_\_\_\_, and I am a first aid provider. May I help you?” If care is being offered to a minor, a parent or guardian must grant permission if they are available. If they are not available, permission is implied.

If responsive, the injured or ill person should give permission before you provide care. Not asking for permission or forcing care against a person’s will exposes you to potential legal action for involuntary assistance or battery. If a person is unresponsive, permission to provide medical assistance is implied.



Emotional Stress and Fear of Doing Something Wrong

Helping others in need can be rewarding, but it can also create emotional stress before, during and after the rescue.

When a person has an accident, is injured or is in sudden cardiac arrest, bystanders commonly wait for someone to take charge or provide aid. Hesitation is often caused by:

- Fear of doing something wrong, causing harm or not being able to bring back life
- Fear of being sued
- Fear of infection (Later in this course you will learn how to mitigate.)

Anxiety is a normal emotion for both the rescuer and injured person during an emergency. A pounding heart and breathless feeling are to be expected; these feelings, however, generally do not interfere with the ability to use your skills and provide the needed care. Your knowledge and training will likely reduce your anxiety level. Making serious mistakes, causing harm to an injured person or causing death are unlikely; providing care to the best of your ability and with the resources available is better than providing no care at all. When breathing and circulation stop or are severely impaired, oxygen supplies are interrupted. Without oxygen, body organs suffer and eventually die. Especially vulnerable tissues such as the brain may start dying after 4-6 minutes. The need for immediate action is therefore crucial.

When providing care for an injured person, treat them, their family, friends and coworkers with respect, and perform according to your knowledge and skill level. Be sure the injured person is referred to medical care or to someone with training equal to or higher than yours.

Once you initiate care, continue until another rescuer or medical personnel relieves you or you are too exhausted to continue.

**Note:**

The hard truth regarding cardiac arrest is that in most cases CPR, even when coupled with advanced techniques, does not restart the heart or restore a life-sustaining rhythm — even when performed perfectly. CPR increases the chances of survival but does not guarantee it.

If an injured diver’s condition does not improve or CPR is unsuccessful, it is not evidence that you were responsible or that you performed inadequately. Unsuccessful rescue attempts may cause emotional distress; rescuers may blame themselves for not saving a life, or they may think they did something wrong. Memories of the incident may replay in the responder’s mind causing emotional distress. All of these reactions are legitimate feelings a responder may experience. Sometimes these feelings can be overwhelming and can eclipse normal day-to-day functioning. Other times, these feelings are mild or intermittent. Regardless of how they manifest or how often, seeking help in dealing with those feelings and thoughts is not a sign of weakness. In fact, recognizing help is needed and seeking that help is often the strongest thing you can do. Some rescuers may benefit from a critical-incident debriefing or professional counseling to help work through such concerns. Some companies will have resources available to assist with this intervention.

### Note:

Three main objectives of a Critical Incident Stress Debriefing (CISD):

- Mitigate the impact of a traumatic event
- Facilitate normal recovery processes
- Provide a screening opportunity CISD requires certain conditions:
- A small group that is homogeneous (with regard to their roles in the event)
- Members whose involvement in the situation has concluded
- Completed any required work/paperwork
- Members have about the same exposure to the traumatic event
- Psychologically ready and not fatigued

Facilitated by:

- Trained clinician
- Trained cohort

## Review Questions

1. Duty of care is an obligation to provide assistance regardless of training.
  - a. True
  - b. False
2. To avoid legal problems,
  - a. always ask an injured person for permission to assist
  - b. always ask the parent/guardian of a minor for permission to assist their child
  - c. obtain written permission to provide care
  - d. all of the above
  - e. a and b only
3. Anxiety is a normal response in an emergency.
  - a. True
  - b. False
4. If a rescuer experiences emotional distress, relief may be achieved by
  - a. a critical-incident stress debriefing
  - b. professional counseling
  - c. both a and b

Review answers are on Page [250](#).

## Basic Sciences

## Chapter 3: Anatomy & Physiology

### Part 1: Respiration & Circulation

#### Objectives

1. What is hypoxia?
2. Why is oxygen necessary for life?
3. Where does gas exchange occur in the body?
4. What body structures comprise the respiratory system?
5. What body structures are included in the cardiovascular system?

Oxygen (O<sub>2</sub>) is essential for life. Within minutes of experiencing severe oxygen deficiency (hypoxia) or the absence of oxygen (anoxia), severe discomfort, unconsciousness or death may occur.

Under normal circumstances, breathing ensures an adequate oxygen supply to tissues. The respiratory system provides an effective interface between the bloodstream and the atmosphere and facilitates gas exchange. Most critical to normal life is the intake of oxygen and removal of carbon dioxide (CO<sub>2</sub>).

Carbon dioxide results from cellular metabolism and is transported by blood to the lungs, where gas exchange across the alveolar-capillary membrane enables elimination in the exhaled breath. Elevated levels of carbon dioxide, not low levels of oxygen, provide the primary respiratory stimulus. The rapid elevation of dissolved carbon dioxide during short periods of breath-holding provides quick insight into the power of its influence.

The Respiratory System

The respiratory system is comprised of the upper airways (mouth, nose and pharynx), the trachea (windpipe) and the lungs. Key supporting structures include the chest wall (ribs and intercostal muscles) and diaphragm (a muscle critical to respiration that separates the thorax from the abdomen). Surrounding the lungs and lining the inside of the chest wall is a thin membrane called the pleura. Although this is one continuous membrane, its coverage of both the lungs and chest wall forms a double layer. Between these two pleural-membrane layers is a potential space (see Advanced Concepts box) that contains a thin layer of fluid that acts as a lubricant, allowing efficient movement of the lungs during breathing.

Air is drawn into the mouth and nose and passes into the pharynx. The pharynx divides into two distinct passages: the trachea and the esophagus. The opening to the trachea is protected from food (solids and liquids) during swallowing by a flexible flap of tissue called the epiglottis. The esophagus, located behind the trachea, is a conduit for food and fluids en route to the stomach.

In contrast to solids and fluids, air travels from the pharynx through the larynx (voice box) and into the trachea. The trachea consists of a series of semicircular cartilaginous rings that prevent collapse. The trachea passes down into the chest cavity and branches into the right and left bronchi, which enter the right and left lungs, respectively. The bronchi progressively divide into smaller and smaller tubes and finally into the alveoli. This branching pattern is commonly referred to as the bronchial tree.

The alveoli, located at the end of the smallest branches of the respiratory tree, have extremely thin walls and are surrounded by the pulmonary capillaries. The alveoli have been likened to tiny balloons or clusters of grapes.

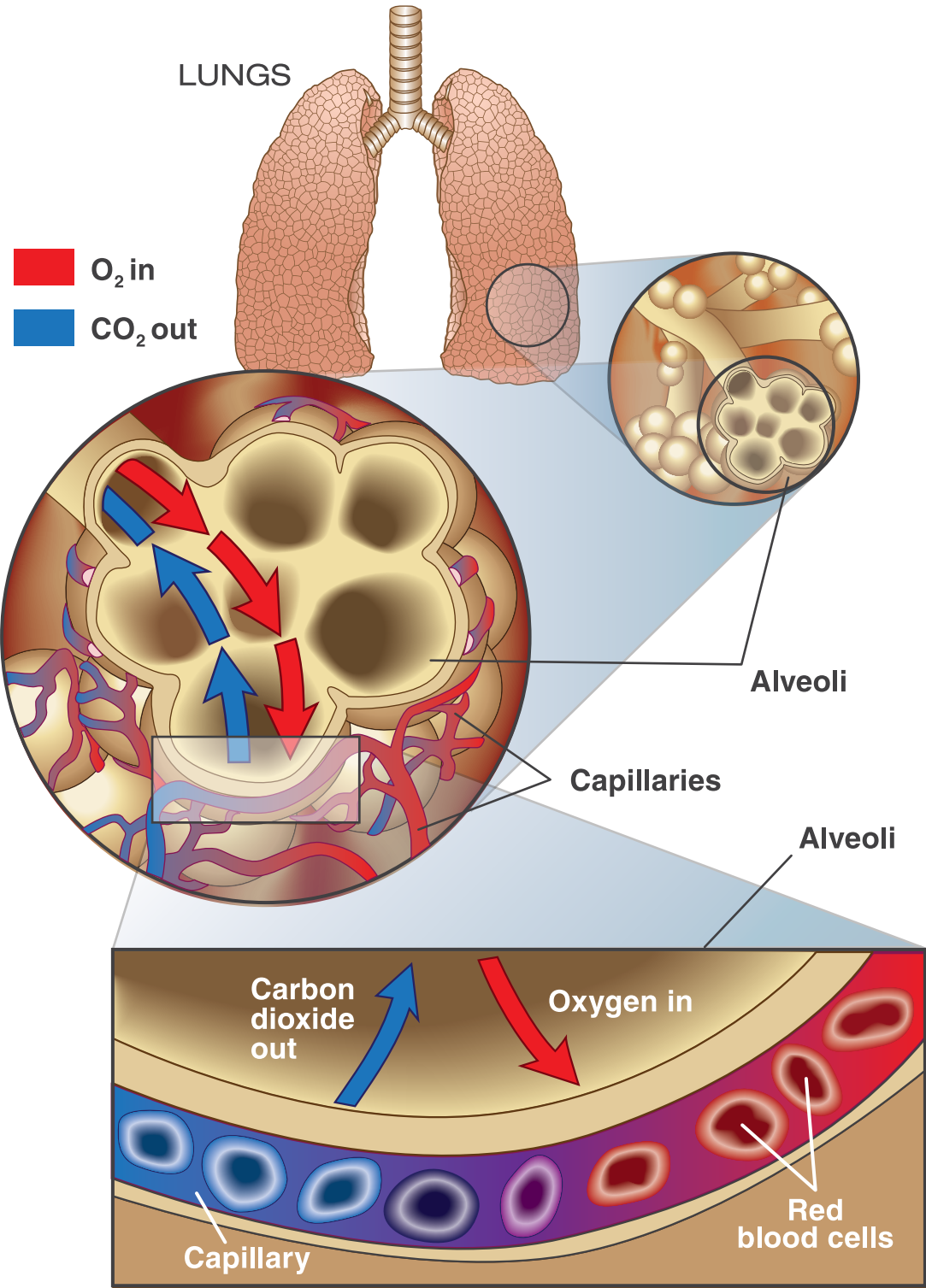
Advanced Concepts

Potential Space: The double-layered pleural membrane is made up of the parietal layer, which lines the thoracic cavity, and the visceral layer, which coats the organs.

These two layers normally remain closely adherent due to a slightly negative pressure that keeps them from separating. Because there isn't a separation between these membranes, this area is known as a potential space and becomes a true space only if the membranes are injured or rupture.

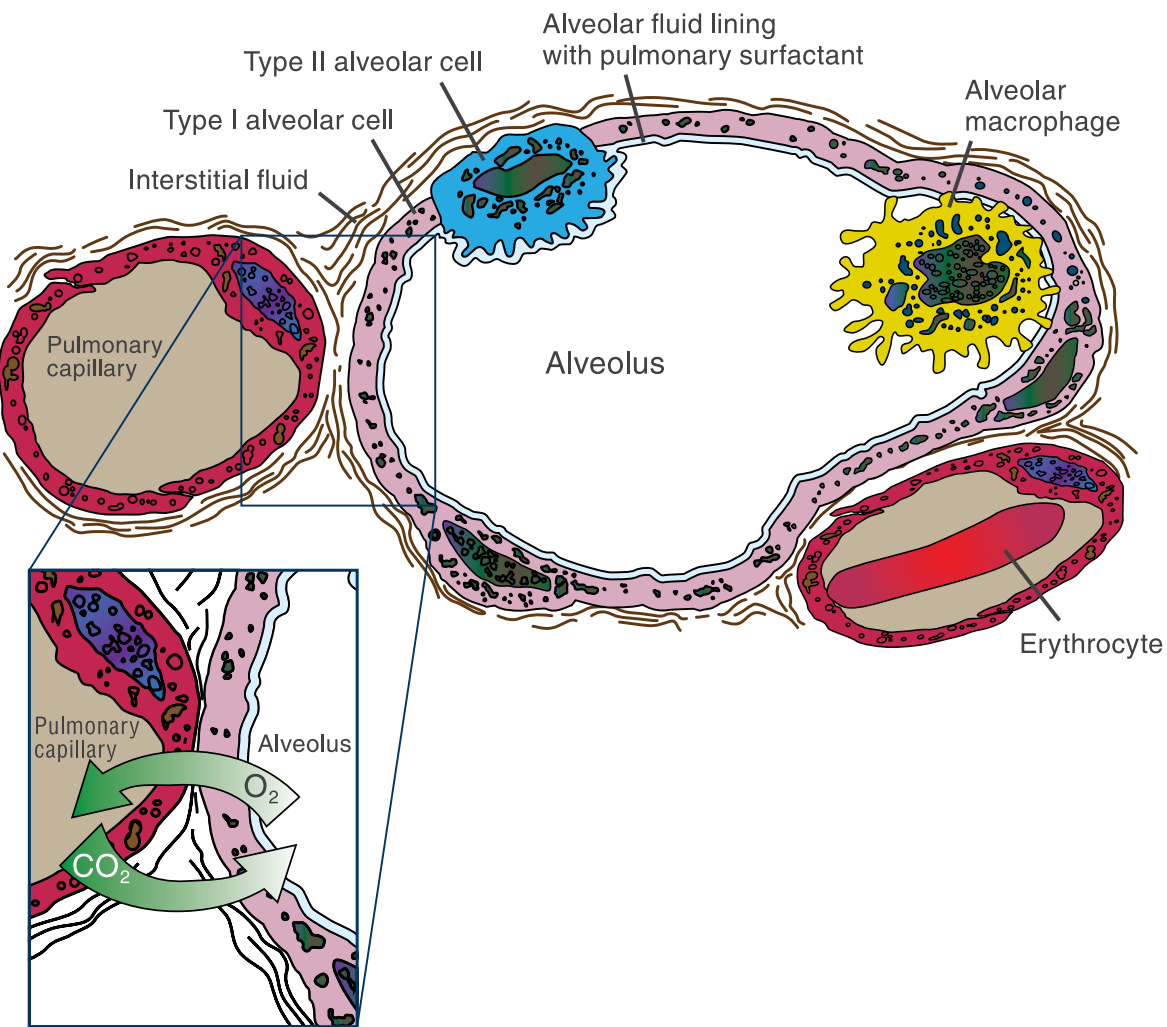
A pneumothorax forms from the entry of air between these layers (intrapleural space) and may form from escaped alveolar air subsequent to pulmonary barotrauma.

In both lungs, millions of alveoli cover a combined surface area of around 70 square meters (750 square feet) — or roughly the size of a tennis court.



A detergent-like substance known as lung or pulmonary surfactant coats the inner surface of the alveoli. Pulmonary surfactant decreases the surface tension of water within the alveoli and thus reduces its tendency to collapse at the end of expiration. If the surfactant is removed, as may occur in a submersion incident, the alveoli may collapse and remain collapsed after the inhaled water is removed (or reabsorbed), severely compromising gas exchange.

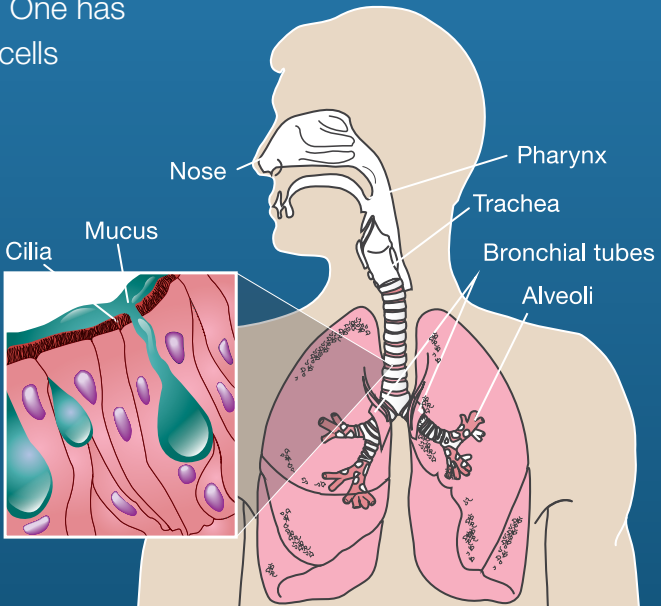
Large areas of collapsed alveoli are known as atelectasis and may evolve into a pneumonic focus (pneumonia) if they become infected. This is one reason why follow-up medical care is critical in nonfatal drowning. Appropriate intervention can reduce or prevent complications associated with drowning.



The average adult alveolus has an estimated diameter of 200-300 micrometers and is only a cell layer thick. Alveoli lie adjacent to capillaries that are also one cell layer thick, and this proximity enables the rapid exchange of carbon dioxide and oxygen. The thin alveolarcapillary membrane separates the content of the lung from the bloodstream. If this membrane tears or becomes compromised due to trauma from a lung-overexpansion injury (pulmonary barotrauma), it may enable gas to pass out of the alveoli and into the bloodstream. Gas entering the vascular system can travel throughout the body as an air embolism. This topic is discussed in more detail later in this chapter.

Advanced Concepts

Two types of cells line the respiratory system. One has small hairlike structures called cilia; the other cells produce a mucous substance that is swept by cilia. These two cells work in concert. The sticky mucous substance captures foreign particles, and the cilia move this mucus up into the pharynx, where it can be swallowed and digested together with any trapped foreign particles. In smokers, the mucus is thicker and the cilia are damaged, which hinders the lungs' natural self-cleaning mechanism.



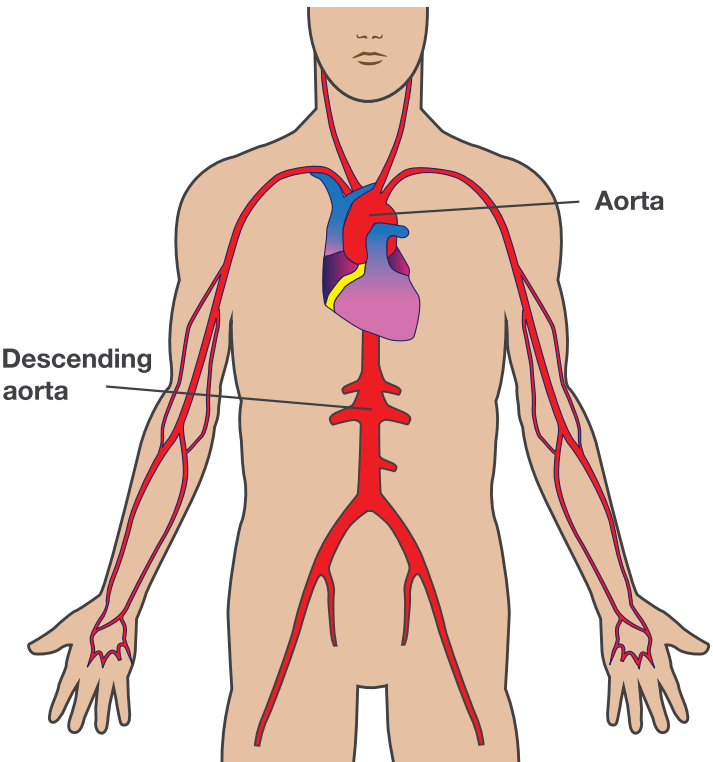
The Cardiovascular System

The cardiovascular system includes the heart and blood vessels. It is a closed-circuit system dedicated to pumping blood, transporting oxygen and nutrients to tissues via the arteries and removing waste products such as carbon dioxide via the veins.

The Heart

The heart is a hollow muscular organ situated in the thoracic cavity between the lungs in a space called the mediastinum. A thin connective tissue sac called the pericardium surrounds it. The pericardium — like the pleural linings of the lungs — reduces friction between the heart and surrounding structures.

The heart is a strong muscular pump that, in the average adult, has the capacity to beat spontaneously at a rate of about 70 times per minute. (The normal resting heart rate is 60-100 beats per minute and may be as low as 40 beats per minute in athletes.)<sup>2</sup> Approximately 6 liters (about 1.5 gallons) of blood is pumped throughout the body every minute. When exercising, this output may double or triple depending on exertion.



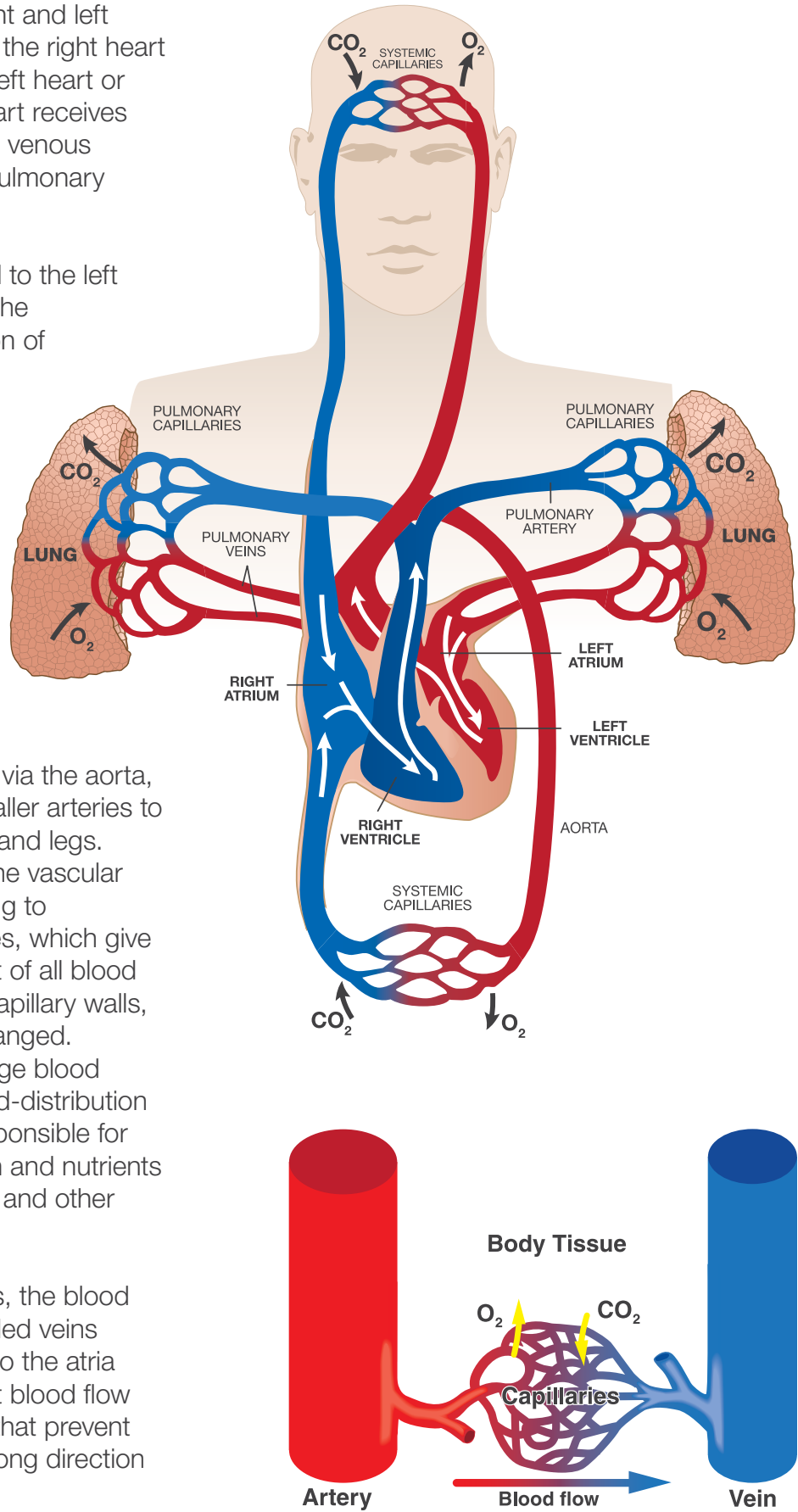
The heart is divided into a right and left pump system (also known as the right heart or pulmonary circuit and the left heart or systemic circuit). The right heart receives deoxygenated blood from the venous system and pumps it to the pulmonary circuit to exchange gases.

Oxygenated blood is returned to the left heart, where it is pumped to the systemic circuit. Transportation of blood through both circuits completes a circulatory cycle.

### Blood Vessels

Blood leaves the left ventricle via the aorta, which then branches into smaller arteries to supply the head, arms, torso and legs. The blood vessels make up the vascular tree, with each branch heading to progressively smaller branches, which give rise to capillaries, the smallest of all blood vessels. Through these thin capillary walls, gases and nutrients are exchanged. Functionally, the heart and large blood vessels represent a pump-and-distribution system for the capillaries, responsible for supplying tissues with oxygen and nutrients and removing carbon dioxide and other metabolic waste products.

From the peripheral capillaries, the blood is gathered into small, thinwalled veins and returned via larger veins to the atria of the heart. Most veins direct blood flow by means of one-way valves that prevent blood from traveling in the wrong direction or pooling due to gravity.

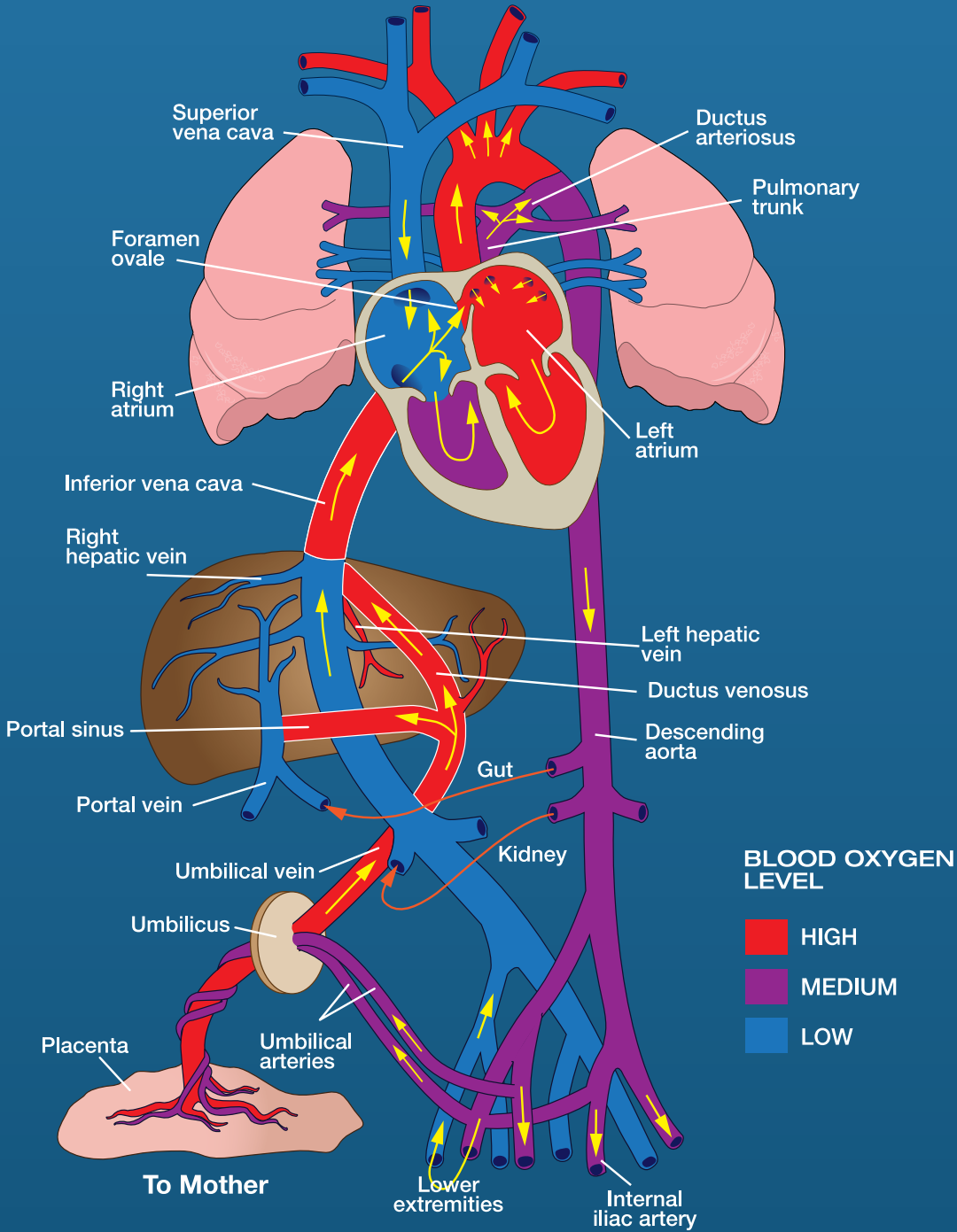


### Advanced Concepts

#### Fetal Circulation

Within the uterus, the fetus lives in a fluid-filled environment. As such, the lungs are not used for gas exchange, and circulating blood is largely shunted away from pulmonary tissue. In the fetus, gas exchange takes place in the placenta, drawing available oxygen from the mother's blood.

(Continued on the next page.)





### Fetal Circulation (Continued)

Two unique passages in the fetal circulation allow blood to bypass the lungs. These two portals, known as the ductus arteriosus and foramen ovale, usually close soon after birth with the baby's first breaths.

The ductus arteriosus (a duct between two arteries) enables blood coming from the right ventricle to directly enter the aorta and thus bypass the lungs. Once this passage closes, blood is transported to the lungs, which are now needed for blood oxygenation. A vestige (remnant) of the ductus will remain as a ligament bonding the aorta and the pulmonary artery (ligamentum arteriosum or arterial ligament).

The foramen ovale (an oval-shaped hole) is a passage between the atria that allows blood to shunt from the right atrium to the left, thus bypassing the nonfunctional lungs. At birth, when the pressures in the left atrium increase, this passage usually closes, leaving only a depression in the wall, known as the fossa ovalis. Closure of the foramen is incomplete in approximately 25-30 percent of the population, thus leaving a patent (open) foramen ovale (PFO). The PFO is not physiologically relevant in many persons, but it may predispose a small number of people to certain medical issues.

### Advanced Concepts

Blood is a specialized fluid (actually a distinct organ system) that links the respiratory system to the rest of the body. Approximately 55 percent of our circulating blood volume is comprised of plasma, the visible fluid fraction of blood. While mostly water, plasma also contains proteins, glucose, minerals, nutrients, waste products and dissolved gases. The cellular constituents of blood include erythrocytes (red blood cells, or RBC), which transport oxygen and carbon dioxide, and leukocytes (white blood cells, or WBC), which play a critical role in infection control and inflammatory responses. The third constituent is platelets, which are cell fragments responsible for initiating the clotting process.

1. Hypoxia is a condition of low oxygen supply.
  - a. True
  - b. False
2. An absence of oxygen
  - a. may cause cell death
  - b. is known as anoxia
  - c. may cause unconsciousness
  - d. all of the above
3. Gas exchange takes place at the
  - a. vein-artery interface
  - b. long bone joints
  - c. alveolar-capillary membrane
  - d. muscle-nerve junctions
4. The respiratory system does not include which of the following:
  - a. nose
  - b. mouth
  - c. trachea
  - d. heart
5. The circulatory system does not include which of the following:
  - a. mouth
  - b. veins
  - c. arteries
  - d. heart

Review answers are on Page [250](#).

Part 2: Nervous System

Objectives

1. What are the primary components of the nervous system?

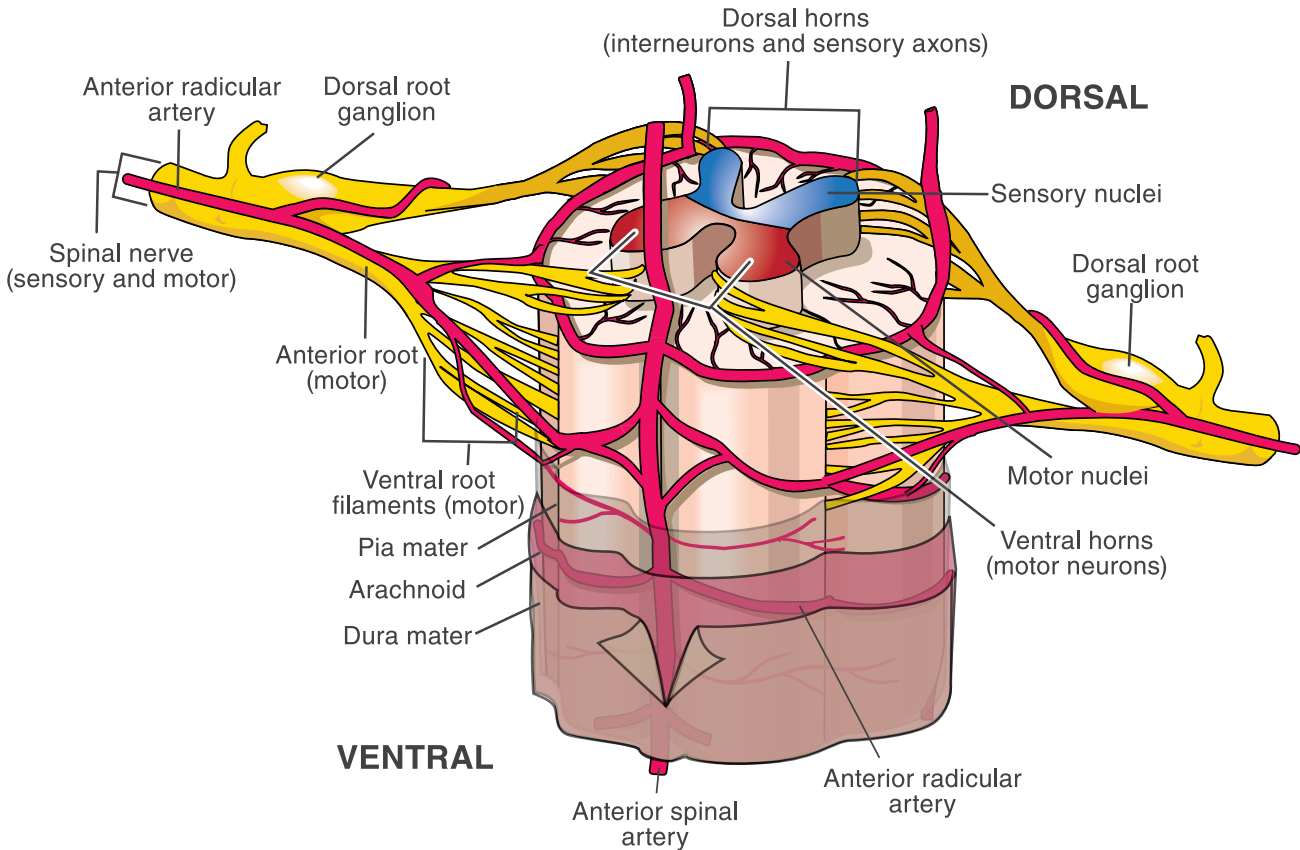
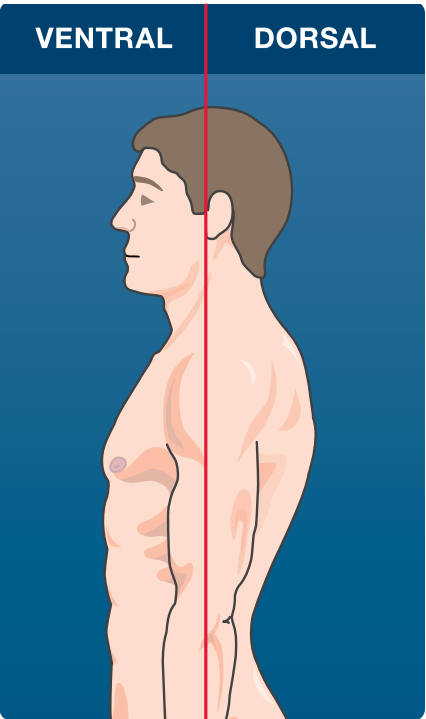
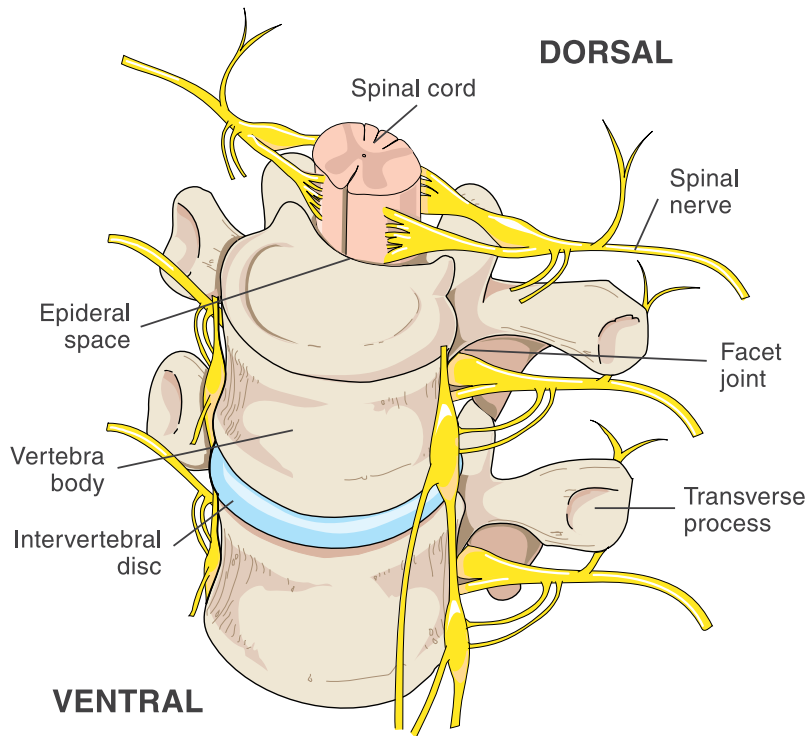
2. What is the functional unit of the nervous system?

3. What are possible causes of interruptions along neural pathways?

The primary components of the nervous system are the brain, spinal cord and nerves. The brain and spinal cord form the central nervous system, and the nerves that extend from the spinal cord or brain out to the body comprise the peripheral nervous system. The functional unit of this system is the nerve cell or neuron.

The spinal cord is the interface between the central and peripheral systems and contains the nerve tracts or columns that conduct impulses either to or from the brain. Sensory tracts travel up the dorsal or posterior columns, and motor tracts are located along the ventral or anterior columns.

Trauma, stroke or decompression illness (DCI) may result in interruptions of nerve pathways at any point along a tract or peripheral nerve and may cause symptoms or signs of neurological injury. This course includes the skills needed to test for and recognize prominent signs of possible neurological compromise.



Review Questions

↑

1. The nervous system consists of the

a. brain, spinal cord and nerves

b. vertebrae and skull

c. heart, lungs and brain

d. head, torso and limbs
2. Neural pathways may be interrupted by

a. stroke

b. decompression illness

c. trauma

d. all of the above

Review answers are on Page [250](#).

### Part 3: Digestive System

**Objectives**

1. What are the main organs of the digestive system?
2. Where does digestion begin?
3. What organs aid in digestion?

The digestive system’s purpose is to turn the food we consume into the nutrients our body uses to produce energy and eliminate waste products from the body.

The digestive system begins with the mouth. The digestive process starts as we chew our food. Saliva begins to break down the food into smaller pieces so the other parts of the digestive system can work to absorb nutrients.

The esophagus begins at the back of the mouth and ends in the stomach. This approximately 10-inch-long tube lies behind the trachea and passes through the diaphragm to terminate in the stomach. Chewed food travels through the throat, or pharynx, then down the esophagus to the stomach.

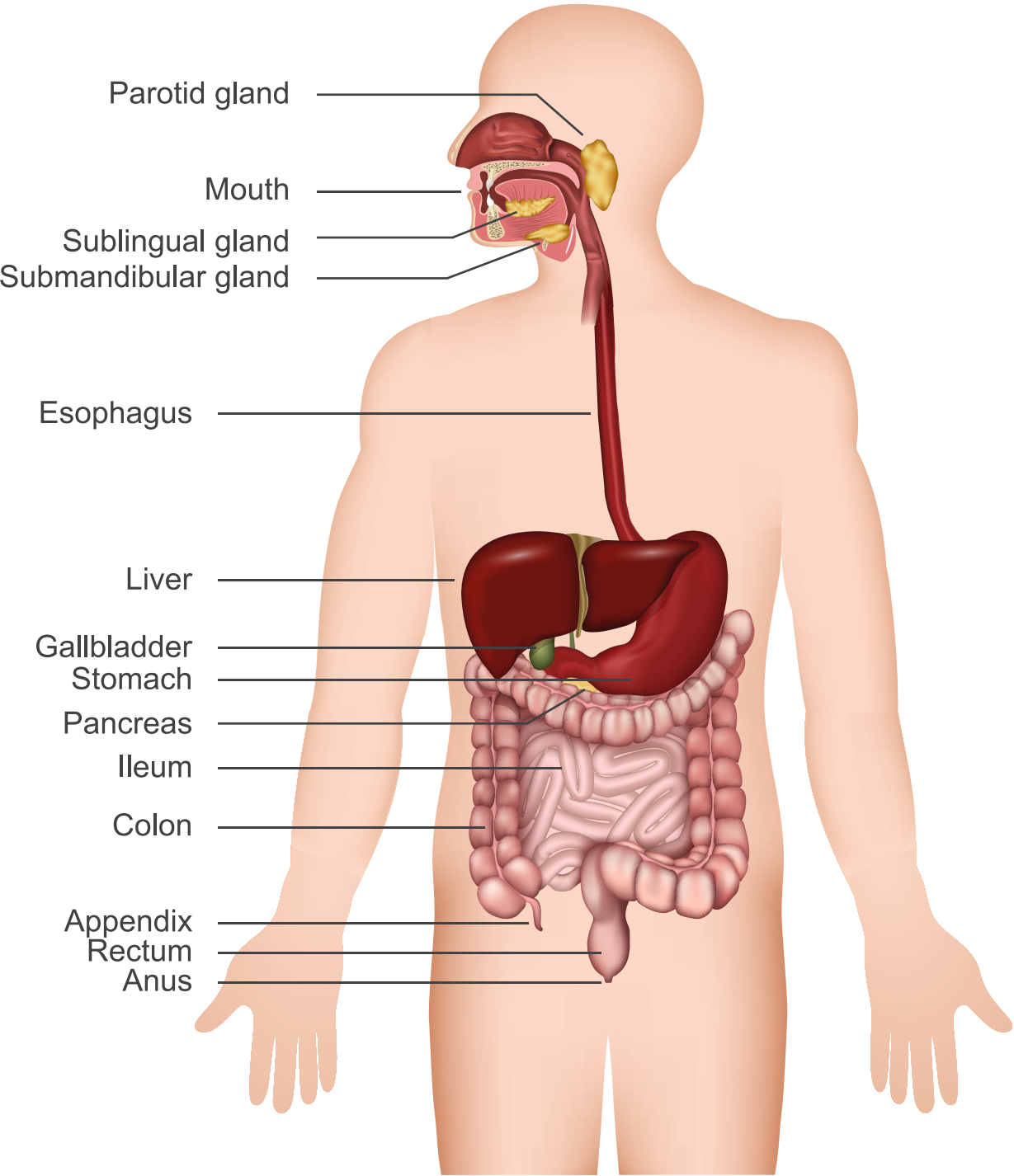
The stomach, one of the main organs of the digestive system, is a hollow organ with strong muscular walls that lies predominately in the abdomen’s upper left quadrant. The stomach secretes gastric acids that are strong enough to dissolve metal. These acids mix with the food to help dissolve it into a mixture called chyme.

From there, the small intestine, another main organ of the digestive system, takes over to carry out the final part of digestion. The small intestine further breaks down the food using bile from the liver and various enzymes from the pancreas. Part of the small intestine, called the jejunum, is where most nutrients are taken up and absorbed by the body. The ileum is where the chyme prepares to enter the large intestine.

Additional parts of the digestive system aid in the process. The pancreas is where the body processes food into energy, such as glucagon and insulin, and produces enzymes that breakdown proteins, carbohydrates and fats. The gallbladder and liver work together to act as a filter that detoxifies the blood; they also carry fats and cholesterol into the intestinal tract.

The final main organ in the digestive system, the large intestine, takes any waste from the digestive process and passes it through the colon, first in a liquid form that is then turned solid. The rectum and anus are the final pieces of the digestive system. The rectum receives the solid stool and signals the brain that the rectum needs to be emptied. The anus helps control that evacuation.

### DIGESTIVE SYSTEM





1. The main organs of the digestive system are:

a. Stomach, small intestine, large intestine

b. Esophagus, liver, gall bladder

c. Mouth, esophagus, stomach, small intestine

d. Liver, gall bladder, anus
2. Digestion begins in the \_\_\_\_\_.

a. Stomach

b. Esophagus

c. Mouth

d. Small intestine
3. Organs that aid in digestion include:

a. Spleen, appendix, gall bladder

b. Heart, lungs

c. Glucagon, insulin, proteins

d. Pancreas, gallbladder, liver

Review answers are on Page [250](#).



Objectives

1. What is oxygen?
2. How much oxygen is in both inhaled and exhaled air as we breathe?
3. How is oxygen transported to body tissues?
4. What is carbon dioxide, and how is it eliminated from the body?
5. What is nitrogen?
6. What is carbon monoxide, and why is it dangerous?

The air we breathe is composed of many different gases. One is critical to our survival; others play a significant role when we breathe under pressure while scuba diving. This chapter provides a brief overview of some of these atmospheric gases and the role they may play under pressure.

Oxygen (O<sub>2</sub>)

Oxygen is a colorless, odorless, tasteless gas that composes approximately 21 percent of the Earth’s atmosphere. It is a vital element for survival and is needed for cellular metabolism. We may experience discomfort, unconsciousness or death within minutes when oxygen supplies are inadequate (hypoxia) or absent (anoxia).

Inhaled oxygen is primarily transported from the alveolar capillaries throughout the body by red blood cells (erythrocytes). Hemoglobin is the oxygen-carrying molecule within erythrocytes responsible for binding both oxygen and carbon dioxide. At rest, humans consume approximately 5 percent of the available 21 percent of oxygen in the air. Exhaled air therefore contains about 16 percent oxygen. These percentages will vary somewhat by individual and level of activity, but they provide a tangible example of oxygen utilization.

This fact has practical importance for rescue breathing, because our exhaled breath contains less oxygen than normal air.

**Note:**

Although exhaled air has lower oxygen content than atmospheric air, this amount is still sufficient for effective rescue breaths.

**Advanced Concepts**

During aerobic metabolism, our cells require oxygen to convert biochemical energy in the form of nutrients (sugar, proteins and fatty acids) into the energy-storage molecule called adenosine triphosphate (ATP). The production of ATP generates water, heat energy and carbon dioxide.

In health care settings, blood oxygen levels are commonly measured with a pulse oximeter. This device, which is often placed over the end of a finger, measures hemoglobin saturation — the percent of hemoglobin binding sites occupied by oxygen — through a color shift between oxygenated and deoxygenated blood states. Normal values while breathing air are 95-100 percent at low to moderate altitudes. Values below this warrant medical attention. Hypoxemia (low levels of blood oxygenation) may necessitate prolonged supplemental oxygen therapy to maintain values within normal levels.

The role of oxygen for diving injuries is to promote inert gas washout and enhance oxygen delivery to compromised tissues. When providing supplemental oxygen to an injured diver, a pulse oximeter is not used as a measure of oxygen treatment effectiveness or as an assessment of inert gas washout.

**Advanced Concepts**

Carbon dioxide is heavily concentrated in blood as bicarbonate ( $\text{HCO}_3^-$ ) and serves a critical role in acid-base buffering. The remaining carbon dioxide is found either dissolved in plasma or bound to hemoglobin.

**Carbon Dioxide ( $\text{CO}_2$ )**

Normal air contains only about 0.04 percent carbon dioxide, which is a waste product of cellular metabolism. Exhaled gas from respiration contains approximately 4-5 percent carbon dioxide. Elevated levels of carbon dioxide in a breathing-gas mixture can lead to drowsiness, dizziness and unconsciousness; this is especially true when diving or breathing under increased atmospheric pressure.

**Note:**

Although exhaled air contains higher levels of carbon dioxide than air, rescue breaths — if performed correctly — should not result in significant elevations in the individual's carbon dioxide levels. In all immersion-related cases in which rescue breaths or other respiratory devices are used (bag valve mask or positive pressure device), supplemental oxygen is recommended.

**Advanced Concepts**

An elevation in exhaled carbon dioxide levels, relative to inhaled air, is an indication of metabolic activity. In some medical settings, carbon dioxide levels in exhaled air are monitored (capnography) and indicate cellular respiration and adequacy of airway management.

**Nitrogen ( $\text{N}_2$ )**

Nitrogen exists in different chemical forms. As a gas, nitrogen composes about 78 percent of the Earth's atmosphere and in this form is physiologically inert, meaning it is not involved in cellular metabolism. In nondivers who remain at a constant ambient pressure, the concentration of nitrogen in the exhaled air is also about 78 percent. In the case of divers who have been breathing inert gas under pressure, the percentage of exhaled nitrogen would be expected to rise above this level while offgassing. Because nitrogen is an inert gas, however, it does not interfere with resuscitation efforts during rescue breathing.

Inert gas absorption (nitrogen and helium) is associated with decompression sickness (DCS). DCS and the role of oxygen are discussed in the next chapter.

**Advanced Concepts**

Ingested or organic nitrogen (taken in as a solid, liquid or supplement) is compounded with hydrogen and other ions to form amines — the foundation of amino acids, which make up proteins. These amine groups are broken down and absorbed by our digestive system but do not enter our tissues or bloodstream as absorbed gas ( $\text{N}_2$ ). As a result, ingestion of amines does not pose a decompression risk or alter our propensity for DCS. The only form of nitrogen that plays a role in DCS is the inorganic gas molecule nitrogen.

Carbon Monoxide (CO)

Certain gases such as CO interfere with tissue oxygen delivery. CO binds more readily to hemoglobin and inhibits both the uptake of oxygen and the delivery to tissues. CO poisoning can lead to fatal tissue hypoxia. Even small amounts of CO in a diver’s breathing gas can be hazardous. Inspired gas partial pressures increase with depth, so even small fractions of CO within a cylinder can become toxic when breathed under pressure. For this reason it is critical to regularly test compressor air purity and quality. The use of portable gasoline-powered air compressors require extra caution because combustion engines generate CO in the exhaust. A diver exposed to elevated levels of CO may exhibit severe headaches, altered levels of consciousness and other neurological symptoms.

Note:

Use of certain lubricants, even with electrically driven compressors, can also release CO.

The body requires a constant supply of oxygen to maintain cellular metabolism. In the absence of oxygen, the body’s cells will rapidly deteriorate and die. Some cells are more sensitive than others to hypoxia. Nervous tissue (forming the brain, spinal cord and nerves) is typically very sensitive and will sustain irreversible damage within minutes of inadequate oxygen delivery.

Review Questions



1. Oxygen is a clear, odorless gas essential to life.  
a. True  
b. False

2. The atmospheric air we inhale contains \_\_\_\_ percent oxygen.  
a. 12  
b. 16  
c. 21  
d. 27

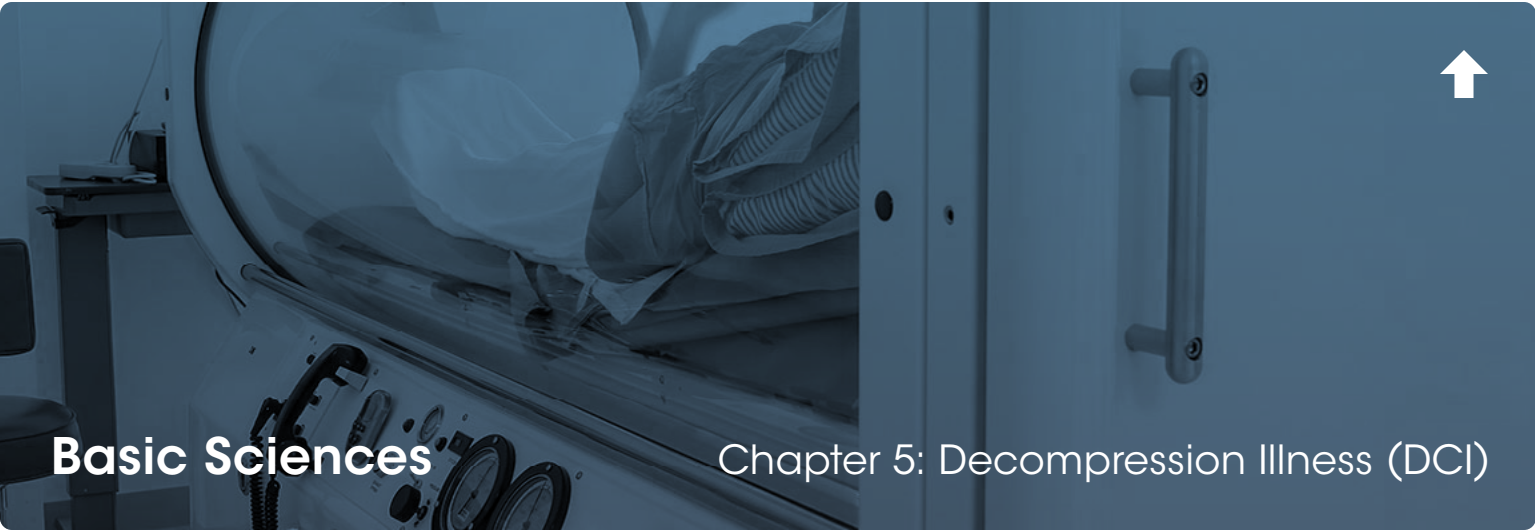
3. The air we exhale contains about \_\_\_\_ % oxygen.  
a. 12  
b. 16  
c. 21  
d. 27

4. Oxygen is carried throughout the body by  
a. white blood cells  
b. red blood cells  
c. bone marrow  
d. blood plasma
5. Carbon dioxide is  
a. a waste product of metabolism  
b. a toxic gas  
c. essential for life  
d. an inert gas

6. Nitrogen comprises \_\_\_\_ percent of atmospheric air.  
a. 21  
b. 27  
c. 67  
d. 78

7. Carbon monoxide is  
a. a waste product of metabolism  
b. a toxic gas  
c. essential for life  
d. an inert gas

Review answers are on Page [250](#).



Objectives

- 1. What are the most important initial actions in responding to diving accidents?
- 2. What is decompression illness (DCI)?
- 3. What is the primary cause of decompression sickness (DCS)?
- 4. What are the primary symptoms of DCS?
- 5. What is arterial gas embolism (AGE)?
- 6. What is the primary risk factor for AGE?
- 7. Why is it important to seek medical evaluation when DCI is suspected?
- 8. What are the most prevalent symptoms of DCI?
- 9. What are the typical onset times of DCS and AGE symptoms?

The term decompression illness (DCI) describes signs and symptoms arising either during or subsequent to decompression, and it encompasses two different but potentially linked processes:

- 1. decompression sickness (DCS)
- 2. arterial gas embolism (AGE)

Note:

While the underlying cause of these two conditions may be different, the initial medical management (first aid) is the same. The most important initial actions performed in diving accidents are early recognition and the use of supplemental oxygen.

Decompression Sickness

DCS results from bubbles formed within tissues or blood from dissolved inert gas (nitrogen or helium). The size, quantity and location of these bubbles determine the location, severity and impact on normal physiological function. Besides the anticipated mechanical effects that can cause tissue distortion and blood-flow interruption, bubble formation may trigger a chain of biochemical effects. These include activation of clotting mechanisms, systemic inflammation, leakage of fluids out of the circulatory system and reactive vasoconstriction. These effects may persist long after bubbles are gone and may play a significant role in the duration and severity of clinical signs and symptoms.

While the effects of bubbles have an impact on us on a systemic level, specific signs and symptoms are thought to result from either bubble accumulation or its impact on specific areas. Examples include joint pain, motor or sensory dysfunctions and skin rash.

The mild or ambiguous nature of some DCS symptoms may result in denial on the part of some injured divers. The assessments and tools offered during this course may help with motivation for providers as well as injured divers to pursue first aid care and follow-up treatment.

DCS is generally only life-threatening with extreme exposures. Early treatment with high concentrations of oxygen (as close to 100 percent as possible) has been shown to speed symptom resolution and optimize the impact of recompression therapy.<sup>4</sup> Though symptom resolution is a desired effect of oxygen first aid, it is important to emphasize that it should not be considered a definitive treatment or arbitrarily stopped when symptoms resolve.

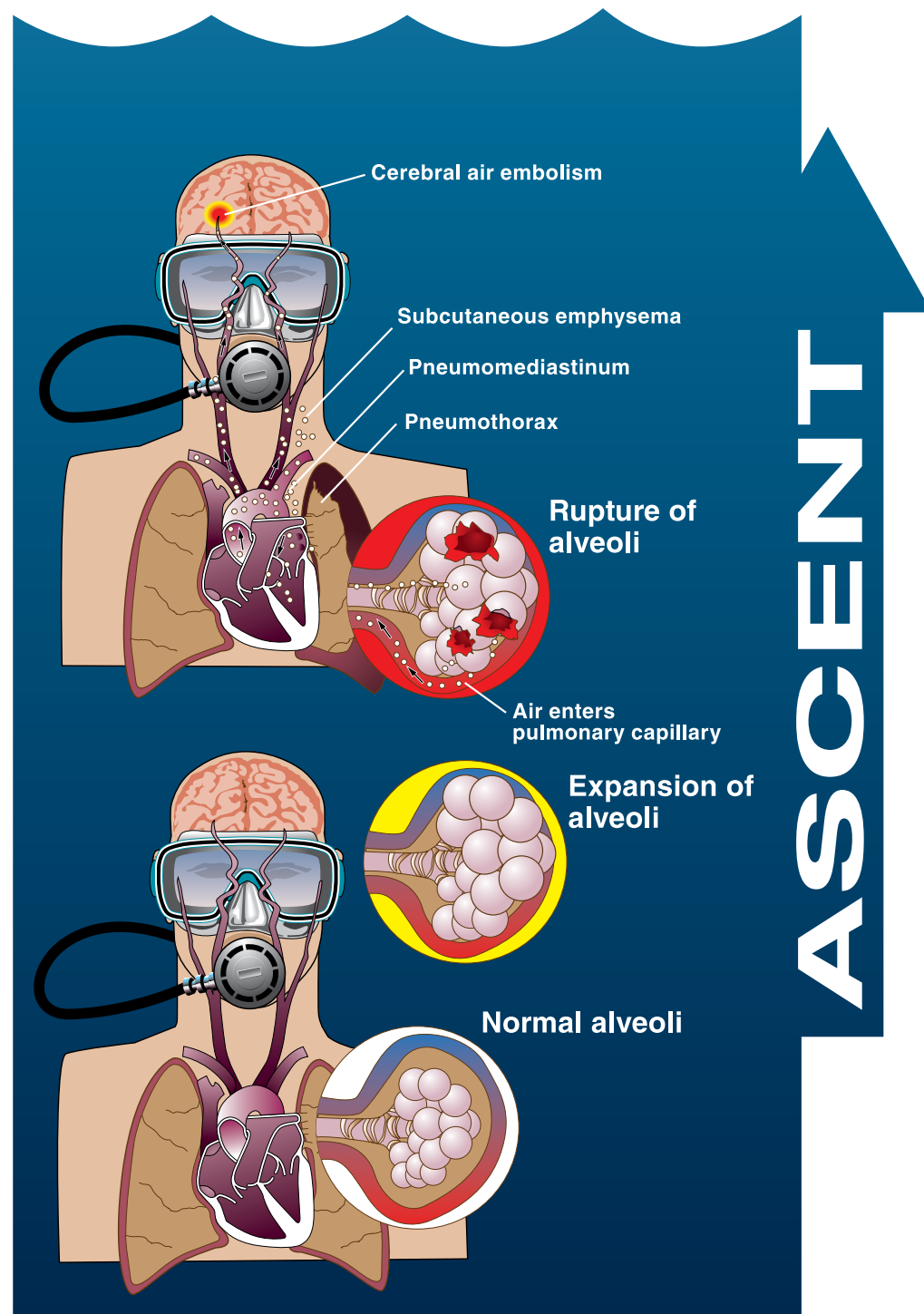
Important aspects to remember about DCS include:

- Symptom onset occurs after surfacing or, in some extreme exposures, well into ascent.
- Factors contributing to bubble formation include the degree of supersaturation (the amount of excess inert gas), rapid ascent and decreasing ambient pressure (such as when flying or driving to altitude after diving).
- The development of DCS symptoms may differ substantially among individuals; symptoms may be subtle or obvious.
- Multiple areas of the body may be involved.

Arterial Gas Embolism (AGE)

AGE in divers typically results from a lung-overexpansion injury. The greatest risk for this injury occurs in shallow water and may result from breath-holding in as little as 1.2 meters (4 feet) of seawater. Lung-tissue trauma can allow the entrance of breathing gas into the blood vessels returning to the heart (pulmonary veins). These bubbles, if transported to the brain, can cause rapid and dramatic effects.

AGE is the most severe result of pulmonary barotrauma and often presents suddenly either near or at the surface.



Pulmonary barotrauma with subsequent AGE and representation of brain (cerebral) injury. Recreated by Divers Alert Network from *Lancet* 2011; 377: 154.

**Any suspicion of neurological symptoms should prompt immediate oxygen therapy and transportation to a medical facility.**

The primary risk factor for AGE is breath-holding during ascent. Other potential risk factors include underlying conditions such as lung infections and preexisting diseases such as asthma that may increase the risk of air trapping.

It is important to state that not all pulmonary tissue injuries result in AGE (this includes lung-overexpansion injuries in divers). Pulmonary trauma from stab wounds, projectiles or blunt force can also lead to lung-tissue damage and enable the escape of intrapulmonary (within the lungs) air without causing arterial bubbles. Signs of pulmonary barotrauma include extra-alveolar air (air outside the lungs) such as a pneumothorax, subcutaneous emphysema (air beneath the skin), mediastinal emphysema (air in the mediastinum) and pneumopericardium (air trapped around the heart).

Depending on the location of gas collection, signs and symptoms may include chest pain, changes in voice pitch, difficulty breathing or swallowing, gas bubbles felt under the skin (typically around upper thorax, neck and/or face) and cyanosis (bluish coloration of the lips).

### Advanced Concepts

A separate but related concern is AGE that occurs secondary to venous bubbles bypassing the pulmonary filter and entering the arterial system directly. The process through which blood passes from the right side of the circulatory system to the left and bypasses the pulmonary filter is called shunting — in this case, right-to-left shunting. Shunting may occur through a physiologically relevant PFO or passage through the lungs (transpulmonary shunt). Regardless of the method, problems can occur when bubbles enter the arterial circulation. Bubbles may affect the central nervous system (CNS) and cause acute neurological symptoms. Symptom onset in this scenario could develop after a longer interval than the 10-15 minutes typically described in cases of AGE since the source of the arterialized bubbles is from the venous system and not pulmonary barotrauma. It is important to note that while bubbles in the systemic circulation are undesirable, their presence does not automatically cause symptoms. Bubbles have been visualized in the left heart following decompression in subjects who have not developed symptomatic DCI.

### Common Signs and Symptoms of DCI

While providing emergency oxygen to injured divers, you may see their condition change with time. In the case of complete symptom resolution, continue oxygen administration, and seek medical attention regardless of perceived improvement.

Injured divers may have one or more of the following signs and symptoms. This list is ranked in order of presentation frequency based on decompression illness of 2,346 recreational diving accidents reported to Divers Alert Network from 1998 to 2004.

• **Pain** (initial symptom in 41 percent of cases)

Commonly associated with neurological symptoms, the pain has been characterized as a dull, sharp, boring or aching sensation in or around a joint or muscle. It may begin gradually and build in intensity or be so mild that it is disregarded.

- Movement of the effected joint or limb may or may not make a difference in the severity of the pain. The pain may be out of proportion to the amount of work or exercise performed and may be referred to as unusual or just “different.”
- DCI pain can be difficult to distinguish from normal aches and pains. Symptoms can mimic other illnesses such as viral infections, muscle or joint pain, fatigue from exertion and other nonspecific discomforts.

• **Paresthesia/Numbness** (initial symptoms in 27 percent of cases)

Paresthesia/anesthesia/dysesthesia are terms that refer to altered sensations and may present as abnormal sensation (paresthesia), decreased or lost sensation (anesthesia) or hypersensitivity (dysesthesia). Paresthesia is commonly characterized as a pins-and-needles sensation. These altered sensations may affect only a small patch (or patches) of skin and may go unnoticed by the diver until they are revealed by a thorough medical evaluation. A diver may complain that an extremity has “fallen asleep” or a “funny bone” has been hit. Numbness and tingling most often occur in the limbs and may be associated with complaints such as a cold, heavy or swollen sensation.

• **Constitutional symptoms** (initial symptoms in 14 percent of cases)

These are generalized symptoms that do not affect a particular part of the body. Examples include extreme fatigue, general malaise and nausea.

- Extreme fatigue: It is not unusual to be fatigued after a scuba dive or other physical activity. The fatigue associated with DCI is typically more severe and out of proportion with the level of exertion required by the dive. The diver may want to lie down, sleep or ignore personal responsibilities such as stowing gear or cleaning equipment.

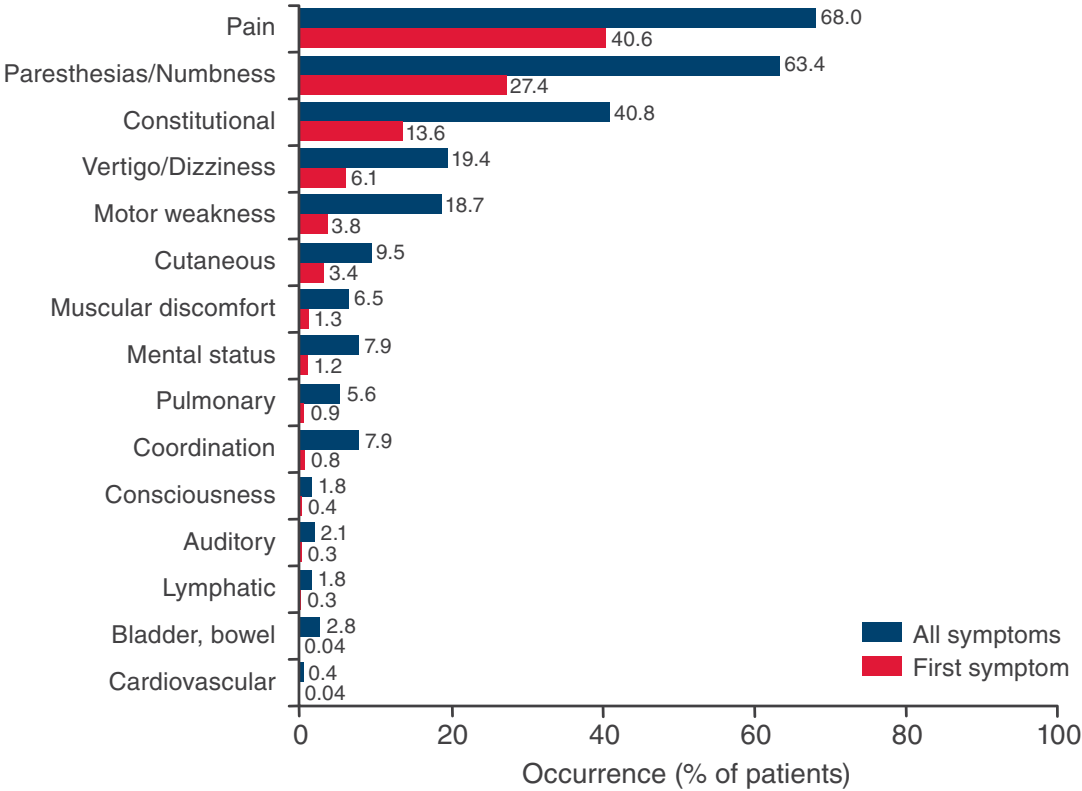
• **Vertigo/Dizziness** (initial symptoms in 6 percent of cases)

Vertigo: Vertigo is generally described as an acute “sensation of spinning” (i.e.,the environment moves around the diver or the diver around the environment), merry-go-round, drunkenness, or being off-balance. Vertigo presenting during or after the dive should be considered a serious symptom suggesting inner-ear/vestibular involvement.

- There are several causes for such symptoms that are not related to DCI. These include round- or oval-window rupture (associated with difficulty equalizing), alternobaric vertigo (each ear experiencing a different pressure exposure) and caloric vertigo (each ear experiencing a different temperature exposure).
- Dizziness: Dizziness is a feeling of unsteadiness, which may also be characterized as lightheadedness, and is commonly associated with nausea.

• **Motor weakness** (initial symptom in 4 percent of cases)

This symptom may present as difficulty walking due to decreased muscular strength or limb paralysis.



Classification and frequency distribution of initial and eventual manifestations of decompression illness in 2,346 recreational diving accidents reported to Divers Alert Network from 1998 to 2004

• **Cutaneous (skin) symptoms** (initial symptom in 3 percent of cases)

Skin signs are often located on the chest, abdomen, back, buttocks or thighs. Rashes commonly migrate (move to different parts of the body). Effected areas may be tender or itch and are thus often confused with allergies or contact dermatitis.

• **Altered mental status** (initial symptom in 1.2 percent of cases)

Symptoms may include confusion, personality changes or speech disturbances (slurring of words or nonsensical speech).

• **Pulmonary issues** (initial symptom in 0.9 percent of cases)

Difficulty breathing may be the result of pulmonary barotrauma or a severe form of DCS known as the chokes (a rare but life-threatening condition caused by an overload of venous gas emboli that severely affects cardiorespiratory function). There are also many other causes of respiratory compromise not necessarily related to or associated with DCI — all of which should prompt medical evaluation.

• **Coordination/cerebellar function** (initial symptom in 0.8 percent of cases)

Cerebellar function controls the coordination of the body’s voluntary movements. Although lack of coordination rarely appears as an initial DCS symptom, it is a common clinical finding on exam and generally associated with a form of neurological DCS. It can be manifested as the inability to walk a straight line or decreased motor function and control.

**Any suspicion of neurological symptoms should prompt immediate oxygen therapy and transportation to a medical facility.**

## Other Signs and Symptoms of DCI

- **Altered level of consciousness:** Identified as an initial symptom in 0.4 percent of cases
- **Lymphatic DCS:** Identified as an initial symptom in only 0.3 percent of cases, it deserves mention because this symptom does not immediately resolve with successful recompression treatment. It is often characterized by localized swelling affecting the trunk and shoulders.
- **Audiovestibular or inner-ear DCS:** This is an alteration of balance or hearing that can be associated with vertigo.
- **Visual disturbance:** Loss or blurring of vision or loss of visual fields
- **Bowel and bladder issues:** Spinal cord DCS may injure the nerves responsible for bladder and bowel control. Urinary catheterization is often indicated to relieve injury to the bladder.
- **Cardiovascular issues:** Hypotension and/or chest pain caused by bubbles within the chambers of the heart or extravascular bubbles around the heart can be the result of pulmonary barotrauma as well as a compression or tension pneumothorax.
- **Convulsions are rare.**

## Epidemiology of DCI and DCS

DCI is an uncommon event that nonetheless warrants attention and concerted efforts to prevent. Based on 441 confirmed or possible incidents of DCI referenced in the *2008 DAN Annual Diving Report*, 3.9 percent were classified as possible AGE.<sup>5</sup>

The occurrence of DCS varies by population. Based on DAN data, the per-dive rate among recreational divers is 0.01-0.019 percent; among scientific divers it's 0.015 percent; for U.S. Navy divers it's 0.030 percent; and for commercial divers it's 0.095 percent.<sup>5,6</sup>

Previously published per-dive DCS rates based on 135,000 dives by 9,000 recreational divers were 0.03 percent. This rate was higher in those who performed deep cold-water wreck dives versus the group aboard warm-water liveaboards. The incidence of DCS from warm-water liveaboards was 2/10,000 (0.0002) and among cold-water wreck divers in the North Sea 28/10,000 (0.0028).<sup>7</sup>

## Symptom Onset

While the timing of symptom onset varies, the majority of people complain of DCS symptoms within six hours following a dive. Symptom onset may be delayed by as much as 24 hours, though beyond this time frame the diagnosis becomes increasingly questionable.

In contrast to DCS, AGE will typically show a more dramatic array of neurological symptoms, most of which will show up immediately upon surfacing or within 15 minutes of the time of injury. As one might expect, sudden neurological injury that leads to unconsciousness may result in drowning.

## Oxygen and the Importance of Proper Medical Evaluation of DCI

The diagnosis of DCI is based on history and clinical findings — there is no diagnostic test. Symptoms can range from very mild to severe and, particularly in the former case, may be dismissed by divers or appear to resolve by the time medical care is sought.

In some cases the use of oxygen leads to symptom resolution, which may prompt the decision to forego medical assessment. DAN recommends seeking prompt medical evaluation in all cases of suspected DCI regardless of the response to oxygen first aid. For those tempted to avoid medical assessment, be advised that symptoms may recur, and the risk of recurrence may be reduced with hyperbaric treatment.

## Recompression Therapy

An injured diver may feel better or experience reduced symptom severity after receiving emergency oxygen. Despite symptom improvement, and in some cases resolution, divers should still seek medical evaluation. The primary medical concern is that symptoms (especially neurological symptoms) may recur when supplemental oxygen therapy is stopped. This is one of the reasons DAN recommends transportation to the nearest medical facility for evaluation and not necessarily to the nearest hyperbaric chamber.

This is advised for several reasons.

- Only a small number of hospitals are equipped with hyperbaric chambers.
- Many hospitals with hyperbaric chambers are not equipped to treat diving injuries 24 hours a day. It takes time to assemble a chamber crew for treatment of a diving injury.
- Before accepting the transfer of an injured diver, many hospitals require a referral from DAN or a physician.
- Some chambers are open only when they have patients.
- Some chambers are not equipped to treat divers.

Every dive injury is unique, and crucial medical decisions must be made individually by a physician trained in dive medicine. The decision about where to treat an injured diver can be made only after a thorough medical evaluation and appropriate consultation. DAN is always available to provide information to emergency medical staff regarding diving injuries and the potential benefit of hyperbaric treatment. DAN also provides evacuation assistance and care coordination with

treating facilities. Prolonged treatment delays, usually measured in days, may reduce the effectiveness of treatment and may extend the time needed to achieve optimal symptom resolution. It should be understood, however, that in the majority of less severe cases, minor delays of a few hours rarely affect the final treatment outcome.

### Residual Symptoms

Residual symptoms following hyperbaric oxygen treatment are not uncommon, especially in severe cases or when considerable delays (sometimes measured in days) in treatment initiation have occurred.

Divers who experience persistent symptoms following hyperbaric oxygen therapy should remain under the care of a hyperbaric physician until symptoms have resolved or further therapy is deemed either unnecessary or unlikely to provide further benefit. A decision to return to diving should be made in consultation with a physician knowledgeable in dive medicine.

## Review Questions



- Decompression illness includes
  - decompression sickness
  - arterial gas embolism
  - both of the above
- The most important initial actions in responding to diving accidents are to recognize there is a problem and to administer 100 percent oxygen.
  - True
  - False
- DCS is caused by
  - breath-hold during descent
  - breath-hold during ascent
  - inert gas bubbles in the body
- The primary risk factor for AGE is
  - breath-hold during descent
  - breath-hold during ascent
  - inert gas bubbles in the body
- It is important to seek medical evaluation when DCI is suspected because
  - symptom resolution does not mean DCI is no longer present
  - symptoms may recur
  - risk of recurrence may be reduced by hyperbaric treatment
  - all of the above
- The single most common symptom of DCI is
  - numbness
  - constitutional (fatigue, nausea)
  - muscle weakness
  - pain
  - balance/equilibrium
- Initial DCS symptoms
  - occur within 15 minutes of the time of injury
  - typically occur within six hours of surfacing
  - may be delayed up to 24 hours
  - both b and c
- AGE symptoms
  - occur within 15 minutes of the time of injury
  - typically occur within six hours of surfacing
  - may be delayed up to 24 hours
  - both b and c
- People who received first aid for suspected DCI should always receive a follow-up evaluation by a dive medicine physician.
  - True
  - False
- Returning to diving following DCI should be done in conjunction with a physician knowledgeable in dive medicine.
  - True
  - False

**Review answers are on Page [250](#).**

### Disease Transmission

For diseases to be transmitted, four things must converge:

- An infectious pathogen
- A sufficient quantity of the pathogen
- Exposure to a susceptible host
- A site of entry/mechanism of transmission

Disease-transmission mechanisms include direct and indirect contact, airborne or vector transmission.

- **Direct** — transfer of a disease agent by person-to-person contact such as touching, biting, kissing, through an open wound and sexual contact
- **Indirect** — transfer of a disease agent through an inanimate object such as clothing, utensils, furniture or doorknobs
- **Airborne** — transfer of a disease agent by droplets containing pathogens subsequently inhaled by another person (Sneezing or coughing by an infected person produces airborne pathogens.)
- **Vector** — transfer of a disease agent via an insect bite (e.g., Lyme disease)

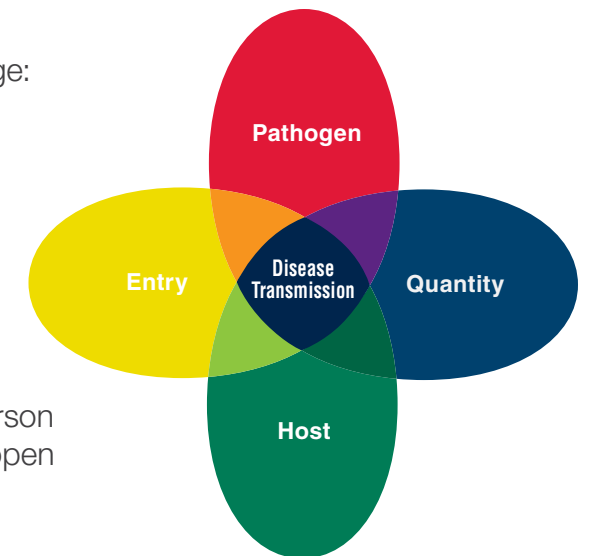
The first three mechanisms of disease transmission are the most common modes of infection in the marine/aquatic environment. Bloodborne pathogens are the specific concern for the first aid provider because blood exposure presents the greatest risk. But the presence of blood is not always as clearly visible as in a cut or wound. It may be present in vomit, urine and feces. Other body fluids can also contain pathogens of concern, although their level of risk is much lower. Simple prevention by avoidance of direct contact is the most effective means of minimizing the risk of infection.

### Prevention

Prevention is the best protection. For this reason, first-aid courses focus heavily on use of personal protective equipment (PPE) such as gloves, eye shields, masks and other barrier devices. (PPEs are covered in Chapter 9: Scene Safety Assessment and Standard Precautions.)

Prevention strategies also include thorough washing after any contact with potentially infectious materials and avoiding handling contact lenses, eating or drinking in exposure areas. With the exception of petroleum- or oil-free hand creams, the use of cosmetics should be avoided in these areas.

In some environments you may need protective clothing as barrier devices. If barrier gowns, scrubs or other protective garments are used, the facility will provide them and either dispose of or launder them after use. Such garments should not be worn outside the exposure area. Doing so increases the risk of spreading diseases beyond the controlled exposure areas.



### Objectives

1. What is the purpose of the OSHA Bloodborne Pathogens Standard?
2. What four things must be present for disease transmission to occur?
3. How is disease transmission prevented?
4. What action should you take if you think you may have been exposed to a bloodborne pathogen?
5. What is zoonosis?
6. What is required when diving in contaminated water?

The U.S. Occupational Safety and Health Administration (OSHA) was created in 1970 “to ensure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.”<sup>8</sup> The Bloodborne Pathogens (BBP) Standard in OSHA regulations applies to employees who may come into contact with human blood, bodily fluids, body tissues or organs while carrying out their occupational duties. The primary purpose of the BBP required training is to assist you in understanding the need for protection from bloodborne pathogens, the options for meeting that need, and what to do if an exposure occurs.

Given the wide variety of entities that use the DFA Pro course for their training needs, most of the BBP information that follows is very generic. If applicable, facility-specific protocols will be covered by authorized individuals within your company to provide the details needed for your specific operation.

### Engineering Controls

Permanent facilities such as aquariums or some commercial diving operations will have stations in designated high-risk areas to facilitate hand washing, eye flushing, and disposal or isolation of contaminated instruments, especially sharps. Field stations or mobile operations will have other options to meet such needs. All options address the requirement to control exposure and minimize the risk of infection.

Three areas should be clearly designated:

- First aid equipment/hand-washing/eye-flush stations
- Hazardous materials disposal (used gauze or bandages, blood-spill kits)
- Areas for eating, drinking, food storage, and cosmetics use

### Exposure Control Plan

Each facility that falls under OSHA regulations is required to have an exposure control plan (ECP). This plan is tailored to the specific needs of the individual facility; the designated safety or OSHA Compliance Officer will provide details for your center.

The ECP addresses the use of PPE as well as how contaminated materials are to be handled and properly disposed of. Vaccinations against some BBP, such as Hepatitis B, may be recommended. If so, protocols for receiving vaccinations are covered as part of this plan, as are the steps to be taken if an exposure occurs, including follow-up procedures.

Documented annual ECP reviews with all personnel are required. The facility is responsible for all record keeping and documentation. You will be advised if your facility is exempt from these protocols.

### Epidemiology

There are three specific human bloodborne viral pathogens of which first aid responders should be aware: Hepatitis B, Hepatitis C and human immunodeficiency virus (HIV).

#### Hepatitis B

Hepatitis B virus (HBV) attacks the liver and may cause both acute and chronic disease. Those infected with the HBV are themselves potentially infectious.<sup>9</sup> Fewer than 5 percent of otherwise healthy people infected with HBV as adults will develop chronic liver disease. The percentage is higher in children infected before age 5. Roughly 20 to 30 percent of adults with chronic infections will develop cirrhosis and/or liver cancer.

- **Transmission.** HBV is transmitted via blood and other bodily tissues including blood transfusions, needle sticks, tattooing and piercing, as well as intravenous drug use and sexual intercourse (vaginal fluids and semen). HBV is very contagious; one in three people exposed to the virus from a puncture wound with a contaminated object will become infected. The virus is also very stable on surfaces outside the body. It can last for up to seven days, making decontamination and clean up very important. There is a vaccine available for HBV that is 98-100% effective and is required of most health care workers.



- **Symptoms.** Most people do not experience symptoms when newly infected. Acute symptoms can last for several weeks. Symptoms may include:
  - Yellowing of the skin and eyes (jaundice)
  - Extreme fatigue
  - Dark urine
  - Nausea and vomiting
  - Abdominal painFor some people, symptoms may persist for several months or up to a year.

#### Hepatitis C

Hepatitis C virus (HCV) is another bloodborne pathogen that can cause severe liver damage. Of those infected with HCV, about 30 percent of infected people spontaneously clear the virus in six months without treatment. Antiviral medications cure more than 95 percent. The remainder have a 15 to 30 percent risk of developing cirrhosis within twenty years.<sup>10</sup>

HCV may cause a relatively mild acute illness or jaundice. Approximately 80 percent of people do not exhibit symptoms, and symptoms may take 2 weeks to 6 months to manifest. Acute symptoms are similar to those of Hepatitis B. Even chronic disease may remain asymptomatic.

- **Transmission.** Routes of transmission/infection are the same as for HBV. The most common source for infection is seen in people who share injection equipment or reuse needles. HCV has also been contracted from blood transfusions (prior to July 1992), needle sticks in health care settings and through sexual intercourse.<sup>10</sup>
- **Symptoms.** People infected with HCV are potentially infectious even if asymptomatic. Symptoms for HCV include:
  - Fever
  - Fatigue
  - Decreased appetite
  - Nausea and vomiting
  - Abdominal pain
  - Dark urine
  - Gray colored feces
  - Joint pain
  - Yellowing of skin and eyes (jaundice)

#### HIV/AIDS<sup>11</sup>

The human immunodeficiency virus (HIV), which causes acquired immunodeficiency syndrome (AIDS), attacks the immune system and impairs the body's ability to fight infections.

- **Transmission.** HIV can be transmitted from person to person through contact with infected blood and bodily fluids, including breast milk. HIV cannot be transmitted through casual contact. A puncture-wound exposure from an infected source has an infection risk of 1 in 300. There currently is no immunization or known cure for HIV. However, treatments are available that have been successful in suppressing the virus, reducing its transmission.

- **Symptoms.** People infected with HIV may remain asymptomatic for 2 to 15 years years but can still pass the infection to others. Most infected people develop antibodies within 28 days. Once infection has been confirmed, retesting and treatment options should be pursued. Some of the potential signs and symptoms of infection include:

The first few weeks after initial infection may be characterized by influenza-like illness including fever, headache, rash or sore throat.

As the infection progresses symptoms may include:

- Swollen lymph nodes
- Weight loss
- Fever
- Diarrhea
- Cough

## If You Have Been Exposed

If you believe you have potentially been exposed to a bloodborne pathogen, follow these steps:

- If there is an open wound, **do not milk it** and encourage it to bleed.
- Wash the wound with soap and water.
- Wash potentially contaminated material off your skin as quickly as possible with soap and water. This is especially important when your skin has cuts, rashes or scrapes.
- For splashes in your face, flush potentially contaminated material from the mucous membranes of your eyes, nose and mouth using large amounts of running water.
- Report the injury per the protocol outlined in your company's emergency action plan.
- Seek medical evaluation and counseling regarding exposure at a local medical facility (emergency department).

## Zoonosis

In the marine environment there is also concern about transmission of diseases or infections from marine life to humans. Zoonosis is a general term describing diseases carried by vertebrate animals and contractible by humans. This disease group is not technically part of bloodborne pathogens; however, many of the same disease transmission concerns and prevention measures apply. Therefore, it is practical to address them here.

- **Transmission.** These diseases can be transmitted via direct contact, handling of contaminated inanimate objects or aerosols. Zoonotic diseases result from infection by bacteria, fungi or protozoa. Human infection typically occurs through penetrating wounds but can occur through existing open wounds, ingestion, inhalation or contact with mucous membranes. The possibility that any animal or habitat may be carrying a zoonotic disease should be considered when planning diving activities.
- **Symptoms.** Symptoms will vary with the specific disease but may include itching, rashes, nodules, inflamed lymph nodes, nausea, diarrhea and fever. Any symptoms should be evaluated by a health care provider.

- **Prevention.** Use of protective clothing is recommended when around animal areas. Cuts, abrasions and other open wounds should remain covered when the possibility of contact may occur. Injuries incurred should be thoroughly cleaned and monitored for symptoms. Diving activity is discouraged until adequate healing has occurred.

Thoroughly wash all areas in direct contact with animals or their habitat following exposure. Full showers as soon as possible after any diving activity are recommended. To reduce the risk of inadvertent ingestion of infectious matter, avoid eating or drinking in areas where animals are or have been present.

## Contaminated Water and Chemicals

Exposure to contaminated water and chemicals is a common risk faced by some professional divers, including commercial and public safety divers; this requires specialized training that is beyond the scope of this course.

Hazardous-material and contaminated-water training is available through emergency and disaster training agencies. A number of resources are provided in the back of this book for those interested or in need of this kind of training.

Whatever care you provide, particularly as it relates to emergency and disaster response, act within the scope of your training and preparation and with the appropriate equipment. Do not put yourself in danger.



1. The OSHA Bloodborne Pathogens Standard exists to

a. ensure safe and healthful conditions for working men and women

b. set and enforce standards

c. provide training, outreach, education and assistance guidelines

d. all of the above
2. Disease transmission occurs when which of the following is present?

a. an infectious pathogen

b. sufficient quantity of the pathogen

c. exposure to a susceptible host

d. site of entry/mechanism of transmission

e. all of the above
3. Disease transmission can be prevented by

a. personal protective equipment

b. thorough hand washing

c. engineering controls

d. all of the above
4. If you think you may have been exposed to a bloodborne pathogen, you should

a. cover it tightly to protect it

b. milk it to make it bleed

c. report it according to your organization's emergency action plan

d. both b and c

e. all of the above
5. Zoonosis is a generic term describing diseases transmitted from vertebrate animals to humans.

a. True

b. False
6. Specialized training is required when diving in contaminated water.

a. True

b. False

Review answers are on Page [250](#).



Objectives

1. What elements are included in an emergency action plan?
2. Why is transport to a medical facility instead of to a hyperbaric chamber the best course of action in a dive emergency?
3. What emergency equipment should be readily available as part of an emergency action plan?

Accidents will happen. As a dive professional or volunteer, you are expected to be prepared and to recognize signs and symptoms of various injuries or illnesses. Once you have completed all sections of this course, you will have the skills required to provide appropriate interventions. Support your skills with proper preparation. This includes emergency action planning, equipment preparation and regular drills with response teams.

Emergency Action Plan

An emergency action plan (EAP) consists of many elements. Thorough planning will reveal specific elements that should be included in your company's EAP. A well-prepared EAP can be a vital resource and save valuable time. In addition, it may also enable others to assist.



In its simplest form, an EAP provides directions for activating emergency medical services (EMS) and facilitating entry into care. In larger organizations, there may be action teams to which specific tasks are assigned to ensure a quick and efficient response to an incident. Meeting or collection points/zones for evacuation of an injured diver and a required chain of notification will also be a part of more involved EAPs.

Regular review of an EAP should be conducted to be sure it is up to date and essential elements have not changed over time.

Basic elements of an EAP include:

- Locations of all emergency kits and supplies
- Communication equipment and how to use it
- Local resources
  - Local EMS contact information
  - Location of the nearest medical facility
  - Transportation options to the nearest medical facility
- Directions for EMS to get to your location if required
- **DAN's Emergency Hotline number is +27 828 10 60 10** for emergency medical consultation
- Method for documenting signs and symptoms of injury/illness and aid rendered

You will also need to be able to record information about the injured diver. Include the following information:

- Diver's name, address and DAN Member number if available
  - Include gender (and age, if available)
- Emergency contact information
- Diver's medical history (see **S-A-M-P-L-E** in Chapter 12)
- Current complaint (signs and symptoms)
  - Progression of signs and symptoms
- Assessments conducted and what interventions were rendered
- Dive profile information
  - How many days of diving
  - Number of dives
  - Maximum depth
  - Surface interval times
  - Gas used for diving (air, nitrox — include percentage, trimix — mix percentages, other)
  - Open circuit or rebreather

You may also want to include steps for providing care. In an emergency it is not uncommon for anxiety to overwhelm thought processes, inhibiting the action of providers. First aid slates and dive accident management slates should be kept with emergency equipment and used in rendering care.

### Medical Facility vs. Hyperbaric Chamber

If you must transport an injured diver, go to the nearest appropriate medical facility, not to a hyperbaric chamber. Medical evaluations must be completed before hyperbaric treatment. Not all dive-associated injuries or illnesses require hyperbaric intervention, and not all hyperbaric facilities treat divers.

Other reasons to start with a medical facility include:

- Before accepting the transfer of an injured diver, many chambers require a referral from DAN or a physician.
- Many chambers are not staffed 24/7. Assembling a crew often takes time.
- The chamber may already have a patient under care and therefore may not be available.

By starting with a medical evaluation and contacting DAN Medical Services, unnecessary delays can be avoided. DAN Medical Services can assist a local physician or involve a physician trained in dive medicine in evaluating the individual. If the need for a chamber is identified, DAN can also assist in locating an available chamber. **DAN's Emergency Hotline number is +27 828 10 60 10.**

### Emergency Equipment

**First aid kits.** Another essential item for dive-accident management is a first aid kit that is appropriate for its intended use and the location of diving activity. Many kits are commercially available, or you can assemble one yourself. In choosing or assembling a first aid kit, consider the types of marine life in the diving environment and any special first aid requirements that may be warranted. Whether commercially or personally assembled you should familiarize yourself with the contents of the first aid kit and other kits or equipment to which you will have access during any dive excursion.

The following items should be included, at a minimum, in a standard first aid kit:

- Protective case (waterproof if used in wet environments)
- Resuscitation barrier device (face shield or mask)
- Nonlatex examination gloves
- Cleansing wipes
- Sterile saline for wound irrigation
- Bandages
- Sterile dressings (various sizes)
- Sterile gauze
- Sterile eye pads
- Adhesive tape
- Scissors (strong enough to cut away clothes)
- Triangular bandage
- Safety pins



- Tweezers
- Adhesive dressings (several sizes)

Optional, but recommended:

- Wound-closure strips (Steri-Strips)
- Isothermal blanket
- Irrigation syringe
- Infectious waste bag
- Penlight
- Splint to immobilize fractures
- Thermometer
- NuMask® or oronasal resuscitation mask
- Disposable razor
- First aid manual
- Cold and hot compresses
- A list with emergency numbers
- Tourniquet or materials to improvise a tourniquet
- Hot and/or cold packs

Medications and ointments may also be helpful but may require input from your doctor to ensure appropriate use. While we have provided suggestions for some common over-the-counter medication, first-aid providers are not legally authorized to dispense medications or share their own prescriptions.

Recommended medications include:

- Antiseptic solution
- Antihistamine tablets
- Eyewash
- Antibiotic ointment
- Hydrocortisone ointment
- Pain reliever

**Oxygen units.** An appropriate oxygen unit is essential for dive accident management and should be available at every dive site, whether confined water or open water. Oxygen units are discussed in detail later in this course. Appendix 1 lists several DAN oxygen units that are available.



Remember to check components regularly. Replace any items that have expired or have been used. Check both the first aid kits and oxygen units before each outing, and replenish after every use.

## Review Questions



- Essential equipment to have available at every dive site includes
  - oxygen unit
  - first aid kit
  - emergency action plan
  - all of the above
- Emergency action plans should include
  - local resources and emergency phone numbers
  - communication equipment
  - method of documenting information about injured divers and first aid provided
  - location of the nearest hyperbaric chamber
  - a, b and c only
- Oxygen and first aid kits should be checked and assessed for appropriate supplies
  - on a monthly basis
  - on a weekly basis
  - before every dive outing
  - as needed
- Hyperbaric chambers will always be available to treat injured divers.
  - True
  - False

**Review answers are on Page [250](#).**

## Dive Emergency Preparation

## Chapter 8: Lifting & Moving

### Objectives

1. What are the general considerations for a rescuer when attempting to move an ill or injured person?
2. When should an ill or injured person be moved?

It is extremely rare that a rescuer would be called upon to move an injured person. In fact, moving a person is strongly discouraged due to the additional injury that is often caused to the individual in the attempt. You should leave the person in the position found. Avoid moving anyone with suspected neck, spinal or pelvic injury.

There are two exceptions:

- The person needs to be moved onto their back for CPR.
- The person is in imminent danger (e.g., due to fire, explosives or uncontrolled traffic).

Use discretion when moving an injured or ill person, and avoid it if at all possible. If a situation presents in which a move is absolutely necessary, however, there are several ways to move someone.

Move the person in an orderly, planned and unhurried fashion to protect both the first aid provider and the person being moved. Plan ahead, and select the safest and easiest method(s) that involves the least chance of rescuer injury. Remember that rescuer safety comes first. Putting yourself in danger is generally not recommended.

When lifting, protect yourself, and remember important principles of body mechanics, including maintaining a straight, rigid back and bending at the hips, not at the waist. Keep your head in a neutral position, not flexed forward or extended backward. Use your legs, not your back, to lift. Body alignment is also critical for the injured person. Keep the spine aligned, and move the person along the long axis of their body.



### Armpit-Forearm Drag (Rautek Technique)

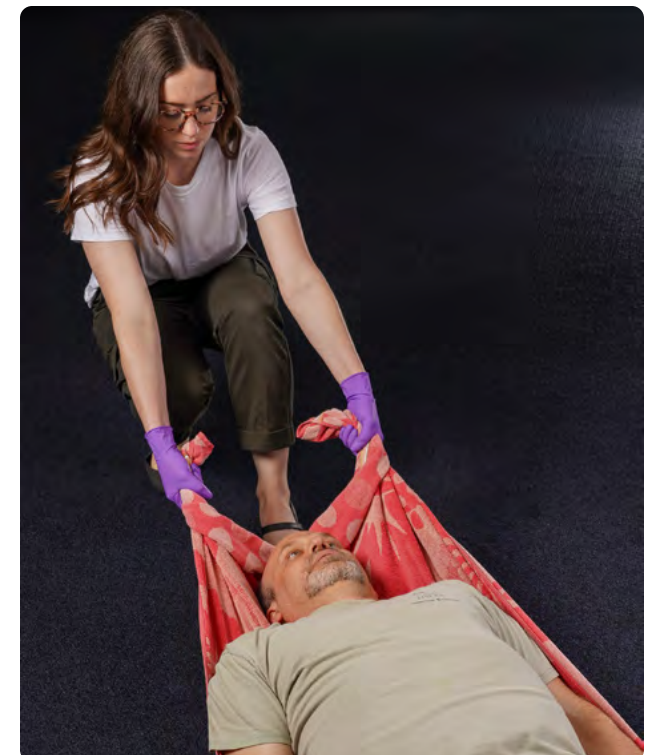
To perform the armpit-forearm drag (also known as the Rautek move), reach under the individual's armpits from behind, and grab their left forearm with your right hand and their right forearm with your left hand. Pull the person in the direction of the long axis of the body.

### Shirt Drag

If the individual is wearing a collared shirt, you can use it to support their head and pull by grabbing the shoulders and collar of the shirt. Support their head at the base of their skull with your fists, and pull along the long axis of the body. Be careful not to compromise the person's airway.

### Coat or Blanket Drag

Another effective technique is to use a coat or a blanket to drag a person to safety. To get the individual onto the blanket, you will need to roll them onto their side and then tuck the blanket underneath them. Lay the person back down, and pull the other edge of the blanket out from beneath them. Gather the blanket into place under the person's head in a similar manner to the shirt drag, and pull.



Lifts

To lift a person off the ground, use a direct ground or an extremity lift. Use these techniques only when there is immediate danger to the injured or ill person; none of these techniques allows you to adequately protect the individual's spine in case of an injury to the head, neck or spine. With heavier individuals, a long backboard is more effective and minimizes potential injury to the individual and rescuer.

A direct ground lift requires two or more rescuers, 3 to 5 is ideal. They should be alternating sides of the person. For example, one rescuer supports the person's head, neck and lower back from one side. The other rescuer supports the hips and legs from the other side.

The extremity lift also requires two rescuers: one to lift from behind the person, reaching under the arms and grasping the person's opposite wrists, and the other to lift at the person's knees by wrapping their arms around the individual's legs.

Review Questions

1. Movement of an injured person should be limited to times of emergency or when the current location places the individual at risk of further injury.

a. True

b. False
2. The rescuer should consider which of the following body mechanics when lifting?

a. keep back straight

b. bend only from hips

c. keep head neutral

d. lift with legs

e. all of the above

Review answers are on Page [250](#).

Response & Assessment

Chapter 9: Scene Safety Assessment & Standard Precautions

Objectives

1. What is **S-A-F-E**?
2. What are some hazards that need to be assessed before providing first aid?
3. Why is exposure protection critical for rescuers?
4. What are some examples of personal exposure protection equipment?

**Rescuer safety comes first.** A rescuer's ability to provide first aid is impaired if they are injured when approaching the individual or rendering care. Taking the time to assess the scene and circumstances surrounding the person may prevent compromising the rescuer and causing further injury to the individual. Before providing basic life support (BLS), assess the scene, and take steps to avoid or remove any sources of potential injury. Look for indications of what may have happened and how your response may need to be adapted to accommodate the circumstance.



ANZCOR Guidelines utilize DRS ABCD.  
D - Check for DANGERS to you, bystanders, and the injured/ill person.  
R - Is the injured/ill person conscious?; do they RESPOND?  
S - SEND for Help (Activate EMS and answer questions from the dispatcher)

A - Is the AIRWAY open and clear?  
B - Is the injured/ill person BREATHING?  
C - Begin CPR if the injured person shows no signs of breathing or circulation  
D - DEFIBRILLATE with an AED

Note: this reflects an ABC protocol versus the CAB protocol currently used in most of the world

Scene Safety Assessment

Before providing aid, take a moment to remember the mnemonic **S-A-F-E**. DAN uses **S-A-F-E**; other acronyms may be used in different regions, but they all serve the same purpose.

**S-A-F-E** is a reminder to:

- **Stop:** Take a moment to think before acting.
- **Assess the scene:** Before assisting another person, determine if the scene is safe. Dangers may include but are not limited to:
  - fire
  - chemicals
  - electricity or gas
  - traffic
  - animals (tentacles from a jellyfish or a pet that may be trying to protect their person.)
- **Find** a first aid kit, oxygen unit and automated external defibrillator (AED).
- **Exposure protection:** Avoid contact with blood and other body fluids.
  - Locate and use barriers such as gloves, eye shields and resuscitation masks.

S	Stop	<ul style="list-style-type: none"><li>• Stop</li><li>• Think</li><li>• Act</li></ul>
A	Assess the scene	<ul style="list-style-type: none"><li>• Is the scene safe?</li><li>• Is it safe to approach the injured diver?</li><li>• Is the ventilation adequate to use oxygen?</li><li>• Are any other hazards present?</li></ul>
F	Find oxygen unit, first aid kit and AED	<ul style="list-style-type: none"><li>• Take them to the injured person</li><li>• First aid kits contain critical supplies such as barriers</li></ul>
E	Exposure protection	<ul style="list-style-type: none"><li>• Use barriers such as gloves and mouth-to-mask barrier devices</li><li>• Don gloves, and inspect them for damage</li></ul>

Risk of Infection

As noted in the previous chapter, anyone in a position to provide first aid care may come in contact with body fluids or other potentially infectious tissue. Personal protection is a critical aspect of first aid and should be exercised in all situations and for all people — this is the principle of standard precautions.

Standard Precautions

The first aid provider must be aware of possible disease transmission. Blood, semen and vaginal secretions have the highest risk of transmitting bloodborne pathogens. Saliva, sweat, urine and feces have a lower risk. Casual social contact will not transmit these infections.

When providing care to an injured person, be aware of any active bleeding, and protect yourself from possible exposure. Use appropriate personal protective equipment (PPE), including gloves, face shields, protective eyewear and ventilation masks. In some instances you may consider gowns for added protection. Many employers provide PPE in locations where high-risk exposures are likely.

Additional safety precautions include:

- Avoid contaminated sharp objects such as needles or scalpel blades. Dispose of sharps in an approved container after use.
- Thoroughly wash hands after providing first aid.

Responsibility for the use of standard precautions lies with the rescuer. To minimize your risk, know where first aid supplies are located in your work environment, and carry protective barrier devices in your own first aid kit. Gloves should be a standard part of an emergency response kit and should be donned before providing care. If they become torn, punctured, contaminated or compromised, replace them.

When removing gloves, avoid contact with the contaminated exterior of the gloves. Gloves should be removed in a manner that keeps the outer surfaces of the gloves from touching your bare skin. Details on how to remove gloves are covered in the skills-development section.



Note:

Gloves protect a rescuer but may be contaminated while providing aid. Be careful to avoid skin contact with bodily fluids when removing gloves.



1. Potential hazards that should prompt caution when approaching the scene of an accident include

a. fire and animals

b. expired first-aid certifications

c. electricity, gas and traffic

d. a and c
2. The **S-A-F-E** mnemonic helps us remember

a. to activate EMS

b. scene safety assessment

c. to use personal protective equipment

d. b and c

e. none of the above
3. Personal protective equipment is a critical part of keeping yourself safe while providing care.

a. True

b. False
4. Protective equipment includes

a. nonlatex gloves

b. eye shields

c. resuscitation masks

d. all of the above
5. When removing gloves after providing first aid, it is important to keep the outer surface of the glove from touching your skin.

a. True

b. False

Review answers are on Page [250](#).



- Objectives:**
- List the steps in performing a scene safety assessment.
  - Perform a scene safety assessment in a scenario.
  - Use appropriate first aid barrier devices in a scenario.

Follow these steps to perform a scene safety assessment.

Remember S-A-F-E

S	Stop <ul style="list-style-type: none"><li>• Stop</li><li>• Think</li><li>• Act</li></ul>
A	Assess the scene <ul style="list-style-type: none"><li>• Is the scene safe?</li><li>• Is it safe to approach the injured diver?</li><li>• Is the ventilation adequate to use oxygen?</li><li>• Are any other hazards present?</li></ul>
F	Find oxygen unit, first aid kit and AED <ul style="list-style-type: none"><li>• Take them to the injured person</li><li>• First aid kits contain critical supplies such as barriers</li></ul>
E	Exposure protection <ul style="list-style-type: none"><li>• Use barriers such as gloves and mouth-to-mask barrier devices</li><li>• Don gloves, and inspect them for damage</li></ul>

SKILL: Donning and Doffing Gloves After Use

Objectives:

- Demonstrate donning of gloves without tearing or compromising glove integrity.
- Demonstrate removal of gloves without contaminating exposed skin.

Before donning gloves, remove rings or jewelry that may tear the gloves during use.

To doff gloves:

- Grasp the first glove at the outside of the wrist, and pull the glove toward the fingers of that hand.
- Turn the glove inside out.
- Use your protected hand to crumple the glove into a ball (making a fist with the gloved hand).
- When the removed glove is in the palm of the still-protected hand (fist), place an “unprotected” finger inside the second glove (between wrist and glove), and pull the glove toward the fingers as before.
- This glove will also turn inside out, and the first glove will be inside the second.
- Avoid touching the outside of the glove with your unprotected hand as you remove it.
- Place the gloves in a hazardous waste container to avoid others having contact with the gloves.
  - This container can also be used for the disposal of all other infected materials after use.



Objectives

1. What are the steps to the assessment sequence?
2. How is a pulse located on an adult, a child and an infant?
3. What technique assists the rescuer in placing an unresponsive person on his back?
4. What is agonal breathing?
5. When should the recovery position be used?
6. When should the recovery position not be used?

The initial assessment sequence consists of these primary steps:

- Assess for responsiveness, including rapid assessment of normal breathing and evidence of circulation.
- Activate EMS.
- Adjust the individual’s position for ongoing care as appropriate.

Assessing Responsiveness & Pulse Check

Once a rescuer ensures the scene is safe, assess the individual’s level of responsiveness.

The level of consciousness can be evaluated using the **A-V-P-U** acronym.

This assessment can and should be used continuously during care while awaiting EMS. It will identify changes in responsiveness, alerting you to changes in the injured diver’s condition.

A	Person is alert
V	Not alert but responds to verbal stimuli
P	Not alert but responds to painful stimuli
U	Unresponsive to all stimuli

If the injured diver is responsive, remember to introduce yourself, state you are trained in first aid, and ask permission to help. The injured person should initially be left in the position in which they were found. Call EMS. Conduct a secondary assessment (discussed later in this book) to determine if any injuries are present. If no evidence of injury is present, then the person may be placed in the recovery position or a position of comfort. Reassure the individual by showing a caring attitude, and talk to them about what is happening. The rescuer should also try to keep bystanders at a distance to avoid added stress.

If the individual is unresponsive, tap their collarbone and shout, “Are you OK?” At the same time, look quickly for normal breathing and evidence of circulation: chest movement and pink nail beds.

**Note:**  
Abnormal respirations are commonly associated with cardiac arrest. Breathing efforts may be infrequent, irregular, diminished or characterized by noisy gasps known as agonal breathing. This type of breathing is quite different from that seen in a normal resting or sleeping person and is not adequate to support life.

**Note:**  
For individuals with a definite pulse or showing signs of life (movement) but not breathing normally, chest compressions are not required. Provide rescue breaths to supplement abnormal or absent breathing. This skill is addressed later in this course.

If breathing is not present and airway adjustment is ineffective, check for a pulse. To check for a pulse, use the first two fingers of either hand to press gently. For adults and children, check for the presence of a pulse at the carotid artery in the neck. Locate the carotid artery by placing your fingers on the “Adam’s apple” of the individual’s throat, and slide your fingers toward you and slightly upward into the groove on the side of the neck. Allow at least five seconds but no more than 10 seconds to determine if a pulse is present. Some pulses may be difficult to identify if thick tissue is present in the neck. Adjust the pressure of your fingers as necessary, but avoid excessive pressure because blood vessels can be collapsed, obscuring a pulse. If no pulse is present or you are unsure if a pulse is present, activate EMS immediately or send a bystander to call for help.



To establish responsiveness in infants, rub or tap the soles of their feet, or tap their shoulder or chest. Do not shake an infant. Check for a pulse in infants at the brachial artery in the upper arm as high on the underside of the arm as close to the arm pit as possible. Locate the brachial pulse by placing your fingers in the groove along the inside of upper arm. Use gentle pressure here as well, adjusting as necessary to find a pulse. Allow at least five seconds but no more than 10 seconds to determine if a pulse is present. If no pulse is present and you are alone, begin CPR (described later in this book). For infants, conduct CPR for two minutes then activate EMS if not already done.

Activate EMS if not already done then turn them on their back and begin CPR. (CPR techniques are covered later in this book.) To turn an adult from a face-down position onto their back, use the log-roll technique.

Log Roll

If the person is not on their back, you need to roll them into that position. To minimize the risk of neck and back injury or in the case of suspected spinal trauma, use the log-roll technique.

- Kneel at the unresponsive person’s side.
- Carefully straighten their arms and legs; place the arm closest to you above their head; place their other arm against their torso.
- Support the head and neck with one hand.
- Place your other hand on the opposite arm, and pull it gently into their side.
- Roll the individual toward you, while avoiding twisting their head, neck and back.
- Use a smooth, continuous movement to roll the person to their side and then onto their back.
- Keep twisting movements to a minimum throughout the entire roll.



**Note:**  
When two rescuers are present, one should immobilize the individual’s head while the second person rolls them onto their back. The rescuer at the head controls the action by directing when to roll the person.

Positioning an Injured or Ill Person for Care

- Responsive, breathing injured diver — After assessing for injuries, place an injured person who is responsive and fully alert in a position of comfort: seated, supine position (lying flat on the back) or in the recovery position.
- Unresponsive, breathing diver — Place an injured person who is unresponsive but breathing in the recovery position. This minimizes the risk of airway obstruction by the tongue or body fluids for individuals with a reduced level of consciousness.

Recovery Position

Placing the injured person in the recovery position to ensure an open airway. In the absence of other relevant factors (injury, trauma, access), it does not matter which side. This helps prevent blood and vomit from obstructing the airway or flowing into the lungs. Should vomiting occur, or if blood or other fluids are present in the mouth, gravity will aid in removal and minimize the chance of aspiration.

Remember to call local EMS. Until help arrives, continually check that the individual is still breathing. If EMS is delayed, rotate the person to the other side every 30 minutes. The recovery position is accomplished from a supine position.

- Kneel beside the individual, and make sure that both of their legs are straight.
- Place the individual’s arm nearest to you at a right angle to their body, with elbow bent and palm facing upward.
- Bring the far arm across the individual’s chest, and hold their hand against the cheek nearest to you.
- Place your other hand under the leg farthest from you just above the knee, or grab the pant leg of their clothing, and pull the knee up, keeping the foot on the ground.
- Holding the individual’s hand against their cheek, pull the far leg to roll them toward you and onto their side.
- Adjust the top leg to form 90-degree angles at both the hip and knee.
- Tilt the head to ensure the airway remains open.
- Adjust their hand under their cheek, if necessary, to keep the head tilted.
- Assess breathing and circulation regularly.



Note:

Do not place people with suspected spinal injury in the recovery position because it places them at increased risk of further injury.

If you use the recovery position, monitor the peripheral circulation of the person’s lower arm, and ensure that the duration of pressure on this arm is kept to a minimum.

Review Questions



1. Initial assessment includes:  
a. assessing for responsiveness and activating EMS  
b. adjusting the individual’s position for care  
c. initiating CPR  
d. all of the above  
e. a and b only  
f. b and c only

2. To check for a pulse on an adult or child, use gentle finger pressure on the  
a. carotid artery  
b. brachial artery  
c. femoral artery  
d. radial artery

3. To check for a pulse on an infant, use gentle finger pressure on the  
a. carotid artery  
b. brachial artery  
c. femoral artery  
d. radial artery

4. Any breath sounds at all are considered normal.  
a. True  
b. False
5. Placing an unconscious, breathing person in the recovery position is important to maintain an open airway and to minimize the potential of blood and vomit to cause obstruction.  
a. True  
b. False

6. Persons with suspected neck, spine or pelvis injuries should not be placed in the recovery position.  
a. True  
b. False

7. A breathing, responsive injured diver should be placed in a position of comfort or the recovery position.  
a. True  
b. False

Review answers are on Page 250.

# SKILL: Initial Assessment



## Objectives:

- Demonstrate the technique for establishing unresponsiveness in an adult or child.
- Demonstrate the technique for establishing unresponsiveness in an infant.
- Demonstrate the technique for determining the presence of a pulse in an adult or child.
- Demonstrate the technique for determining the presence of a pulse in an infant.

Remember **S-A-F-E**.

## Assess Responsiveness

- State your name, training and desire to help.
- Ask permission to help.
- Tap the adult or child on the collarbone and speak or shout, “Are you all right?”
  - Tap or rub the bottom of the feet for an infant, and watch for a response.

## If the adult or child responds:

- Have them remain where they are unless urgent evacuation is necessary to avoid further danger.
- Try to find out what is wrong, and get help if needed.
- Reassess regularly.

If the infant responds, move the infant to safety if required and continue to monitor for changes.

## If the adult or child does not respond:

- Shout for help, or call EMS.
- Turn the individual onto their back.
- Check for a pulse and normal breathing.
  - Gently tip the injured person’s head back to open their airway while assessing for normal breathing and presence of a pulse.
  - To take a carotid pulse, place the tips of your index and middle fingers on the person’s “Adam’s apple,” then slide your fingers toward you and slightly upward into the groove between the muscles of the neck. Apply gentle pressure. Adjust the position of your fingers slightly if necessary to access the pulse. Check for at least five seconds but no more than 10 seconds. Normal adult pulse rates are between 60 and 100 beats per minute and may be lower in athletes.
- If the person does not have a pulse or is not breathing normally, send someone for help, or if you are on your own, leave them and alert EMS; return and start CPR, beginning with chest compressions.



## If the infant does not respond:

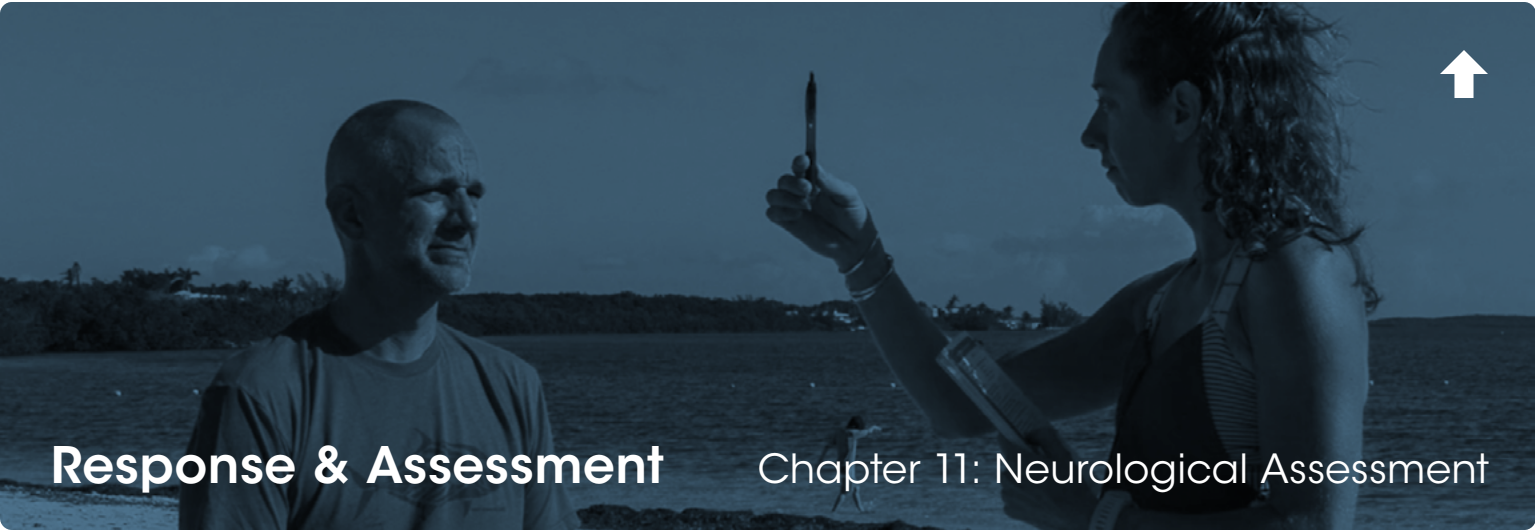
- Check the infant for a pulse.
  - To check the pulse of an infant, place the tips of your index and middle fingers on the infant’s inner arm just under the armpit and in the groove formed by the muscles of the arm. Use gentle pressure, adjusting as may be required to find a pulse if present. Check for at least five seconds but no more than 10 seconds.
- If a pulse is not present, conduct CPR for two minutes, then go call for help.

# SKILL: Recovery Position

## Objective:

- Demonstrate rolling a simulated injured or ill person from his back into the recovery position, keeping the spine aligned.
- Kneel beside the person, and make sure that both of his legs are straight.
- Place the individual’s arm nearest to you at right angles to the body, with elbow bent and palm facing upward.
- Bring the far arm across the chest, and hold the back of his hand against the cheek nearest to you.
- Place your other hand under the leg just above the knee, or grab the pant leg of the his clothing, and pull the knee up, keeping the foot on the ground.
- Keeping his hand pressed against his cheek, pull the far leg at the knee to roll him toward you and onto his side.
- Adjust the top leg to form 90-degree angles at both the hip and knee.
- Tilt his head back to ensure the airway remains open.
- Adjust his hand under his cheek, if necessary, to keep the head tilted.
- Check breathing regularly.





**Objectives**

- 1. How can you minimize the risk of permanent disability caused by a blood-flow interruption to the brain?
- 2. What is F-A-S-T?

Most dive incidents involve a breathing, responsive diver. However, some injuries can progress rapidly. Brain injury can occur when blood flow within the brain is interrupted. In scuba diving, this can be the result of a gas embolism. The manifestations can be very similar to those of a stroke, so they are assessed similarly. A quick, easy method of assessing neurological injury is the F-A-S-T examination. If any of the following signs are present, activate EMS. Prompt intervention can prevent or reduce permanent disability.

When the condition is the result of a dive accident, oxygen administration should not be delayed. Place the injured diver on oxygen while conducting further evaluations; assessments and oxygen administration can and should occur concurrently. Oxygen administration is covered later in this course.

**F** Facial droop

**A** Arm weakness

**S** Speech difficulty, sudden severe headache

**T** Time (note the time, and call EMS immediately)

**Facial Droop**

Facial droop occurs on one side of the face and may involve either the left or right side. This is usually associated with speech difficulty or reduced vocal clarity.



**Arm Weakness**

Assess the presence of arm weakness by asking the injured person to raise both their arms in front of them. Ask the person to hold that position for about 10 seconds. Watch for lowering of an arm.



Image depicts left-arm weakness.

Speech

Inability to speak clearly is cause for immediate concern. Speech difficulty or reduced clarity is often associated with facial droop.

Time

Note the time, and activate local EMS immediately if any of these symptoms are present.

The **F-A-S-T** examination is an easy way to determine if signs of neurological injury are present. Whether from stroke, trauma or diving-associated injury, if signs are present, call EMS.

Once EMS is activated, complete the full neurological assessment. Your findings will help medical personnel determine injury progression and create a clinical baseline from which future changes can be compared.

Review Questions

1. Prompt medical intervention may reduce the possibility of permanent disability.  
a. True  
b. False
2. F-A-S-T stands for  
a. facts, attitude, sensitivity, talent  
b. facial droop, arms, speech, time  
c. feet, arms, spine, toes  
d. face, ankles, stability, touch

Review answers are on Page [250](#).

SKILL: F-A-S-T



Objectives:

- Conduct a **F-A-S-T** assessment on a simulated ill person suspected of having a neurological impairment.

**F** Facial droop

**A** Arm weakness

**S** Speech difficulty, sudden severe headache

**T** Time (note the time, and call EMS immediately)

- Have the injured person remain seated during the assessment.
- Have the injured person smile. Observe their face for asymmetry. Is one side drooping? Is the smile equal on both sides?
  - Ask the injured person to extend and raise both arms straight out in front. Can they raise both arms? If so, do both arms remain up, or does one drift down?
  - Ask the injured person to repeat a simple phrase. Are all the words clear? Is there any slurring? Is the speech garbled?
  - If any abnormal signs are present, call 911 or your local EMS number immediately.



Response  
& Assessment

Chapter 12: Conducting a  
Neurological Assessment

Objectives

- 1. What is the purpose of collecting an injured diver's history?
- 2. What is **S-A-M-P-L-E**?

Use a neurological assessment as a follow-up to the **F-A-S-T** exam or when symptoms are obscure, creating uncertainty about the diver's condition. The neurological assessment can uncover signs that may not be noticed otherwise and provide the motivation for further medical evaluation.

If signs and symptoms are noted, place the injured diver on oxygen (covered in the next section), then conduct the neurological assessment, which will provide a clinical baseline. A neurological assessment should be repeated every 60 minutes if emergency services are delayed or more frequently if the injured diver's condition changes.

When faced with a possible neurological injury, regardless of cause, remember the **F-A-S-T** first principle. Once a problem is identified or you think injury is likely, initial action includes:

- 1. Call your local EMS number immediately.
- 2. If the injury is immersion related, provide oxygen first aid.
- 3. Be prepared to initiate basic life support and CPR.



Once EMS has been activated, conduct the neurological assessment described below. A neurological assessment should be performed only on a conscious individual. Their responses and your observations facilitate the process. The information you gather may influence the initial treatment and subsequent impact of the injury. In the case of diving accidents, your assessment may also convince an injured diver of the need for oxygen first aid. Fortunately, most diving injuries are not life-threatening, and there is frequently time prior to EMS arrival when it is both appropriate and helpful to perform this examination.

Note:

Performing a neurological assessment should never interfere with EMS activation, evacuation or essential first aid measures.

Taking a History

A critical aspect of all medical evaluations is the individual's history. Understanding what happened (the events leading up to the injury) as well as any underlying medical issues can provide a more accurate context for the assessment.

The mnemonic **S-A-M-P-L-E** provides a guide to collecting relevant information. This portion of the evaluation is done first and precedes the actual neurological examination.

**Signs/Symptoms:** Signs are what the responder can observe about the injured or ill person such as the color of their nail beds or their breathing (rate and depth), responsiveness, or visible bleeding. A symptom is what the injured or ill person tells you they are experiencing. Examples of symptoms include dizziness, nauseous, hot or cold, and blurry vision. Has the injured or ill person ever experienced these signs/symptoms before? Record any signs or symptoms that you notice or are reported. When possible, record direct quotes by the injured or ill person as they describe their symptoms.

**Allergies:** This includes medications, food, animals, and environmental exposures. While an allergy may seem benign at first, that allergy may give you, and EMS, other information that could be critical. Common allergies are to bee stings, certain foods such as peanuts or strawberries and certain medications like penicillin (PCN).

S	Signs / Symptoms
A	Allergies
M	Medications
P	Pertinent medical history
L	Last oral intake
E	Events leading to the current situation

**Medications:** Ask the person if they are taking any medications, including any over-the-counter medications, such as pain relievers, cold remedies, multivitamins or herbal supplements. Consider asking if they have been using recreational drugs if the circumstance warrants.

**Pertinent Medical History:** Pertinent is a key term here. Major medical issues are the concern. For example, we do not need to know about childhood illnesses with no after effects, but we do need to know if they had a cardiac event in the last few years.

**Last Oral Intake:** Ask what and when the person has had to eat or drink most recently. Even if the injury appears minor, ask.

**Events Leading to the Current Situation:** Have the injured or ill person describe in as much detail as they can, the events leading up to the incident. When recording their statements, use as many direct quotes as possible.

If the person is unresponsive, and their spouse, parent/guardian, significant other or friend is present, you should ask them for as much of this information as possible. Asking them will help you in your assessment, and the information gathered will be helpful to EMS when they arrive.

Part of the initial history includes recording pulse and respiration rates (vital signs). Vital signs, which help provide a baseline of the individual's condition, should be monitored because they may indicate a change in the individual's condition. Each measurement is recorded in a per-minute format. To quicken the process, count each for 30 seconds and multiply by two.

**Note:**

Normal pulse and respiratory rates are based on statistical norms. Values outside these ranges are not necessarily causes for concern or indicative of abnormality. Factors like fitness level, recent exertion and emotional stress can result in heart and respiratory rates outside normal ranges but do not amount to a medical emergency. In all medical evaluations, consider the individual's situation and how they are presenting.

Dive History

In the case of injured divers, additional information is also important and includes a description of all dive profiles during the 24 hours leading up to the injury. Information recorded should include maximum depths, dive times, use of safety stops, surface intervals, breathing gases and any problems experienced during the dives. When possible (and if appropriate), obtain additional information about the incident from the diver's buddy or other observer. DAN's Injury Report Summary slate is useful for recording the dive profile and other relevant information.

Symptoms are often underreported because many people consider dive-related injuries an admission of error. Therefore, the seemingly simple act of a diver talking about symptoms should get your attention and prompt you to ask more questions.

Review Questions

1. An emergency action plan should be activated

a. as soon as you suspect a neurological injury

b. after conducting a complete neurological assessment

c. only if the injured diver does not respond to oxygen first aid
2. **S-A-M-P-L-E** is a mnemonic to assist with

a. obtaining information about an injured diver

b. remembering to get a dive profile

c. calculation assessment in mental function

d. obtaining insurance and compensation

Review answers are on Page [250](#).

SKILL: Taking a History

**Objectives:**

- Interview a person in a simulated scenario using the **S-A-M-P-L-E** mnemonic to identify previous medical history and determine where they might have acute problems or feel discomfort. Record findings in a usable format.

As noted previously, it is important to get information about conditions that may influence the individual's assessment. To help you remember what information to gather when taking a history, use the mnemonic **S-A-M-P-L-E**.

Record any signs and symptoms. In the case of pain, attempt to describe the severity, quality (sharp, dull, throbbing), its location and association with movement. Document symptom-onset times, their progression and a description of all first aid provided. The neurological assessment slate includes an area to record your findings.

S	Signs / Symptoms
A	Allergies
M	Medications
P	Pertinent medical history
L	Last oral intake
E	Events leading to the current situation

## SKILL: Taking Vital Signs

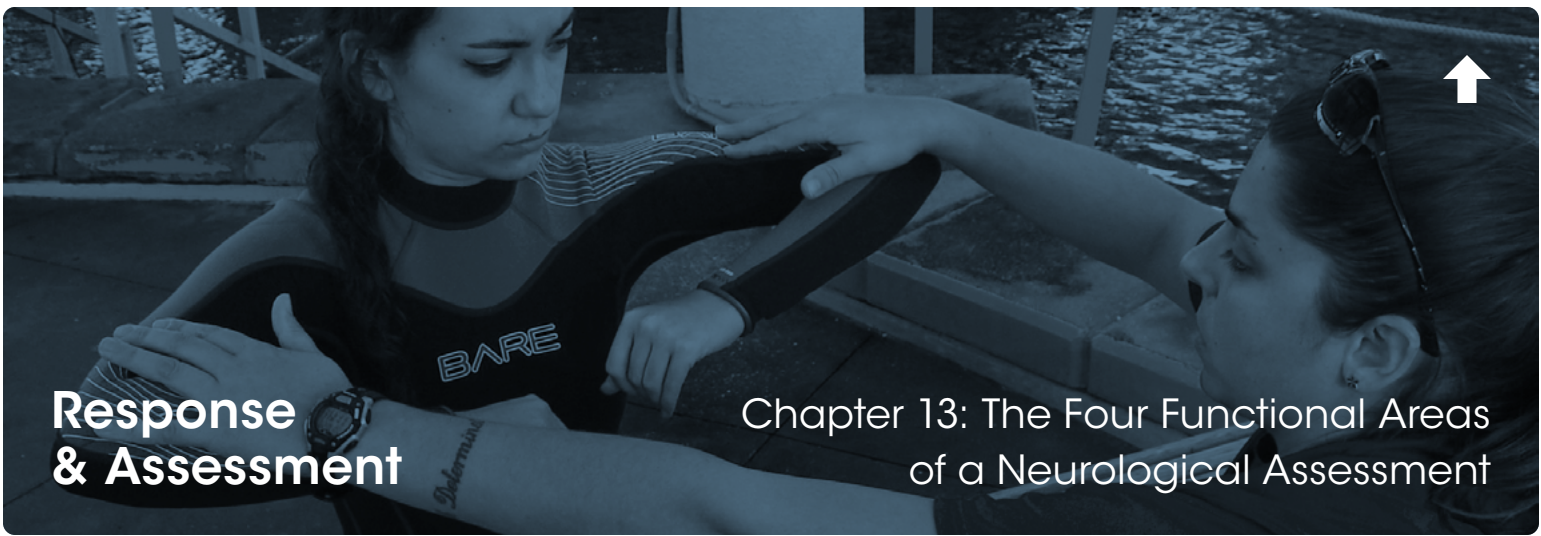
**Objectives:**

- Demonstrate the proper technique to determine a person’s pulse rate and breaths per minute by counting each for 30 seconds and then multiplying by two.

Take the individual’s pulse, and note their respiratory rate. Each of these measurements is recorded in a per-minute format. To quicken the process, count each for 30 seconds and multiply by two.

**Pulse.** To take a pulse, place your index and middle finger on the inside of the wrist just proximal (toward the heart) to the base of the thumb, and apply gentle pressure. Refrain from using your thumb to take a pulse. The pulse of the examiner’s thumb may be confused with the injured person’s pulse and result in a false measurement. Normal adult pulse rates are between 60 and 100 beats per minute and may be lower in athletes.

**Respirations.** Prior to counting breaths per minute, you will already have a sense of the person’s level of respiratory distress from your previous questions. If they are unable to finish sentences or visibly short of breath, more immediate respiratory aid may be necessary. To minimize self-consciousness and the potential influence your observations may have on respiratory rate, try to count without letting the individual know that you’re monitoring their breathing. It may be helpful to have a bystander count respirations, or you can continue to hold the individual’s wrist after taking their pulse for a full minute while you count respirations for the second 30-second period. Normal adult resting respiratory rates are between 12 and 20 breaths per minute.



## Response & Assessment

## Chapter 13: The Four Functional Areas of a Neurological Assessment

**Objectives**

1. What are the four functional areas of a neurological assessment?
2. What functions are evaluated in the “cranial nerves” section of the neurological assessment?
3. What is assessed during the “mental function” section?
4. How do motor-function deficits manifest?
5. How are balance and coordination evaluated?

Dividing the neurological assessment into four functional compartments focuses the first aid provider’s attention on specific areas. This division allows the examiner to evaluate specific nervous-system functions and simplifies documentation of abnormal findings. These areas are reviewed according to significance of impact from most important to least important.

- Mental function
- Cranial nerves
- Motor function (strength)
- Coordination and balance

As you conduct the neurological exam, if you find a deficit, verify that EMS has been called. If the individual has been scuba diving, place him on oxygen and continue the exam.

In the case of severe neurological injury, it may not be possible to assess certain vocal or motor responses. If the injured person is unable to speak or move a particular limb, note the deficit and proceed to the next part of the examination.

In the case of garbled, slurred or nonsense speech, defer the medical history and mentalfunction portions of the examination. Focus on what you can assess, and tell medical personnel your findings.

Mental Function

A key component of neurological examinations is an assessment of mental function. This is a subjective process that is susceptible to bias based on factors such as age, education, stress, language barriers and cultural background.

This portion of the examination begins with “orientation” and starts with simple questions. Ask the individual his name, current location, the approximate time and reason for being there. These four questions are often referred to by the description “person, place, time and event” and are written as alert and oriented (A&O) x 4 — when the individual answers each question appropriately. If questions are answered incorrectly, note what was asked and the response.

AOx4 (person, place, time and event)  
AOx2 (person and location)

Record the level of consciousness the injured person exhibits during the assessment by using the following terms as discussed in Chapter 10.

These terms are abbreviated as **A-V-P-U** on the neurological assessment slate. Be aware the individual’s level of consciousness can change during or even after the assessment. If changes do occur, note the change and the time it occurred.

Once the levels of orientation and responsiveness are determined, further questions can help assess mental functions such as memory, speech, comprehension and computational skills. As with the initial questions for orientation, these are particularly prone to individual differences that may make their interpretation difficult. What is important is a change from the person’s baseline and not a comparison of their mental ability relative to yours. Some people may be able to tell you that their memory is off, and in other cases a close friend or relative will provide a reference point for subtle changes.



**A** Individual is alert

**V** Not alert but responds to verbal stimuli

**P** Not alert but responds to painful stimuli

**U** Unresponsive to all stimuli

Advanced Concepts

**Sensory Exam** - The sensory portion of a neurological exam has been recognized by neurologists as the most difficult to conduct and interpret, thereby interfering with its usefulness. Such training is beyond the scope of this course. However, if an abnormal sensory finding to light touch, temperature, or pain is suspected, record your findings and report them to medical personnel exactly as discovered. Remember, too, if the opposite side is not affected, it can be useful for comparison during any portion of the neurological assessment.

Cranial Nerves

Emanating from the base of the skull are 12 pairs of nerves that control the special senses and muscles of the eyes and face. Neurological injury from DCI or cerebral vascular accident (CVA) may affect one or more of the cranial nerves. Cranial-nerve injury commonly results in facial-movement asymmetry. Examples may include facial droop, loss of certain eye movements and slurred speech. Deficits or injuries are frequently detected during your initial interactions as you watch for facial asymmetry or alterations in eye movements.

Motor Function (Strength)

Neurological injury may affect motor control. Symptoms of injury can range from weakness to paralysis. Proper examination of strength entails comparison with the other side of the body. Subtle abnormalities are often detected or confirmed by this process.

DCI rarely affects both sides of the body simultaneously. When it does, the abnormality is usually obvious. Strokes are usually confined to the brain, and these effects almost always influence one side of the body.

Any sign of weakness or paralysis, no matter how slight the abnormality, should prompt you to seek immediate emergency medical assistance and professional medical evaluation.

Coordination and Balance

If the injured person’s responses at this point are normal, then assess coordination and balance. DCI and CVA may cause nerve-cell injury or impairment of the cerebellum or spinal proprioception tracts, affecting coordination and balance. (For more information, see Advanced Concepts below.) Coordination is evaluated using a finger-nose-finger test (see Page 88). To assess balance, have the injured person walk a straight line and then perform a Romberg (or Sharpened Romberg) test (see Page 89). These assessment steps are completed in sequence. Inability to perform would preempt conducting the subsequent elements.

### Note:

Speech, balance and coordination may also suffer temporary impairment from seasickness, alcohol intoxication or use of certain medications.

### Reassessment

Neurological injuries often change with time. If EMS or access to advanced medical care is delayed, reassess the individual every 60 minutes or more frequently if changes in the individual's condition are noted. Make note of the time of reassessment and any changes in their condition.

### Advanced Concepts

Proprioceptors are specialized sensory nerves located within muscles and tendons that provide our brain with feedback about movement and muscular activity. These special sensors convey movement information up the spinal cord to our brain. An example of proprioception is seen with the small posture adjustments that occur while standing still. Even slight changes in body position result in muscular stretch that can result in quick postural adjustments.

### Advanced Concepts

Nerve tracts refer to “bundles” of nerve fibers within the spinal cord that convey messages either to or from the brain. Sensory nerve tracts, located primarily in the posterior and lateral bundles of the spinal cord, convey information up the cord to the brain. Motor tracts, located on lateral and anterior bundles, convey movement directives from the brain.

## Review Questions



1. Which of the following is not one of the areas evaluated during a neurological assessment?
  - a. mental function and cranial nerves
  - b. range of motion
  - c. motor function
  - d. coordination and balance
2. Mental function evaluates
  - a. orientation to person, place, time and event
  - b. memory and speech
  - c. comprehension and computational skills
  - d. all of the above
3. Cranial nerves can be evaluated using all of the following except:
  - a. facial droop
  - b. eye movements
  - c. grip strength
  - d. slurred speech
4. Motor functions may be classified as normal, evidence of weakness, or paralysis.
  - a. True
  - b. False
5. To test balance use
  - a. the finger-nose-finger test
  - b. **F-A-S-T**
  - c. hip flexor assessment
  - d. a straight walk

Review answers are on Page [250](#).



Objectives:

- Determine an individual’s level of consciousness in a scenario with a simulated injury.
- Utilizing interview techniques, assess an individual’s
  - Speech and language abilities
  - Orientation to person, place, time and event
  - Short-term memory
- Assess an individual’s ability to do calculations utilizing a standardized protocol.

Begin your mental-function assessment by simply talking to the person. You’ve already been doing this while taking the history, and this observation will help you form an opinion about the person’s mental status. Although the individual may appear normally alert, answers to the following questions may reveal underlying changes and should be a standard part of every evaluation.

Level of Consciousness (A-V-P-U)

Indicate the person’s level of consciousness on your slate using the **A-V-P-U** acronym:

- If they are responding to you timely and appropriately, note on your slate “alert.” If not, record their level of responsiveness according to the following descriptions:
- Responds to verbal stimuli (verbal)
    - At times you may need to shout.
  - Responds to painful stimuli (pain)
    - If unresponsive to verbal stimuli, check for a response to painful stimuli such as a sternal rub.
  - Unresponsive
    - If unresponsive, monitor vital signs and intervene as necessary.

Orientation to Person, Place, Time and Event

- **Person:** Ask the injured person their name and if they know who you are.
- **Place:** Ask the injured person if they know where they are.
- **Time:** Ask the injured person the time, date and year.

A

Person is alert

V

Not alert but responds to verbal stimuli

P

Not alert but responds to painful stimuli

U

Unresponsive to all stimuli



- Time perception can vary, especially in an accident. As an alternative, consider asking about what part of the day it is (e.g., morning, afternoon or evening).
- **Event:** Ask the injured person if they know why they are there or why you are having this conversation.
  - Ask them to describe the events leading to the incident and about the event itself. Ask them to explain what they were doing prior to the event. Alternately, they should be able to identify that you are performing the exam because you are concerned about a possible injury or illness.

The ability to answer these questions correctly is noted as A&O x4 (alert and oriented to person, place, time and event).

Speech and Language

- Assess ability to understand, follow directions and communicate effectively.
  - Can the individual both understand and respond?
- Test ability to follow a command by having them close their eyes and stick out their tongue.
- Test ability to communicate by asking them to repeat any simple phrase.
- Point out three easily identifiable objects and have the individual tell you what they are. Examples include a mask, pen, watch, light, snorkel and fins. Any three easily recognizable items should suffice.

Abstract Reasoning

Test abstract reasoning by asking the injured person to describe relationships between objects such as cat and mouse, father and son, water and dirt, student and teacher or classroom and school.

Such questions are an attempt to determine the individual’s ability to describe the connection between ideas or words.

Calculations

Assess the ability to perform simple arithmetic by asking the injured person to count backward from 100 by sevens. An alternative is to ask them to repeat their phone number in reverse.

- Many people struggle with this task. The goal is to see if the injured person can figure out the next answer. Most evaluators don’t force people to count down to single digits.

100	99	98	97	96	95	94	93	92	91
90	89	88	87	86	85	84	83	82	81
80	79	78	77	76	75	74	73	72	71
70	69	68	67	66	65	64	63	62	61
60	59	58	57	56	55	54	53	52	51
50	49	48	47	46	45	44	43	42	41
40	39	38	37	36	35	34	33	32	31
30	29	28	27	26	25	24	23	22	21
20	19	18	17	16	15	14	13	12	11
10	9	8	7	6	5	4	3	2	1

Short-Term Memory

Have the injured person repeat back to you the three objects previously identified during the speech and language examination.

# SKILL: Cranial Nerves

## Objectives:

- Assess control of eyes and facial muscles using simple commands.
- Assess an individual's ability to hear by rubbing or snapping fingers 1 foot/30 cm from the ear.

The next step of the exam assesses facial movement and hearing.

## Eye Control

This exam assesses the ability of the injured person to symmetrically move their eyes in all directions. Hold your finger about 1 meter (3 feet) away from their face; while their head is kept still, move your finger to the right, left, up, down and diagonally. Record any direction the injured person cannot follow with their eyes.



## Facial Control

To evaluate the facial muscles, ask the injured person to tightly close their eyes and then smile. Watch for symmetry of facial movement and skin creases. Facial-muscle movement and skin creases should be essentially the same on each side of the face. Note any facial-movement asymmetry.



## Hearing

Test hearing by holding your hand about 30 cm (1 foot) from the injured person's ear and rubbing together your thumb, index and middle fingers. Check each ear separately. Do not attempt to determine hearing loss but whether hearing is symmetrical or if one side is reduced.

If the surroundings are noisy, this test may be difficult to perform. An alternative to rubbing your fingers is to speak in a quiet voice in each ear.

# SKILL: Motor Function (Strength)

## Objectives:

- Assess strength of muscle groups using muscle isolation and resistance.

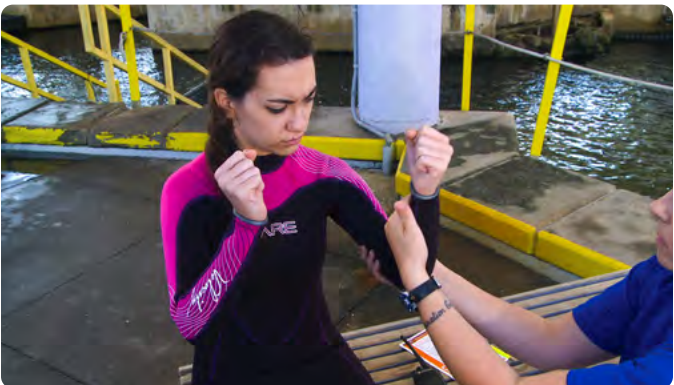
Evaluate strength and symmetry of specific muscle groups. Note any differences between right and left. Hand dominance as well as a history of previous injuries are also important aspects to include in your evaluation and your report to medical personnel.

The primary muscle groups tested are the shoulders, biceps, triceps, finger spread, grip strength, hip flexors, quadriceps, hamstrings and feet.

Check each muscle group independently by providing gentle resistance. Record motor strength as normal, weakness or paralysis.

Assess shoulder strength by first bringing up the elbows level with the shoulders and hands level with the arms. Instruct the individual to resist while you push down and then pull up on the elbows.

Test bicep and tricep strength by supporting the elbow with one hand (to isolate the muscle group being tested), and have the injured person push and pull against your hand.



Test ability to spread fingers by attempting to squeeze fingers together two at a time.



Test grip strength by having the person grip two of your fingers in each hand and squeeze as tightly as they can.



To test hip flexors, have the person raise their knee, lifting their foot off the ground. Do this for each side.



Isolate the quadriceps and hamstrings by placing your hand under the person's thigh just above the knee, supporting the foot just off the ground.



Test the quadriceps and hamstrings by having the injured person resist your pressure as you gently but firmly push then pull the lower leg just above the ankle of each leg.

To test the injured person's foot strength, have them pull up their foot against your hand as well as press down against your hand.



**Note:**  
Strength deficits that the person was not previously aware of or that did not exist prior to injury are of particular importance.

SKILL: Coordination and Balance

Objectives:

- Assess an individual’s coordination with a finger-nose-finger exercise.
- Determine presence of functional balance using a straight walk and a Romberg test.

If the injured person’s responses at this point are normal, then assess coordination and balance.

Finger-Nose-Finger

To test coordination, stand or sit in front of the person. Hold your finger approximately 9 cm (18 inches) from the person’s face.

Have them touch your finger with their index finger, then touch their nose, and touch your finger again.

- Repeat this several times.
- Continue the movement with their eyes closed.
- Perform this with both the left and right arms.

Minor differences may exist between right and left on any of these exams. Significant variations should be included in your notations.

Walking

Test balance by having the person walk forward about 3 meters (10 feet) while looking straight ahead.

Note whether movements are smooth and if the individual can maintain balance without looking down or requiring support.

Be prepared to catch or support the person if he is unsteady or starts to fall. Performing this test may be difficult while on a moving vessel, so it might have to be omitted. Record whether the person was able to stand and walk without assistance or support. Note on the slate the degree of any assistance that was required.



Balance and Equilibrium: Romberg and Sharpened Romberg Tests

Romberg

- Ask the person to stand with his feet together and arms out to his sides.
- Ask him to close his eyes and remain in that position for 60 seconds.

Sharpened Romberg

- Ask the person to stand with their feet in a heel-to-toe stance and their arms crossed. Once stable, have them close their eyes and remain in that position for 60 seconds.

As with the Romberg, be prepared to catch or support him if he shows signs of falling.

**Note:**  
The Sharpened Romberg test is difficult for many “neurologically normal” people to perform. It is a more sensitive test than the Romberg but may lead to false signs of acute neurological deficit.





# Oxygen First Aid in Scuba Diving Injuries

## Chapter 14: Oxygen and Diving Injuries

### Objectives

- 1. What are the benefits of providing a high concentration of oxygen to an injured diver?
- 2. How does establishing a gas gradient help the injured diver?
- 3. What is the primary goal of emergency oxygen for injured divers?
- 4. What critical factors affect the percentage of oxygen delivery when using a demand valve?
- 5. What is the initial flow rate for constant-flow oxygen-delivery systems?
- 6. What is the priority for oxygen delivery in remote areas?
- 7. What are the concerns for oxygen toxicity when delivering emergency oxygen first aid?
- 8. What are the symptoms of nonfatal drowning?
- 9. What is the first responder’s role in a nonfatal drowning?

The most common diving injuries for which oxygen use is recommended are AGE and DCS. In the case of AGE, bubbles may enter the arterial system following lung overexpansion and lung-tissue rupture. In the case of DCS, problems arise when gas dissolved in body tissues during a dive comes out of solution in the form of bubbles during or after decompression. Bubbles may cause tissue disruption, compromise blood flow, trigger inflammatory responses and/or cause other problems.

Though most cases of DCS are mild and do not pose an immediate risk to life, impaired circulation or function in vital areas such as the brain and spinal cord can result in severe neurological symptoms. These can range from mild tingling and pain to weakness, paralysis, difficulty breathing, unconsciousness and even death.

Oxygen administration for a suspected diving injury creates a partial-pressure gradient that accelerates the rate of inert-gas elimination, and therefore bubble elimination, from the body. Effectively, when oxygen instead of inert gas is inhaled, the oxygen blood levels are so much higher, relatively speaking, that a more rapid outflow of inert gas into the lungs develops to restore equilibrium. This can slow and then reverse bubble formation. The high concentration of inhaled oxygen increases the inbound gradient for oxygen, increasing oxygen delivery to injured or ischemic tissues (areas with poor circulation). This may also reduce pain and swelling (edema) and limit or reverse hypoxic injury.

The Diving First Aid for Professional Divers course emphasizes the use of oxygen for diving injuries and nonfatal drowning but does not address other indications for oxygen treatment.

### Nonfatal Drowning

Nonfatal drowning refers to a situation in which someone almost died from being submerged underwater and was unable to breathe. In the case of prolonged asphyxia (not breathing) or reduced cardiac and lung function due to submersion, oxygen therapy may be crucial. While nonfatal-drowning victims may quickly revive, lung complications are common and require medical attention. In addition, fluid and electrolyte imbalances may develop with the potential for delayed symptom onset.<sup>12</sup>

Symptoms of nonfatal drowning may include difficulty breathing, bluish discoloration of the lips, abdominal distention, chest pain, confusion, coughing up pink frothy sputum, irritability and unconsciousness. Individuals may also be anxious or cold and would benefit from removal of wet clothes and possible treatment for hypothermia.<sup>11</sup>

As a first responder, your primary role is to monitor vital signs, provide supplemental oxygen and transport to the nearest medical facility as soon as possible.

### Note:

Keep yourself safe. Avoid in-water rescue unless trained and properly equipped.

### Oxygen Flow Rates

The primary goal of emergency oxygen for injured divers is to deliver the highest percentage of inspired oxygen possible. Remembering this goal is key to delivering optimal care.

There are two variables that affect delivered oxygen concentrations: mask fit and flow rate (measured in liters per minute or lpm). In the case of demand valves with oral resuscitation masks (discussed in Chapter 16: Oxygen Delivery Systems and Components), proper fit and seal are critical because the flow rate is not adjusted. When using constant-flow systems, mask fit is still crucial because leaks result in decreased inspired fractions of oxygen (FiO2). Enhanced flow rates are an inefficient way to compensate for a poor-fitting mask.

Delivery Device	Flow Rate	Inspired Fraction <sup>+</sup>
Oronasal mask (pocket mask)	10 lpm	≤ 0.5–0.6 (50%–60%)*
Nonrebreather mask	10-15 lpm	≤ 0.8 (80%)**
Bag valve mask	15 lpm	≤ 0.9–0.95 (90%–95%)
Demand valve (MTV)	N/A	≤ 0.9–0.95 (90%–95%)

*\* May vary with respiratory rate \*\*Less variation with changes in respiratory rate  
+Delivery fractions vary with the equipment and techniques used. This table summarizes various oxygen-delivery systems and potential values of inspired oxygen with their use.*

Nasal cannulae are generally operated at relatively low flow rates of 2-4 lpm. Nasal cannulae are the least-efficient method of oxygen delivery, typically delivering fractions no greater than 0.3 (30 percent). Simple face masks may deliver fractions of 0.5-0.6 at flow rates between 10-15 lpm.

Nonrebreather masks can deliver a higher fraction but probably still no greater than 0.8. Demand valves are appropriate for conscious and spontaneously breathing divers and with careful mask management may deliver fractions up to 0.9-0.95.

Accidents frequently occur in remote locations or far away from medical services, and oxygen supplies are generally limited. Rescuers face the dilemma between maximizing inspired fractions and limiting flow rates in an attempt to conserve oxygen supplies. The priority should always be to maintain the highest inspired fractions possible.

As shown in the above table, the best solution is the demand valve (or manually triggered ventilator used as a demand valve). If continuous-flow delivery is required or the only method available, start at 10-15 lpm and increase or decrease in increments based on the needs of the diver, ensuring that the reservoir bag remains full.

Flow rates above 10 lpm will not cause harm but will deplete oxygen supplies more quickly. If the next level of care is accessible before the supply is exhausted, higher flow rates can be used to maintain optimal oxygen fractions and enhance the injured diver’s comfort. Any perceived or suspected worsening in a diver’s condition should prompt reassessment.

Hazards of Breathing Oxygen

Oxygen toxicity can occur when one breathes high concentrations of oxygen for prolonged periods or while under pressure. Oxygen toxicity occurs in two forms: central nervous system (CNS) and pulmonary (lung) toxicity. In CNS oxygen toxicity, seizures may develop when someone breathes oxygen at greater than 1 atmosphere absolute (ATA) pressure. The risk of acute toxicity increases with elevations in partial pressure. For this reason, the accepted safe recreational limit for oxygen partial pressure while underwater is 1.4 ATA.

Breathing high concentrations of oxygen for prolonged periods at the surface can cause pulmonary oxygen toxicity, which is quite distinct from CNS toxicity. In this setting, lung tissue may become irritated when breathing elevated oxygen concentrations. The underlying mechanism for this is the production of oxygen free radicals in a quantity that overwhelms our cellular antioxidant defenses. Initial symptoms may include substernal (behind the sternum) irritation, burning sensation with inspiration, and coughing.

The most severe symptoms may occur after about 12 to 16 hours of exposure at 1 ATA.<sup>13</sup> The time to initial symptom onset is expected to decrease at higher partial pressures (greater than 1 ATA). Symptoms may be seen from 8 to 14 hours at 1.5 ATA<sup>14</sup> and from 3 to 6 hours at 2 ATA.<sup>13,14</sup> At higher pressures, symptoms may occur more quickly but are often less severe due to limited exposure times. The prevailing concern with oxygen partial pressure levels greater than 2.5 ATA is CNS toxicity.<sup>12,14,15</sup>

CNS toxicity is **not** a concern for the oxygen provider rendering first aid. Pulmonary oxygen toxicity is also not a significant concern for first responders delivering oxygen at maximal concentrations on land or at sea level for less than 12-24 hours.

Advanced Concepts

Chemical oxygen systems deliver neither sufficient flow rates nor sufficient oxygen volume to be effective. The average measured flow rates were 3 lpm (Pollock and Hobbs, 2002) and less than 2 lpm (Pollock and Natoli, 2010) with total flow durations of little more than 15 minutes for one reactant set.



1. The primary goal of delivering the highest concentration of oxygen possible to an injured diver is to facilitate inert gas washout and improve oxygen delivery to compromised tissues.
  - a. True
  - b. False
2. Providing a high concentration of oxygen to an injured diver may provide these benefits:
  - a. accelerate inert gas elimination
  - b. reduce bubble size
  - c. enhance oxygen delivery to tissues
  - d. reduce swelling
  - e. all of the above
3. Symptoms of nonfatal drowning may include
  - a. difficulty breathing
  - b. abdominal distension
  - c. chest pain
  - d. hyperthermia
  - e. all but d
4. In the event of an unresponsive drowning victim requiring CPR, begin with ventilations and follow the ABC protocols of CPR.
  - a. True
  - b. False
5. As a first responder to a nonfatal drowning, your role is to
  - a. monitor vital signs
  - b. provide supplemental oxygen
  - c. transport to the nearest medical facility
  - d. all of the above
6. The initial flow rate for constant-flow oxygen delivery is
  - a. 2-4 lpm
  - b. 10-15 lpm
  - c. 20-25 lpm
  - d. the rate the injured diver will tolerate
7. The percentage of oxygen delivered when using a demand valve is influenced by
  - a. flow rate
  - b. mask fit
  - c. mask seal
  - d. both b and c
8. In remote areas, the priority in oxygen delivery is
  - a. to conserve oxygen supplies
  - b. to maximize the highest inspired fraction of oxygen
  - c. limit the flow of oxygen
9. Oxygen toxicity, whether CNS or pulmonary, is not a concern for oxygen first aid administered to an injured diver.
  - a. True
  - b. False

Review answers are on Page [250](#).

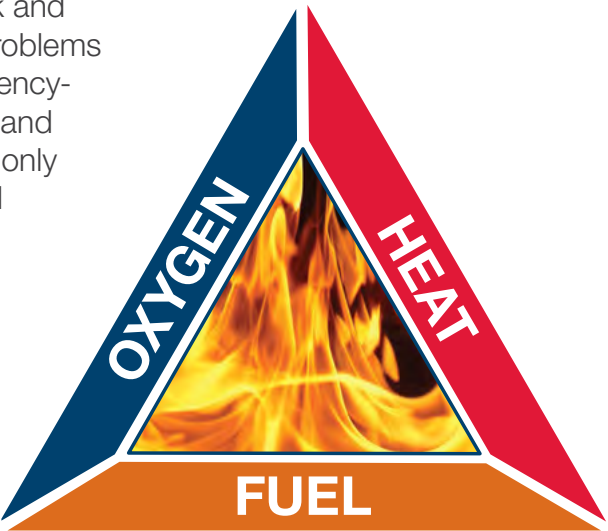


Objectives

1. What is the fire triangle, and how is oxygen involved?
2. What safety precautions should be implemented when handling and using oxygen equipment?
3. What grade of oxygen should be used for diving first aid?
4. What documentation is required to receive an oxygen fill?
5. How should an oxygen unit be stored?
6. When should an oxygen unit’s components and cylinder pressure be checked?
7. When and how should reusable oxygen masks and removable plastic oxygen system parts be cleaned?

Oxygen is not flammable, but all substances need oxygen to burn and may burn violently in an environment of pure oxygen. The higher the oxygen concentration, the greater the potential fire risk and acceleration. (CGA P45 section 4.1 2018) However, problems associated with the use of properly maintained emergency-oxygen devices are rare. Three elements — heat, fuel and oxygen — are required for a fire to exist. This is commonly called the fire triangle. Emergency oxygen systems will always have at least one element: oxygen.

Oxygen providers should reduce the risks of handling oxygen. Be sure that the hazards from fuel (hydrocarbons are commonly used as lubricants in diving and are found on dive boats), heat from the sun and rapid opening of the oxygen cylinder valve are minimized.



## Where Does Pure Oxygen Come From?

Fractional distillation of air yields pure oxygen. Air is first filtered to remove any debris and dirt. Compressed to very high pressures, it is dried to remove water vapor. To liquefy the gas, it is cooled to very low temperatures and allowed to slowly rewarm. As it is rewarming, various components of air (primarily oxygen and nitrogen) are captured and stored in separate containers as they reach their particular boiling points.

There are many grades of oxygen, but the three primary ones that oxygen providers need to consider are

- Aviator-grade oxygen
- Medical-grade oxygen
- Industrial-grade oxygen

Each grade must be 99.5 percent pure oxygen; however, differences exist in how the cylinders are filled, affecting the overall purity of the oxygen. For example, to prevent freezing at high altitudes, aviator-grade oxygen has a lower moisture content than medical-grade oxygen.

The filling procedures for medical-grade oxygen require that an odor test be conducted and the cylinder contents be evacuated before the fill. When odors are detected or damage to the valve or cylinder is observed, medical-grade oxygen cylinders are either retired or cleaned before being returned to use.

Industrial-grade oxygen is not recommended for use with dive injuries. Industrial-grade oxygen guidelines allow for a certain percentage of impurities and other gases to be contained within the cylinder. While both aviator- and medical-grade oxygen are suitable for breathing, industrial-grade oxygen may not be. The procedures for filling industrial oxygen cylinders do not ensure that the oxygen is free of contamination.

## Safety Precautions When Using Oxygen

Oxygen cylinders require the same care as scuba cylinders with a few additional precautions.

- Do not allow the use of any oil or grease on any cylinder or device that comes in contact with oxygen. Hydrocarbons are an especially significant risk due to combustibility. The result may be a fire.
- Oxygen cylinders should not be exposed to temperatures higher than 125°F (52°C) in storage (e.g., in a car trunk).
- Do not allow smoking or an open flame around oxygen and oxygen equipment.
- When turning on an oxygen cylinder valve, always turn it slowly to allow the system to pressurize. This will reduce the possibility of an oxygen fire if combustible contaminants have been introduced into the system. Once the system is pressurized, open the valve one full turn.
- Remember to provide adequate ventilation when using oxygen. In a confined, poorly ventilated space (e.g., the cabin of a boat), the oxygen concentration may build up and create a fire hazard.
- Use only equipment (cylinders, regulators, valves and gauges) made to be used with oxygen. Avoid adapting scuba equipment for use with oxygen.

- Visually inspect the condition of valve seats and oxygen washers, and make sure the materials are compatible for oxygen use.
- Keep the valves closed with the system purged when the unit is not in use. Close valves on empty cylinders. Empty cylinders should be refilled immediately after use.
- An oxygen cylinder should always be secured so that it cannot fall. When carrying an oxygen cylinder by hand, carry it with both hands, and avoid holding it by the valve or regulator. When transporting an oxygen cylinder in a car, secure and block the cylinder so it does not roll.

## Filling Oxygen Cylinders

In many areas, medical-grade oxygen is considered a prescription drug, which can make it difficult to refill your emergency oxygen cylinder. The most common method of documenting the need for oxygen is a prescription; however, prescriptions are for diagnosed medical conditions. The prescription allows for use only by the individual who was given the prescription.

The other method of obtaining an oxygen cylinder fill is by providing documentation of training in the use of emergency oxygen. Your DFA Pro Provider card is your documentation of appropriate training. Since retraining is to be completed every two years, you will need to maintain your skills by taking a refresher program. Ask your instructor about retraining opportunities.

Another less common method is use of a prospective prescription, which allows a trained individual to acquire oxygen for use in a diving injury. A physician trained in dive medicine may be willing to provide this prescription.

Some countries, states and local governments have regulations that require that oxygen supply companies document all medical-grade oxygen distillation, cylinder transfills and sales. These governmental agencies routinely inspect the facility's operations and documentation to verify compliance with these regulations. Other areas have few or no regulations regarding the distribution of oxygen.

## Oxygen Unit Storage and Maintenance

A few simple things will keep the oxygen unit in excellent working condition for years

- Keep the oxygen unit in its storage case, fully assembled and turned off. This allows for rapid deployment. Storing the unit in its case also reduces the likelihood of damage to component parts and prevents exposure to the corrosive properties of sea water.



- Store the oxygen unit with the valve closed and the regulator depressurized. This prevents the oxygen from being accidentally drained if a leak goes undetected.
- Before every dive outing, check the oxygen unit's components and cylinder pressure. Keep the cylinder filled with oxygen at all times. Have extra cylinders, washers and masks on hand for extended delivery and/or to assist more than one injured diver.
- Clean thoroughly any removable plastic oxygen unit parts and reusable oxygen masks after use. Soak the masks in a mild bleach solution of one part bleach and nine parts water for at least 10 minutes. Rinse thoroughly with fresh water, and allow to air dry completely. Harsh detergents or other chemical cleaning agents may cause mask deterioration or irritate an injured diver's skin upon contact. Other cleaning options include the use of chlorhexidine or alcohol.



## Oxygen First Aid in Scuba Diving Injuries

## Chapter 16: Oxygen Delivery Systems and Components

### Review Questions



1. Oxygen is one element of the fire triangle.
  - a. True
  - b. False
2. Safety precautions to implement when using oxygen cylinders include
  - a. not allowing any oil or grease to come in contact with oxygen cylinder
  - b. not exposing oxygen cylinders to high temperatures or allow smoking/open flames around oxygen
  - c. providing adequate ventilation when using oxygen
  - d. using only equipment made for use with oxygen
  - e. all of the above
3. With what grade of oxygen should an oxygen cylinder for diving first aid be filled?
  - a. aviator or industrial grade
  - b. medical grade only
  - c. medical or industrial grade
  - d. aviator or medical grade
4. Methods for obtaining oxygen fills may include
  - a. prescription
  - b. documentation of training in oxygen delivery
  - c. prospective prescription
  - d. any of the above
5. When should an oxygen unit's components and cylinder pressure be checked?
  - a. every two years
  - b. before every outing
  - c. every week
  - d. annually
6. An oxygen unit should be stored
  - a. with the valve closed
  - b. in its protective case
  - c. assembled
  - d. all of the above
7. It is not necessary to clean oxygen parts and masks.
  - a. True
  - b. False

Review answers are on Page [250](#).

### Objectives

1. What are the components of an oxygen delivery system?
2. What are the hydrostatic testing requirements for an oxygen cylinder?
3. What two factors influence what cylinder size is appropriate?
4. When should the oxygen provider switch to a full cylinder?
5. Which oxygen regulator is preferred for diving first aid?
6. How often and by whom should an oxygen regulator be serviced?
7. Why is a demand valve the first choice for delivering oxygen to an injured diver?

### Oxygen Delivery Systems

Oxygen delivery systems consist of an oxygen cylinder, a pressure-reducing regulator, a hose and a face mask. There are many oxygen equipment options. Descriptions for each system component as well as applicable guidelines are listed below.

### Common Oxygen Cylinders

Oxygen cylinders, the principal component of the oxygen system, come in a variety of sizes and are made of either aluminum or steel. Oxygen cylinders are subject to the same hydrostatic testing as all compressed-gas cylinders. The testing cycle is established by law or regulation and may vary by location. Common hydrostatic testing intervals range from annually to every 10 years. For example, the hydrostatic testing period is one year in Australia, two years in some European countries, five years in the U.S., and 10 years according to ISO standards. Visual inspections of oxygen cylinders are typically completed with hydrostatic testing.

Any concerns by you or the fill station about the condition of the cylinder between hydrostatic testing dates should prompt additional testing or inspections before filling the cylinder.

Oxygen cylinders should be clearly labeled. For easy identification and to minimize the risk of using a cylinder and/or its contents for an unintended purpose, oxygen cylinders may be color coded. White is the international standard but is not universally used. Many areas, including the United States, use green. In the U.S. oxygen cylinders are required to be labeled as containing oxygen, with or without the green color designation.

Ask your DFA Pro Instructor about the oxygen cylinder designation requirements in your area.

Capacity is the primary concern when choosing a cylinder. Enough oxygen should be available to allow for continuous delivery to an injured diver from the time of injury at the farthest possible dive site to the next level of emergency response (the nearest appropriate medical facility or point of contact with EMS).

Another consideration is having enough oxygen for a second injured diver.

The duration of common portable oxygen cylinders varies based on the size of the oxygen cylinder as well as oxygen flow, consumption rate and the type of delivery device. Common single portable oxygen cylinders can last from 15 minutes to 60 minutes. Nonportable oxygen cylinders can last up to eight hours or more. DAN Oxygen Units come with either an M9 (248 liters) or a Jumbo-D (636 liters) oxygen cylinder.

A 15-minute oxygen supply may be all that is needed if diving from shore where EMS is available and can respond quickly. A one- or two-hour supply may be required when diving from a boat offshore. When diving farther offshore and assistance is hours away, consider carrying a nonportable oxygen cylinder or multiple portable oxygen cylinders. Consult your DFA Pro Instructor about which cylinder size is most appropriate for your use.

The delivery device affects the duration of the oxygen supply. When using a constantflow regulator (discussed later), the approximate duration of an oxygen cylinder can be determined using this formula:

***Capacity in liters ÷ flow in liters per minute = approximate delivery time***

For example, if a cylinder holds 640 liters and the oxygen flow rate is 15 liters per minute, the cylinder will last approximately 43 minutes. At 10 liters per minute, the same cylinder will last 64 minutes.

When a diver uses a demand inhalator valve (discussed later), it is more difficult to determine an exact time of supply. The rate at which the oxygen is used will depend on the injured diver's breathing rate and volume. Generally, the average oxygen use on a demand valve is equivalent to 8 to 10 liters per minute. Demand-style delivery is preferred because no oxygen is wasted, and usually the oxygen supply lasts longer.

A partially filled oxygen cylinder should be changed to a full one when the pressure drops below 200 **psi** (14 bar). If only one cylinder is available, however, it should be used until the oxygen supply is depleted.

**Oxygen Pressure Regulators**

The pressure regulator attaches to the oxygen cylinder valve and reduces the cylinder pressure to a safe working pressure compatible with demand valve or constant-flow equipment. Various methods of attachment are available.

In some areas, pins engage matching holes on the cylinder valve. This pin-indexed valve is called a CGA (Compressed Gas Association) 870 medical oxygen valve. These pins are aligned to prevent an oxygen regulator from being used on a cylinder that may contain another gas. This system is important in locations where there are various gases in use, and each requires its own regulator and cylinder. Pin placement is specific for each gas.

In other areas, oxygen cylinders may have threaded gas-outlet valves (CGA 540 medical oxygen valve and bull-nose valve) that will accept regulators intended only for medical oxygen use.

Ask your DFA Pro Instructor which connection systems for oxygen cylinders and regulators are used in your region.

Oxygen delivery occurs via three common types of regulators regardless of how the regulator is attached to the cylinder valve.

- 1. A constant-flow regulator can deliver a fixed or adjustable flow of oxygen.
- 2. A demand regulator functions like a scuba regulator and delivers oxygen when the demand valve is activated.
- 3. A multifunction regulator combines the features of both the demand and constantflow regulators.

A multifunction regulator is preferred over the other styles because it will allow a rescuer to provide as close to 100 percent oxygen as possible to two injured divers simultaneously and permits various mask options.

All DAN Oxygen Units come equipped with multifunction regulators.

Regardless of the type of oxygen regulator used, it should be serviced every two years by a factory-authorized service representative.



***Multifunction regulator with CGA 870 connection***



***Multifunction regulator with CGA 540 connection***

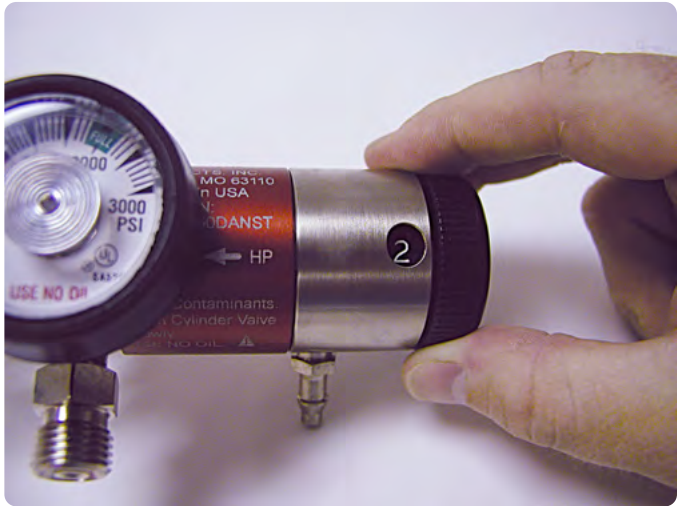
Oxygen regulator features

Several features on the oxygen regulator facilitate delivery of oxygen to an injured diver.

**Pressure gauge.** The oxygen regulator has a pressure gauge that provides visual monitoring of the oxygen level in a cylinder by indicating the volume of gas remaining in the cylinder. As noted previously, once the gas pressure reaches 200 psi, replace the cylinder with a full one. If another cylinder is not available, use the cylinder until it is completely empty, monitoring the injured diver so you can remove the mask when the oxygen supply is depleted.



**Flow meter.** The flow meter, an integral part of the pressure regulator, indicates the oxygen flow rate delivered through the barbed outlet to the constant-flow device (nonrebreather mask or oronasal resuscitation mask with supplemental oxygen inlet). Oxygen flow is measured in liters per minute (lpm). The control valve regulates the flow rate on the regulator. The flow-rate indicator window is on the front of the flow meter.



The DAN multifunction regulator is designed to deliver up to 25 lpm. DAN recommends an initial flow rate 10-15 lpm when used with either a nonrebreather mask or oronasal resuscitation mask. The flow rate can be increased as needed.

**Adapters.** In some regions, oxygen-compatible adapters accommodate various regulators with other oxygen cylinders. These adapters provide flexibility when one travels to other areas where different cylinders and valves are used. Adapters also let you use regulators designed for portable oxygen cylinders with large nonportable ones.

Oxygen system adapters are available commercially. To minimize the risk of fire and explosion, they should be oxygen cleaned. Avoid homemade adapters and the use of scuba regulators with high oxygen concentrations. It should be noted, however, that the CGA discourages use of adapters.

Hoses and Tubing

Since an oxygen demand valve requires approximately 50 psi (3.5 bar), an intermediate pressure hose attaches to the threaded outlets on both the oxygen regulator and demand valve. The threaded outlets are diameter indexed safety system (DISS) attachments that restrict use to only hoses that are oxygen compliant. This hose may be green, white or another color. Use only those hoses originally configured to connect to oxygen regulators or delivery valves. Modified hose connections should not be used.



Oxygen Masks and Delivery Devices

An oxygen mask secured firmly to the face permits the inhalation of higher concentrations of oxygen. Using a demand valve with an oronasal mask can deliver optimal oxygen concentrations with minimal waste, thereby preserving supplies for as long as possible. For diving injuries, it is recommended that oxygen be delivered by a demand valve and oronasal mask to provide as close to 100 percent inspired oxygen as possible. In contrast, common constant-flow masks provide from 35 to 75 percent oxygen.



Demand valve

DAN Oxygen Units contain a demand inhalator valve (similar to a scuba regulator second stage). When an injured diver begins breathing through the mask and a proper seal between the mask and the injured diver's face is maintained, the injured diver will receive the highest oxygen concentration possible. With the demand inhalator valve, oxygen flows only when the injured diver inhales, and the available oxygen supply will often last much longer than with a constant-flow system. You may use either an oronasal mask or an oronasal resuscitation mask to fit the demand valve to the injured diver's face.



Nonrebreather mask

The nonrebreather mask is a constant-flow mask that may be used to assist a breathing injured diver, allowing the diver to inhale oxygen from the reservoir bag positioned below the face mask.

The nonrebreather mask consists of a mask with three nonreturn valves — one on either side of the mask and one separating the mask from the reservoir bag. If any of theses valves is missing, consider not using the mask. Oxygen tubing, located at the bottom of the mask where the reservoir bag is attached, connects the mask to the regulator via the constant-flow barb.

During inhalation, oxygen flows from the reservoir bag into the mask, where the injured diver breathes in the oxygen. The nonreturn valves on the sides of the mask prevent air from being inhaled, which would dilute the oxygen being inspired. During exhalation, the same one-way valves prevent exhaled air from flowing back into the bag and instead release it to the outside. During exhalation, the reservoir bag refills with pure oxygen.

The nonrebreather mask is an effective way to deliver a high concentration of inspired oxygen using the constant-flow feature of the regulator. This mask, however, requires a large supply of oxygen because of the constant flow. Unless the mask completely seals around the face, air will leak past the mask and valves and dilute the oxygen. Thus, this method of oxygen delivery is the second choice, after the demand valve, for a breathing injured diver.

A nonrebreather mask is recommended for the breathing injured diver who does not tolerate the demand inhalator valve or when multiple diving injuries require oxygen. An initial flow rate of 10-15 lpm is suggested when using the nonrebreather mask. Adjust the flow rate to the nonrebreather mask so that the reservoir bag does not completely deflate during inhalations. If the reservoir bag is continually deflated, check the seal of the mask, and adjust the flow rate accordingly, or switch to a demand valve.

With a good fit and proper technique, the nonrebreather mask may deliver inspired oxygen concentrations up to 80 percent.



Note:

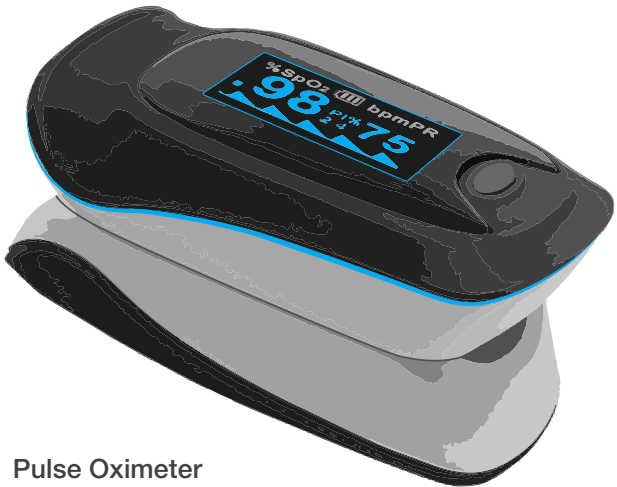
Caution: If the oxygen supply to the nonrebreather mask is interrupted and a good seal is in place, the injured diver faces some risk of suffocating. Therefore, one should never leave an injured diver unattended and should always monitor breathing while providing emergency oxygen first aid using a nonrebreather mask. Remove any mask before turning off the gas supply.

Several other oxygen delivery devices, such as the partial rebreather mask, the simple face mask and the nasal cannula, are available and used in other settings. These devices do not deliver sufficient percentages of oxygen and are not discussed in this course.

Advanced Concepts

Oxygen Saturation Monitoring

An oximeter is a device that monitors blood oxygen levels. Most models will measure pulse rate as well — these are called pulse oximeters. You can use a pulse oximeter while administering oxygen to an injured or ill diver. While lay providers cannot use these devices for diagnosis, titration and some other applications, pulse oximeters supply good information to gather and pass onto EMS personnel. Oximeters have limitations and may produce false readings. They may be less accurate when used on smokers, people with small hands or divers with cold or wet hands. Additionally, carbon monoxide contamination in a diver’s gas source may produce a false reading in an injured diver.



Pulse Oximeter



- Oxygen delivery systems are comprised of which of the following?
  - first aid kits and barriers
  - oxygen cylinders and pressure-reducing regulator
  - oxygen hose and face mask
  - b and c
- Two considerations when choosing an oxygen cylinder are distance to emergency care and size (volume) of the cylinder.
  - True
  - False
- A multifunction regulator is preferred in emergency oxygen for scuba diving injuries because it can provide emergency oxygen to two injured divers at the same time.
  - True
  - False
- An oxygen cylinder should be switched during care when the pressure drops below 200 psi if another cylinder is available; if another cylinder is not available, use the cylinder until it is empty.
  - True
  - False
- Oxygen cylinders are subject to periodic hydrostatic testing.
  - True
  - False
- Oxygen cylinder marking colors are identical internationally to prevent confusion.
  - True
  - False
- Oxygen regulators are fitted with a pin indexing system to prevent use on other cylinder valves that may not contain oxygen.
  - True
  - False
- A demand valve flows only when the injured diver inhales, allowing the oxygen to last longer.
  - True
  - False
- The initial flow rate for constant-flow oxygen delivery is
  - 2-4 lpm
  - 10-15 lpm
  - 20-25 lpm
  - the rate the injured diver will tolerate
- A constant-flow mask that is recommended when a breathing injured diver cannot activate the the demand inhalator valve or when there is more than one injured diver is a
  - nonrebreather mask
  - oronasal resuscitation mask
  - bag valve mask

Review answers are on Page [250](#).



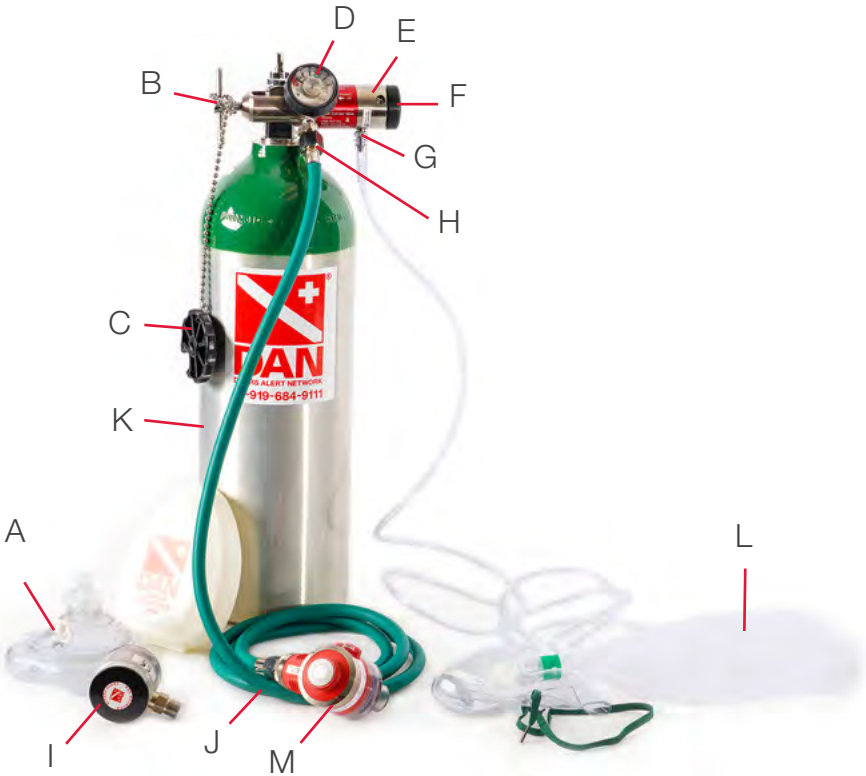
**Objectives:**

- Identify the component parts of an oxygen unit.
- Disassemble and reassemble an oxygen unit with minimal assistance.

Follow these simple steps to assemble and disassemble an oxygen unit.

- Ensure oxygen unit is depressurized.
- Open constant-flow control.
- Check pressure gauge.
- Remove multifunction regulator from the oxygen cylinder valve.
- Secure oxygen cylinder.
- Remove oxygen washer from multifunction regulator.
  - Washer is different from standard scuba O-ring.
- Remove oxygen hose from multifunction regulator.
- If the fitting is too tight, use handwheel/wrench to unscrew the hose.
- Remove oxygen hose from demand inhalator valve.
  - Both ends of the oxygen hose are identical.
- Unscrew the plastic mask adapter from the demand inhalator valve.
- Remove inhalation/exhalation assembly.
- To assemble, repeat steps in reverse.
  - Check valves to ensure oxygen does not flow from threaded ports.

- A. oronasal resuscitation mask with oxygen inlet  
B. T-handle  
C. handwheel wrench  
D. pressure gauge  
E. multifunction regulator  
F. constant-flow controller  
G. barbed constant-flow outlet  
H. DISS threaded outlet  
I. demand inhalator valve  
J. intermediate pressure hose  
K. oxygen cylinder and valve  
L. nonrebreather mask  
M. MTV



# SKILL: Demand Inhalator Valve

**Objectives:**

- Provide emergency oxygen to a responsive breathing injured diver using the demand inhalator valve and oronasal mask.

Follow these simple steps to provide emergency oxygen to a responsive or unresponsive breathing injured diver with the demand inhalator valve. This is the preferred method of providing emergency oxygen to any breathing injured diver.

**Remember S-A-F-E.**

S

Stop

- Stop
- Think
- Act

A

Assess the scene

- Is the scene safe?
- Is it safe to approach the injured diver?
- Is the ventilation adequate to use oxygen?
- Are any other hazards present?

F

Find oxygen unit, first aid kit and AED

- Take them to the injured person
- First aid kits contain critical supplies such as barriers

E

Exposure protection

- Use barriers such as gloves and mouth-to-mask barrier devices
- Don gloves, and inspect them for damage



**Deploy the oxygen unit.**

- Open cylinder valve with one complete turn.
- Check cylinder pressure.
- Ensure that there are no leaks in the system.
- Constant-flow setting should be in “off” position.
- Take a breath from the demand inhalator valve, and exhale away from it.
- Inform the injured diver that oxygen may help. State: “This is oxygen, and it may make you feel better. May I help you?”
  - If the diver is unresponsive, permission to help is assumed.

**Place the mask over the injured diver’s mouth and nose.**

- Tighten the elastic strap to assist with securing the best seal possible.
- Check the mask for any leaks around the injured diver’s face.

**Instruct the injured diver to breathe normally from the mask.**

- Reassure and comfort the injured diver.

**Instruct the injured diver to hold the mask if needed to help maintain a tight seal.**

**Monitor the injured diver and the oxygen pressure gauge.**

- Listen for the demand inhalator valve to open during inspiration.
- Observe mask fogging during exhalation and clearing with inhalation.
- Watch the chest rise during inhalation and fall with exhalation.

**Activate emergency action plan.**

- Call EMS or appropriate medical facility.
- Contact DAN for consultation and coordination of hyperbaric treatment.



# SKILL: Nonrebreather Mask

**Objectives:**

- Provide emergency oxygen to a responsive or unresponsive breathing injured diver using the nonrebreather mask.
- Discern when oxygen delivery options are not working adequately, and switch to another as appropriate.

Follow these simple steps to provide emergency oxygen to a responsive or unresponsive breathing injured diver with the nonrebreather mask. The nonrebreather mask is ideal when you have two injured divers or an injured diver who will not tolerate the demand inhalator valve.



**Remember S-A-F-E.**

**Ensure airway and breathing.**

**Deploy the oxygen unit.**

- Remove nonrebreather mask from bag.
- Stretch oxygen tubing to avoid kinks.
- Attach oxygen tubing to barbed constant-flow outlet on multifunction regulator.

**Set constant-flow control to an initial flow rate of 10-15 liters per minute (lpm).**

**Prime mask reservoir bag.**

- Place a thumb or finger inside the nosepiece, closing the nonreturn valve until the reservoir bag fully inflates.

**Inform the injured diver that oxygen may help.**

- State: “This is oxygen, and it might make you feel better. May I help you?”
  - If the diver is unresponsive, permission to help is assumed.

**Place the mask over the injured diver’s mouth and nose.**

- Adjust the elastic band around the head to hold the mask in place.
- Check the mask for any leaks around the injured diver’s face.
- Squeeze the metal clip over the nose to improve the seal and prevent oxygen leakage.



**Instruct the injured diver to breathe normally.**

- Adjust the flow rate (increase or decrease) to meet the needs of the injured diver.
  - Ensure that the reservoir bag does not collapse completely during inhalation (some deflation is normal and expected).
- Reassure and comfort the injured diver.
- Place the injured diver in the proper position.
- If the injured diver is responsive, ask him to hold the mask to maintain a tight seal.
- Monitor the injured diver and the oxygen pressure system.
- Look for the reservoir bag to slightly inflate and deflate and for movement of the nonreturn valves.
- Observe mask fogging during exhalation and clearing with inhalation.
- Watch for chest rise during inhalation and fall with exhalation.
- Activate the emergency action plan.
- Call EMS and DAN.

## Cardiopulmonary Resuscitation

## Chapter 17: Cardiopulmonary Resuscitation

### Objectives

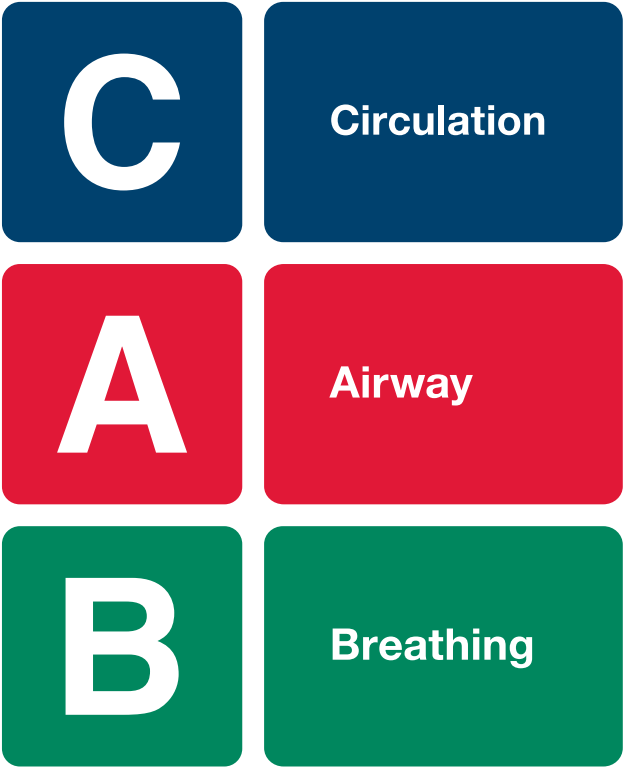
1. What is the goal of CPR?
2. What are the six links in the chain of survival in their proper sequence?
3. What is the first step for a single rescuer once unresponsiveness has been established?
4. What is the first step for a rescuer if the injured person is a child or the victim of a drowning incident?
5. What CPR protocol is to be followed for drowning victims?

Any injury, whether from a diving incident or not, can take a downturn. Constantly monitoring an injured diver and being prepared to take the next step is critical in incident management. Should the injured person quit breathing or if their heart should stop, intervention with cardiopulmonary resuscitation (CPR) is essential to maintain tissue oxygen supplies.

Maintenance of tissue oxygen supply is vital for life. When oxygen supplies are interrupted, our organs will suffer and eventually die. Without oxygen, especially vulnerable tissues such as the brain may start dying after 4-6 minutes. The goal of CPR is not to restart the heart but to provide critical blood flow to the heart and brain and to keep oxygenated blood circulating. CPR delays damage to vital organs such as the brain and improves the chances of successful defibrillation. During CPR, chest compressions and rescue breathing take over the functions of the heart and lungs respectively until emergency assistance and advanced care can be provided.

Key steps in CPR are:

- 1. Check for responsiveness, and activate EMS.
- 2. Quickly check for evidence of normal breathing and circulation (approximately 10 seconds).
- 3. If the person is not breathing normally, provide chest compressions to temporarily take over the function of the heart and circulate blood.
- 4. If no neck injury is suspected, tilt the head back to help open the airway. Provide rescue breaths to deliver air to the lungs.



Note:

The exhaled air used during rescue breathing contains about 16 percent oxygen (compared with 21 percent in room air). Despite this reduction in oxygen concentration, rescue breaths still provide adequate oxygen supplies to sustain vital organs.

Precipitating Conditions

The need for CPR and other basic life-support measures frequently involves the following conditions. Other conditions may also precipitate a need for life support, but those conditions are not covered here. Awareness that something is wrong is the primary concern.

Heart Attack

Heart attack — acute myocardial infarction (AMI) or acute coronary syndrome (ACS) — is the term used to describe the symptoms associated with blockage of the arteries that supply the heart muscle with oxygen and nutrients. If the heart attack is severe enough to cause the heart to stop functioning or to stimulate a life-threatening arrhythmia, first responders may need to initiate CPR and use an automated external defibrillator (AED).

When someone suffers a heart attack but is still conscious and breathing, your role is more supportive. In this situation, keep the person in a position of comfort, and activate EMS. Some people with a history of heart problems may carry nitroglycerine, a vasodilator, which is avail-

able as either pills or a sublingual spray. You may need to assist the person with taking their own medicine, but do not attempt to give nitroglycerine to anyone who doesn't have a prescription. When assisting someone with nitroglycerine, do not handle the pills with bare hands because the medication can be absorbed through the skin. Nitroglycerine is administered **under the tongue** to be absorbed and not swallowed. It can be administered as frequently as every five minutes for a total of three doses. Do not administer more than three doses within 15 minutes, regardless of the person's condition.

Not all heart attacks are painful, and there are many variables to look for with heart conditions.

Possible symptoms of heart attack:

- Heavy pressure or squeezing pain in the center of the chest or center of the back
- Shoulder, arm, neck or jaw pain
- Nausea and vomiting
- Shortness of breath
- Indigestion, heartburn
- Sweating
- Sense of impending doom

Symptoms vary between men and women as well as among individuals with preexisting medical conditions. Although women may experience any of these symptoms, the symptoms may be less severe in women. The pain may be predominantly in the upper back — like a rope being tightened around the chest — or the lower chest and upper abdomen. They may think they just have the flu. Regardless of whether chest pain is present or not, anyone experiencing shortness of breath without exertion should seek medical attention immediately.

Note:

The term “massive heart attack” is often used to describe a sudden cardiac arrest.

Special Circumstances with Resuscitation<sup>1</sup>

Pregnancy

While cardiac arrest is rare in pregnant women, it appears the rate may be increasing for women who are in the second half of pregnancy. There are several potential causes, but these are irrelevant to the first aid provider. To perform effective compressions when the top of the uterus is above the mother's



umbilicus, the recommendation is to manually displace the uterus to the mother’s left to reduce the uterus’ direct compression on the large blood vessels returning to the heart while compressions are performed. For quality compressions to be delivered, a second rescuer is required. Activate EMS immediately because additional measures will be required in a hospital setting.

**Opioid Overdose**

In 2012 opioid overdose became the leading cause of death for people 25-60 years of age in the United States. Most of these deaths are associated with prescription medications. Because of its presentation, opioid overdose can be confused with unconsciousness and can be difficult to ascertain as the cause. An opioid overdose progresses from central nervous system (CNS) depression to respiratory arrest to cardiac arrest. For first aid purposes, this situation is referred to as an opioid-associated life-threatening emergency. Naloxone is a medication that interferes with the action of opioids in the brain, spinal cord and gastrointestinal system. Because there are no known harmful side effects when this medication is used with or without opioid intoxication present, the U.S. Food and Drug Administration has approved a naloxone auto-injector as well as an inhaled nasal mist for use by lay rescuers in the first aid setting.

As with all life-threatening emergencies, check to see if the individual is breathing or gasping. Begin CPR if the person is not breathing or is gasping. If naloxone is available, administer 0.4 mg with an auto-injector, and continue CPR. The dose may be repeated every four minutes. Watch for the person to become responsive with purposeful movement or regular breathing.

Continue to monitor breathing and responsiveness until EMS arrives. Resume CPR if the person’s condition relapses, and administer additional doses of naloxone. If the person does not respond, continue CPR, and verify that EMS is on the way.

**Pectus Excavatum**

Pectus excavatum is a common congenital chest wall deformity, primarily found in males, in which the sternum and anterior ribs present as a concave chest wall. Medical review has suggested that chest compressions during CPR may only require a compression depth of of 3-4 cm (~1.5 inches) versus the recommended 5-6 cm (2-2.5 inches) in normal CPR.

**Drowning**

Drowning is defined as submersion/immersion in a liquid that impairs respiration and can be fatal or nonfatal. In the event the heart stops or experiences an arrhythmia due to submersion, and loss of circulating oxygenated blood results, immediate intervention with CPR can provide the injured person with the support necessary for survival. Multifaceted medical intervention is required, however, so CPR alone is usually not sufficient. As with heart attacks, CPR for a drowning victim is merely the aid that facilitates access to advanced care.

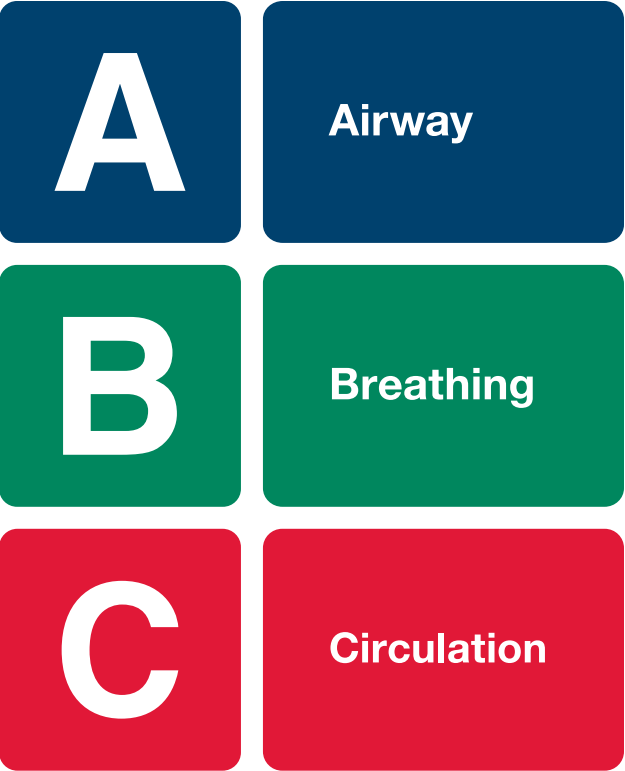
After determining unresponsiveness of a drowning victim, initiate CPR with two rescue breaths (unless regional protocols dictate otherwise). This protocol, with the acronym A-B-C, is used due to the hypoxic condition of drowning. Perform CPR for two minutes, then activate EMS if not already done. Continue CPR with two rescue breaths followed by 30 chest compressions.

**Hands-only CPR is not appropriate in this circumstance.**

Nonfatal drowning refers to a situation in which someone almost died from being submerged and unable to breathe. While nonfatal-drowning victims may revive quickly, lung complications are common and require medical attention.

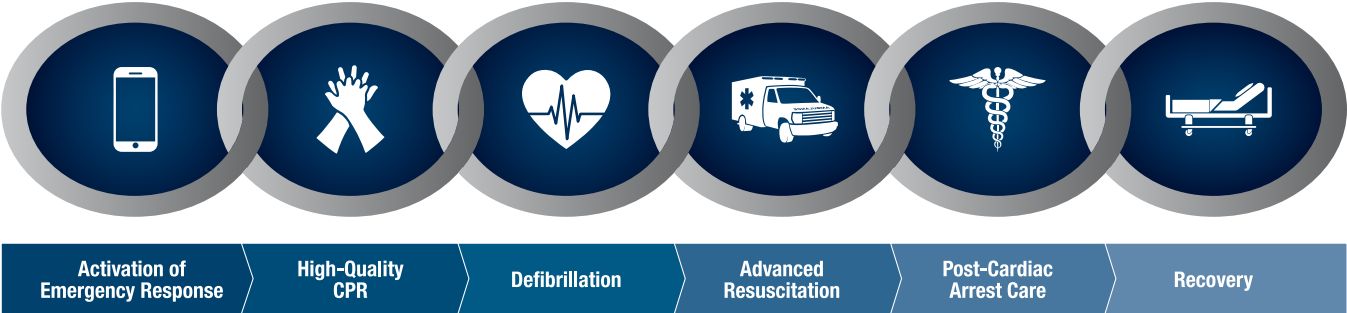
Symptoms of nonfatal drowning may include difficulty breathing, bluish discoloration of lips, abdominal distention, chest pain, confusion, coughing up pink frothy sputum, irritability and unconsciousness. Individuals may also be anxious or cold and would benefit from removal of wet clothes and possible treatment for hypothermia.

As a first responder, your primary role is to monitor vital signs and be prepared to start CPR, provide supplemental oxygen and transport the injured person to the nearest medical facility as soon as possible.



**Chain of Survival**

There are six links in the chain of survival.



**Immediate Recognition and Activation of EMS**

In the event of an emergency, the critical first step is recognizing that an emergency exists. Follow recognition of a medical problem with prompt action. Responses include evaluating the severity of the emergency, assessing available resources and utilizing those resources. After establishing unresponsiveness, call EMS. By activating local EMS, the chance of survival increases. Either call EMS yourself, or ask a bystander or other rescuer to do it.

If you are alone, activate EMS using your phone’s speaker setting. This practice minimizes lost time and can reduce any delays that otherwise may occur in starting CPR. If you are not alone, have someone else activate EMS while you begin CPR. There are two scenarios when the solo rescuer may consider initiating CPR prior to activating EMS:

- When caring for unresponsive children or infants
- When caring for a drowning victim

In these cases, the lone rescuer should perform two minutes or five cycles of CPR before calling for help. This slight alteration in procedural order is recommended because children and drowning victims may spontaneously recover if CPR is initiated immediately.

In contrast, acute coronary syndromes (heart attacks) often cause unstable heart rhythms that respond best to rapid defibrillation. Most people don’t have AEDs readily available, so calling EMS to get an AED on scene as soon as possible provides the best chance of reestablishing a life-sustaining heart rhythm.

Regardless of who calls, the person relaying information to EMS should state:

- |                                   |                          |
|-----------------------------------|--------------------------|
| • Exact location                  | • Care provided          |
| • Number of injured people        | • Call-back phone number |
| • Condition of the injured people | • Their name             |
| • What happened                   |                          |

Do not hang up until the operator releases you. The operator may repeat critical information before ending the call. This ensures that the message was received and key facts conveyed. If someone else is calling EMS, be sure to have that person return after the call to verify that help is on the way. Remember, the sooner you make the call, the sooner advanced life support will arrive.

Rapid Initiation of CPR

Early CPR significantly improves the chance of survival. It will not restart the heart but may delay tissue damage associated with inadequate oxygen supplies. Chest compressions temporarily take over the function of the heart, manually circulating blood in the body. Rescue breaths deliver air to the lungs and ensure a supply of oxygen for the body, especially for critical areas such as the heart and brain. Rescuers should initiate CPR within 10 seconds of recognizing cardiac arrest.

Early Defibrillation

Cardiac arrest often results from a non-life-sustaining rhythm known as ventricular fibrillation (VF). This rhythm disturbance results in inadequate blood flow to vital organs and is therefore life-threatening.

Early defibrillation, the process of delivering an electrical shock to the heart in an attempt to establish a normal cardiac rhythm, is the single most important intervention in the case of an unstable cardiac rhythm and provides the greatest chance of survival.

It is crucial to defibrillate a person with suspected sudden cardiac arrest as soon as possible. For every minute that defibrillation is delayed, the person’s chances of survival diminish 7-10 percent.

In addition, a five-year study showed bystander use of an AED improved survival rates (66.5% vs. 43.0%) and functional outcomes at discharge (57.1% vs. 32.7%).<sup>16</sup>

Circulation article Feb 2018 Survival increased from 43% to 66.5%

Advanced Cardiac Life Support

CPR and defibrillation may not restore a normal cardiac rhythm. In those cases, medical interventions such as advanced airway management and the delivery of medications may increase resuscitation success. Should CPR and/or defibrillation be successful, advanced life support will help stabilize the patient and make them ready for hospital transport. Remember: Advanced cardiac life support will not arrive until local EMS is activated.

Post-Cardiac-Arrest Care

In the event that a spontaneous heart rhythm resumes and effective circulation is restored, there is still work to do. Maintain airway support, and continually monitor the individual until help arrives to provide additional care and transportation to a hospital. Unstable heart rhythms that lead to unconsciousness or death may recur without warning.



1. The goal of CPR (without defibrillation) is to maintain the adequate circulation of oxygenated blood to vital organs such as the
  - a. spleen and pancreas
  - b. stomach and kidney
  - c. heart and brain
  - d. liver and muscles
2. Exhaled air contains about 10% oxygen
  - a. True
  - b. False
3. During CPR, the functions of the heart and lungs are temporarily taken over by
  - a. chest compressions and ventilations
  - b. cardiac defibrillation and an oxygen bottle
  - c. advanced medications and ventilator machines
4. What CPR protocol should be used when responding to a victim of drowning?
  - a. A-B-C
  - b. B-A-C
  - c. C-A-B
  - d. C-B-A
5. In most cases, the heart restarts after someone performs CPR.
  - a. True
  - b. False
6. The five links in the chain of survival in correct order are:
  - a. 911, CPR, AED, advanced cardiac life support, post-cardiac-arrest care
  - b. CPR, 911, AED, advanced cardiac life support, post-cardiac-arrest care
  - c. AED, advanced cardiac life support, post-cardiac-arrest care, 911, CPR
  - d. post-cardiac-arrest care, advanced cardiac life support, 911, CPR, AED
7. In the case of children and drowning victims, once unresponsiveness has been established, the single rescuer should
  - a. check for injuries
  - b. check the mouth for foreign bodies
  - c. activate EMS
  - d. perform CPR for two minutes and then call EMS
8. When calling EMS, you should tell them
  - a. what happened and the condition of the injured person
  - b. the location of the emergency and a call-back number
  - c. how many people are involved
  - d. your name and the first aid provided
  - e. all of the above

Review answers are on Page [251](#).



Objectives

1. What is the recommended depth and rate for compressions on an adult during CPR?
2. What is the recommended depth and rate for CPR compressions on a child? (HCP)
3. What is the recommended depth and rate for CPR compressions on an infant? (HCP)
4. When is full CPR always recommended?
5. When more than one rescuer is available, how are roles divided?

Starting CPR: Supporting Circulation

In many circumstances when normal breathing or a definite pulse is not present, a single rescuer initiates CPR, while another person (if available) activates EMS. The individual activating emergency services should inform EMS that the person under care is not breathing normally and has no pulse.

The single rescuer should ensure the individual is on a hard surface and then begin CPR starting with 30 compressions followed by two breaths. If a second rescuer is not available, the single rescuer should call EMS and secure an AED, if readily available, before beginning CPR on an adult. Once chest compressions have been started, interruptions should be limited to less than 10 seconds. Rescue-breathing techniques are covered in the next chapter.



### Note:

For drowning victims, perform CPR beginning with rescue breaths.

## Chest Compressions on Adults

Begin chest compressions by locating the center of the person's chest. This can be accomplished by drawing an imaginary line between the nipples. Once the site for compressions has been identified, stack your hands with the fingers of both hands interlocked and raised off the chest wall with the heel of the bottom hand on the center of the chest between the nipples. Position your shoulders directly over your hands with elbows straight. Keep your fingers raised off the chest wall, and compress the chest 30 times at a rate of 100-120 per minute. Pivoting from the hips for compressions allows the rescuer to use their body weight to assist with compressions and facilitates a smooth, rhythmic motion.



Compression depth should be 5-6 cm (2-2.5 inches). Compressions should be to this full depth and allow for complete recoil of the chest. It is important to release the pressure on the chest between the compressions but without your hands losing contact with the chest. The exact hand position and compression technique is covered in more detail in the skills-development section.

During compression, blood is pushed out of the left side of the heart and then throughout the body. At the same time, deoxygenated blood is squeezed from the right side of the heart to the lungs, where it takes oxygen from the lungs. When releasing the pressure on the chest, blood flows from the body into the right side of the heart, and oxygenated blood returns from the lungs to the left side of the heart.

When compressions are too fast, the heart does not have time to refill with blood, thus decreasing the resulting volume that flows out of the heart. Rescuer fatigue occurs quickly, resulting in decreased compression effectiveness. When compressions are too slow, the amount of circulating oxygen available to tissues decreases. When compressions are not deep enough, blood flow is also reduced, and the amount of blood pushed out of the heart may be inadequate to support tissue oxygen demands. After each cycle of 30 compressions, pause to provide two rescue breaths. (Rescue breathing is discussed in the next chapter.)

## Two-Person Adult CPR

When a second trained rescuer is available, the two rescuers should perform CPR as a team. Use the same compression and rescue-breathing techniques described for one rescuer but with one rescuer performing compressions and the other performing ventilations using the same 30:2 ratio. The first rescuer begins with chest compressions, while the second rescuer monitors compression rate and depth and maintains an open airway. At the completion of the 30th compression, the first rescuer pauses while the second rescuer administers two breaths (approximately one second per breath). Following the second breath, the first rescuer *immediately* resumes compressions without delay. Reducing the interruption of compressions is a critical element of CPR. Do not interrupt compressions for more than 10 seconds, other than during use of an AED.

### Note:

Pause compressions while ventilations are administered to minimize air moving into the stomach (which could cause gastric distension).

Rescuers should switch roles every two minutes (or five cycles of compressions and ventilations) to minimize rescuer fatigue.

## Chest Compressions on Children

Evaluate unresponsiveness in a child just as you would with an adult. Tap the collar bone and shout, "Are you OK?" while looking for any movement or signs of life, including normal breathing. Feel for a pulse at the carotid artery in the neck of the child. If in doubt about the presence of a pulse and the child shows no signs of life, begin chest compressions.



Performing CPR on a child is very similar to CPR on an adult. Children are generally considered to be between 1 year old and puberty, but the physical size of the child, not their age, will determine how CPR is performed.

### Note:

The lone rescuer should perform CPR for approximately two minutes on a child or infant before going for help or calling EMS. If a cell phone is available, activate EMS using the phone's speaker setting while beginning CPR.

With smaller children, using a single hand for compressions with the same technique as for an adult may be all that is necessary for adequate compressions. Large children, however, may require techniques similar to those used on an adult.

Compression depth on a child is approximately 5 cm (2 inches) or approximately one-third of the thickness of the child's chest. The compression rate remains 100-120 per minute. A single rescuer should use a 30:2 CPR compression and ventilation ratio for children.

Two-Person Child CPR

When a second rescuer is available for CPR on a child, the compression-to-ventilation ratio changes to 15:2, maintaining a rate of 100-120 compressions per minute. The more frequent ventilation rate compensates for the slightly faster natural respiratory rate of children. As with adults, one rescuer performs 15 compressions to a depth of 5 cm (2 inches) then pauses while the second rescuer administers two ventilations. The first rescuer immediately resumes compressions for another count of 15. The cycle of compressions and ventilations then repeats.



Chest Compressions for Infants

Infants are generally considered to be younger than 1 year old. To begin chest compressions on an infant, draw an imaginary line between the nipples to identify the compression site. With two or three fingers positioned vertically on the breastbone in the center of the chest between the nipples, compress straight down about one-third of the chest depth. A lone rescuer should perform 30 compressions at a rate of 100-120 per minute followed by two small breaths (puffs of air from the rescuer's cheeks), then repeat.

Two-Person Infant CPR

With the addition of a second rescuer, the preferred method for compressions on an infant is to use two thumbs for compressions with the hands encircling the chest. This method is less tiring for the rescuers and may allow for more consistent force and depth, resulting in better blood flow and higher blood pressures. Monitor the thumb positions to avoid their migration off the compression site.

The rescuer performing compressions should be positioned at the infant's feet. Draw an imaginary line between the nipples, and place both thumbs on the infant's chest at this line, with the thumbs either overlapping or side by side. Encircle the infant's body with both hands, using fingers to support the infant's back. Press and release the chest with your thumbs, being careful not to squeeze the sides of the chest. Allow the chest to fully recoil between compressions. As with children, two rescuers with an infant should perform 15 compressions followed by two breaths, switching positions about every 10 cycles (approximately every two minutes).

Note:

The technique of two thumbs with hands encircling the chest should be used only with two rescuers. A single rescuer should continue using fingers to facilitate rapid movement between compressions and breaths.

Review Questions



1. The recommended rate of compression for CPR on all ages is

a. 60-80 per minute

b. 100-120 per minute

c. at least 140 per minute

d. rate is not important as long as compressions are being done
2. The recommended depth of chest compressions for an adult is

a. 3.5-5.0 cm (1.5-2.5 inches)

b. 5-6 cm (2-2.5 inches)

c. 7.5-8.5 cm (3-3.5 inches)

d. Depth is not important as long as compressions are being done.
3. The recommended depth of chest compressions for infants and children is

a. one-third of chest depth

b. 5 cm (2 inches)

c. 2.5 cm (1 inches)
4. The compression-to-ventilation ratio for two-person CPR on children and infants is

a. 30:2

b. 30:3

c. 15:2

d. 15:1

Review answers are on Page 251.



### Objectives:

- Demonstrate proper hand positioning for chest compressions on a manikin for both an adult and a child.
- Utilize proper body mechanics to accomplish chest compressions consistently to a depth of 5-6 cm (2-2.5 inches) on an adult CPR manikin at a rate of 100-120 compressions per minute.
- Utilize proper body mechanics to accomplish chest compressions consistently to one-third the chest depth for a child, using one hand on a CPR manikin (adult or child) at a rate of 100-120 compressions per minute.
- Demonstrate proper finger/thumb placement for infant chest compressions.
- Utilize proper body mechanics to accomplish chest compressions consistently to one-third the chest depth on an infant CPR manikin at a rate of 100-120 compressions per minute.

### Chest Compressions: Adult and Child

- Kneel by the person's side.
- Place the heel of one hand in the center of the chest between the nipples.
- For adults, place the heel of your other hand on top of the first hand.
- Interlock the fingers of your hands. Do not apply pressure on the bottom end of the sternum (breastbone) or the upper abdomen.
- Position yourself vertically above the chest, with your arms straight and shoulders directly above your elbows and hands. Using your hips as a pivot point and the weight of your whole body, forcefully but smoothly press down on the sternum 5-6 cm (2-2.5 inches) for an adult, 5 cm (2 inches) for a child.
- After each compression, release all the pressure on the chest without losing contact between your hands and the sternum; repeat at a rate of 100-120 per minute.
- Compression and release should take equal amounts of time.
- For children, use only one hand if the size of the child permits.



### Chest Compressions: Infants — Single Rescuer

- Position yourself at the infant's side.
- Place two or three fingers side by side in the center of the infant's chest perpendicular to the nipple line.
- Using vertical force from your shoulder through your fingertips, compress the chest one-third the depth of the infant's chest.
- After each compression, release all the pressure on the chest without losing contact between your fingers and the sternum. Repeat at a rate of 100-120 per minute.
- Compression and release should take equal amounts of time.

### Chest Compressions: Infants — Two Rescuers

- Position yourself at the infant's feet.
- Circle the infant's chest with both hands, placing your thumbs in the center of the chest at the nipple line. Thumbs may be side by side or stacked on top of each other. Use your fingers to support the infant's back.
- Squeeze the infant's chest, compressing it to one-third the depth of the chest, being careful to not squeeze the sides of the chest wall.
- After each compression, release all the pressure on the chest without losing contact between your thumbs and the sternum. Repeat at a rate of 100-120 per minute.
- Compression and release should take equal amounts of time.

## Cardiopulmonary Resuscitation

### Chapter 19: Continuing CPR: Supporting Respiration

#### Objectives

1. What barrier devices (exposure protection) are recommended when doing rescue breathing?
2. How long should rescue breaths last?
3. What is the compression-to-ventilation ratio for single rescuers on an adult? For two rescuers?
4. What is the compression-to-ventilation ratio for a child?
5. When providing ventilations only, how often should rescue breaths be delivered for an adult? For a child? For an infant?
6. What are the advantages and disadvantages of the following: a) manually triggered ventilator, b) bag valve mask?

#### Rescue Breathing

Rescue breaths deliver oxygen to the lungs to oxygenate the blood and are an important part of CPR. For effective rescue breaths, the person's head must be tipped back and the jaw extended by lifting the chin. This opens the airway and prevents the tongue from creating an obstruction.

A seal must be created with either a barrier device or directly on the person's mouth. Barriers are recommended to minimize exposure risk. Disposable face shields are available in packets that can be carried in a



wallet. Larger barriers such as oronasal resuscitation masks and other devices are often included in first aid kits. Mouth-to-mouth ventilations may be an option if no barrier aids are available.

When providing rescue breaths with mouth-to-mouth ventilations, the person's nose must be pinched closed to ensure effective, adequate ventilations.

Alternatively, in the absence of a barrier device you may perform hands-only CPR if you are unwilling or uncomfortable performing unprotected rescue breaths. Compression-only support is acceptable in the case of a witnessed collapse of an adult who stops breathing normally. For drowning victims or scuba diving injuries, however, full CPR with ventilations is always recommended. This course teaches full CPR, which is part of the requirements for course completion.

Deliver each rescue breath for one second as you watch for the chest to rise. Avoid using excessive volumes of air with rescue breathing for all age groups. The chest rise should be gentle and just visible. Excessive volumes of air and a pronounced chest rise increase the risk of regurgitation and possibly obstruction of the airway. Allow the chest to fall (exhalation) for about one second, then deliver a second breath. If rescue breaths do not cause the chest to rise, reposition the individual's head. If efforts do not make the chest rise after two attempts, return to compressions. Check for visible obstructions after completing an additional cycle of 30 chest compressions and/or try to ventilate again. Each pause from chest compressions to ventilate should not last more than 10 seconds. The skills-development section provides full technique descriptions.

Do not delay compressions if ventilations are ineffective. The priority is chest compressions to keep blood circulating.

#### Note:

Remove a person's dentures only if they cannot be kept in place. In all other situations, keep them in the individual's mouth because this will make it easier to create a seal.

#### Rescue Breathing for Children

For children, use a head-tilt, chin-lift method (similar to the adult technique) and a rescue-breath volume that will achieve a gentle chest rise as you deliver the breaths. Avoid overexpansion of the child's lungs by adjusting your rescue-breath volume to the size of the child.

#### Rescue Breathing for Infants

The technique for providing rescue breaths for an infant requires less extension of the infant's neck and a smaller volume of air. Gently tip the infant's head to straighten the neck and airway to a

neutral position. Overextending the neck as with adults and children will collapse an infant’s airway. The volume of air required to provide rescue breathing to an infant can be met by simply using the air from the puffed cheeks of the rescuer. Breaths should not be long or forceful because infants’ lungs are very small.

Deliver rescue breaths to an infant using either an oronasal resuscitation mask or by placing your mouth over the infant’s mouth and nose. If using an oronasal mask, achieve a better seal by turning the mask 180 degrees from how it would be used on an adult or child. A seal still needs to be maintained for effective rescue breaths. When using mouth to mouth on an infant, both the infant’s mouth and nose must be covered to ensure an adequate seal for rescue breaths.

Full CPR

The combination of chest compressions (previous chapter) and rescue breaths amounts to full CPR, which assumes the functions of the heart and lungs.

In adults, activate EMS then initiate full CPR. In infants and children deliver CPR for 2 minutes first. Activating EMS using your phone’s speaker function while delivering the initial two minutes of CPR is highly recommended. If you are alone and without access to a phone, stop after 2 minutes of CPR to activate EMS. If a second rescuer is available, have them activate EMS while you continue to performs CPR.

Full CPR for all ages begins with chest compressions unless the cardiac arrest is due to drowning or another immersion event. In this situation, full CPR begins with a minimum of two ventilations. (Some regions recommend up to five ventilations before beginning CPR in immersion incidents. Follow your local protocols.)

Person	One Rescuer	Two Rescuers	How to Compress	Depth
Adult	30:2 ratio	30:2 ratio	Two hands stacked	5-6 cm (2-2 1/2 inches)
Child	30:2 ratio	15:2 ratio	Heel of one hand or two hands stacked	5 cm (2 inches) or 1/3 chest depth)
Infant	30:2 ratio	15:2 ratio	Two or three fingers (1 rescuer); two thumbs (2 rescuers)	3.5 cm (1 1/2 inches) or 1/3 chest depth)

NOTE: The rate of compressions for all age groups is 100-120 per minute.

Advanced Concepts

Cardiac arrest in children and infants is usually due to respiratory arrest. If they stop breathing, once the oxygen circulating in the bloodstream has been depleted, the heart stops. Since the underlying cause of their condition is respiratory in nature instead of heart disease, they may respond well to timely CPR. Providing care for two minutes before calling EMS may result in spontaneous recovery before EMS arrives. Any person — but especially a child or infant — who has received CPR should be evaluated by health professionals.

Rescue Breaths Without Compressions

If a pulse is present but the person is either not breathing or not breathing normally, a rescuer who is trained to deliver rescue breaths without compressions should provide rescue breaths. Begin rescue breaths with two ventilations for all age groups. Continue with one breath every five to six seconds for adults and children and every three seconds for infants. Use the same techniques as when providing rescue breaths during full CPR.

Maintain the airway, and monitor the person for regurgitation or spontaneous return of breathing. Continue to monitor pulse as well, checking every two minutes to ensure circulation is continuing. Remain prepared to initiate CPR if the pulse disappears.

Use of Oxygen During Resuscitation

The use of oxygen is especially important for victims of drowning and scuba diving accidents, where hypoxia is a major concern. In the case of prolonged asphyxia (not breathing) or reduced cardiac and lung function due to submersion, oxygen therapy may be crucial. It improves the delivery of oxygen to tissues during resuscitation. When used effectively, the concentration of delivered oxygen may increase to levels approaching 100 percent. Therefore, oxygen should be present at every swimming pool and dive site.



By providing oxygen during CPR for injured scuba divers or drowning victims, the fraction of oxygen delivered to a nonbreathing diver is increased and is critical for restoring oxygen levels in tissues. During ventilations — either as part of CPR or rescue breathing alone to maintain adequate oxygenation — the ability to deliver 100 percent oxygen as part of care is preferred. The use of supplemental oxygen in prolonged resuscitations can increase the effectiveness of CPR.

Two devices, the bag valve mask and manually triggered ventilator, can provide the beneficial higher levels of oxygen than rescue breathing alone.

**Bag valve mask (BVM)**

The BVM is a self-inflating bag that aids rescuers in providing ventilations to a non-breathing or inadequately breathing injured diver or in situations where other barriers are not available. It is a good choice when two rescuers are available because it provides a higher percentage of oxygen than mouth-to-mask ventilations, even without supplemental oxygen, and is less fatiguing than providing rescue breaths.



The BVM is connected to a mask by means of a mechanism with several oneway valves. When available because it provides a higher percentage of oxygen than mouth-to-mask ventilations, even without supplemental oxygen, and is less fatiguing than providing rescue breaths. Air or oxygen is compressed and is directed through the mask into the injured diver's lungs. The BVM can also be connected to an advanced airway device such as an endotracheal tube used by EMS personnel.

Since BVMs ventilate with air, they provide oxygen at concentrations of 21 percent, compared with the 16-17 percent delivered through rescue breathing. BVMs can provide much higher oxygen concentrations when connected to an oxygen cylinder. The oxygen concentrations are substantially reduced when the mask seal is poor. The ventilation bag and the mask are available in sizes suitable for adults, children and infants. Most adult selfinflating bags have a volume of 1600 mL. A system for an adult should never be used on a child since the bag can overexpand a child's lungs. In addition to having a smaller bag, some systems for children include a system for preventing lung overexpansion.

**Note:**

When providing emergency oxygen with a BVM, it is recommended that a tidal volume of 400-600 mL (roughly one-third of the ventilation bag volume) be given for one second until the chest rises. These smaller tidal volumes are effective for maintaining adequate arterial oxygen saturation, provided that supplemental oxygen is delivered to the device. These volumes will reduce the risk of gastric inflation.

Current BVMs incorporate a tube connection for oxygen and a reserve bag that is usually connected to the base of the resuscitation bag. Oxygen passes into both of them every time the

reservoir is compressed.

Many studies have clearly shown that the BVM technique applied by a single rescuer produces very poor ventilations, even though the rescuer may be well trained and conduct it perfectly. Therefore, it is recommended that the BVM be used by a minimum of two trained rescuers to guarantee the optimal ventilation. One rescuer manages the airway and keeps the mask sealed well, and the other compresses the bag. The BVM is a good choice when two rescuers are available because using it is less fatiguing than providing rescue breaths.

**Note:**

Achieving a good seal while lifting the diver's jaw with one hand and using the other to compress the bag is very difficult for a single rescuer. The injured diver's mouth may remain closed beneath the mask, or the tongue may create an obstruction due to poor airway management. Leaks are difficult to prevent when attempted by a single rescuer. Potential leaks are minimized with two-rescuer delivery. On the other hand, if a good seal is obtained on the injured diver's face, the BVM can produce enough pressure to expand the stomach and/or damage the lungs — hence the recommendation to limit tidal volume to 400-600 mL.

Newer versions of the BVM have a stop valve to help prevent overinflation. It restricts air flow from the bag to the injured diver if resistance, due to the lungs being overfilled for example, occurs during ventilations. The stop valve may also be activated if the rescuer uses too much pressure to operate the system. Either way, the stop valve prohibits further air from being administered.

Despite the potential problems, the BVM can be very effective if used by properly trained rescuers.

**Description and Function of a Typical BVM Device**

Even though various models of the BVM have differing design details or characteristics, the operating principles are the same. You should become familiar with the model you use.

**Ventilation bag.** This bag is designed to reinflate after it is compressed. It refills with air or oxygen through a suction valve at the end of the bag. The suction valve also functions as a nonreturn valve, preventing the gas from escaping at the bottom of the bag and preventing strain around the neck of the bag.

**Tolerance valve.** Depending on the manufacturer, this assembly contains two one-way valves. The first is the "lip valve," which opens when the gas exits from the



ventilation bag and closes when the gas goes in the opposite direction. This allows the gas contained in the ventilation bag to be directed toward the injured diver and prevents the expired gas from reentering the bag. The expired gas is directed from the assembly through a separate membrane or through the lip valve, which rises to allow the gas to be dispersed. This membrane also prevents the air from returning to the injured diver.

**Oxygen reserve bag.** The majority of BVM devices have a reserve bag of some type. The reserve bag is designed to collect the oxygen during the expiration cycle so that it is available for the inspiration cycle.



The BVM should include a system for preventing excess pressure in the system and/or in the reserve bag caused by the introduction of unused gas. Some systems have slits in the reserve bag that open under pressure and allow excess gas to escape. Other devices use an outlet valve or a membrane.

In addition, the BVM requires an inlet that allows a certain amount of air to reenter when the reserve bag is used if there is insufficient gas to allow the ventilation bag to refill.

**Manually Triggered Ventilators**

The manually triggered ventilator (MTV), also known as a flow-restricted oxygenpowered resuscitator, is a dual-function regulator. It allows rescuers to provide emergency oxygen with optimal oxygen levels to a nonbreathing or inadequately breathing injured diver. The user can start or stop the oxygen flow immediately by activating a button similar to the purge button of a scuba regulator. It can also function as a demand valve that can deliver maximum oxygen concentrations to the breathing diver and minimize the gas waste.



**Note:**

Lower tidal volumes are recommended with MTVs. These smaller tidal volumes are effective for maintaining adequate arterial oxygen saturation and will reduce the risk of gastric inflation. Ventilations are given over one second until the chest rises. Two rescuers are recommended when using the MTV. One rescuer should maintain the airway and mask seal, while the second rescuer activates the ventilator.



MTVs offer several advantages. They deliver higher concentrations of oxygen than rescue breathing with supplemental oxygen and are less tiring for the rescuers delivering care. MTVs can deliver a flow greater than 40 lpm to a nonbreathing or inadequately breathing injured diver, an amount that is significantly more than what is required to satisfy the breathing requirements of an individual.

The MTV-100, one model of MTV, automatically limits the flow rate to 40 lpm, thereby reducing the risk of introducing gas into the stomach and subsequent regurgitation. This limit corresponds with current American Heart Association recommendations that a lower flow rate be used to reduce complications. The MTV-100's safety valve terminates the flow completely when it detects a mounting pressure of greater than approximately 60 cm H<sub>2</sub>O. In addition, the unit includes a redundant valve for use if the first one fails.

Some older versions of oxygen-powered ventilators exceeded 160 lpm in delivered oxygen. Previously it was thought that this amount was necessary to ventilate an injured diver. Such a high flow rate, however, can very easily cause expansion of the stomach, which can lead to regurgitation and the aspiration of the stomach's contents. Moreover, a high flow rate can potentially damage the lungs.

Some other units terminate the flow but do not allow the pressure to be released, which could impede the injured diver's exhalation. When used on an adult, the safety valve should prevent pulmonary injuries but might not prevent distension of the stomach (which normally occurs when the esophagus pressure is greater than 15-20 cm H<sub>2</sub>O).

Some devices can stop providing gas prematurely without alerting the operator. This can happen when the lungs of the injured diver present resistance or when there is a poor response from the lungs, as can happen when ventilating an individual with asthma or an injured diver who has experienced a submersion incident. The MTV-100 has an audible click that alerts the operator of excessive levels of pressure in the airways. If the device does not deliver an audible click, the

operator may not become aware of the resistance during resuscitation, and therefore an obstruction in the airway or an overexpansion of the lungs may not be detected.

As with all oxygen-assisted ventilation techniques, these units can no longer be used once the oxygen supply is exhausted.

## Review Questions



- Each rescue breath should last about
  - 2 seconds
  - 1 second
  - 5 seconds
- To avoid overexpansion of their lungs, the volume of ventilations for children should be adjusted to accommodate their size.
  - True
  - False
- When delivering rescue breaths to an infant, the head should
  - be extended as it would for an adult or child
  - not be extended at all
  - be extended gently but not as far as you would for an adult or child
- When delivering only rescue breaths (no compressions) on an adult, the rate of ventilations is one breath every
  - 10 seconds
  - 5-6 seconds
  - 3 seconds
- Rescue breaths only (no compressions) on an infant should be delivered every 3-5 seconds.
  - True
  - False
- Full CPR is always recommended for
  - drowning victims
  - scuba diving injuries
  - both a and b
- A bag valve mask
  - is a self-inflating bag with a mask that aids in rescue breathing
  - has a manual trigger that initiates oxygen flow
  - is best used by two rescuers working together
  - a and c
- Manually triggered ventilators
  - allow rescuers to deliver high concentrations of oxygen to nonbreathing or inadequately breathing divers
  - can also function as a demand valve
  - are best used by two rescuers
  - all of the above

**Review answers are on Page [251](#).**

## SKILL: Rescue Breathing



### Objectives:

- Demonstrate the proper rescue-breathing technique for an adult and child on a CPR manikin.
- Demonstrate the proper rescue-breathing technique on an infant manikin.

### Rescue Breathing for Adults and Children

- Remain at the individual's side.
- Place the face shield or resuscitation mask on the person's face using the bridge of the nose as a guide for correct positioning.
- Seal the mask by placing your index finger and thumb of the hand closest to the top of the person's head along the border of the mask.
- Use the thumb and first finger of the other hand to pinch the lower border of the mask to the chin. (Other techniques are acceptable; avoid pressing on the soft tissue of the throat under the chin.)
- Press firmly and completely around the outside margin of the mask to form a tight seal.
- Tip back the head so the chin is pointing up.
- Seal your lips around the one-way valve, and blow through it for one second. Watch the chest rise.
- Remove your mouth from the mask, and watch for the chest to fall as the breath is exhaled.
- Deliver a second breath as before.
- If rescue breaths do not make the chest rise:
  - Reposition the head, and reattempt to ventilate.
  - Check the person's mouth, and remove any obstruction.
  - Do not attempt more than two breaths each time before returning to chest compressions.
  - When in doubt, ventilate less, not more.



### Rescue Breathing for Infants

- When using an oronasal mask on an infant, place the mask on the infant's face so the narrow portion of the mask covers the chin (placement is 180 degrees to placement on an adult).
- Seal the mask tightly with downward pressure along all edges, and gently tip back the infant's head. Avoid overextending the head and collapsing the airway.
  - For infant rescue breathing, use of an oronasal mask is optional. When using mouth-to-mouth resuscitation on an infant, it may be necessary to cover both the mouth and nose.
- Use gentle puffs of air from your cheeks to ventilate an infant.
- Allow the chest to fall with the exhale before ventilating again.

SKILL: Full CPR

Objectives:

- Perform two minutes of full CPR as a single rescuer on adult and infant CPR manikins, completing at least five cycles of 30:2 compressions/ventilations.
- Perform four minutes of full CPR as a two-person rescue team on an adult CPR manikin, completing at least 10 cycles of 30:2 compressions/ventilations.
- Perform four minutes of full CPR as a two-person rescue team on an infant CPR manikin, completing at least 20 cycles of 15:2 compressions/ventilations.

Full CPR: Adult

- Using the compression and ventilation techniques from the previous skills, deliver chest compressions at a rate of 100-120 per minute, followed by ventilations using a ratio of 30:2 as a single rescuer for a minimum of five cycles (two minutes).
- Using the compression and ventilation techniques from the previous skills, deliver chest compressions at a rate of 100-120 per minute followed by ventilations, using a ratio of 30:2 as a two-rescuer team for two minutes.
- Switch roles, and continue for an additional two minutes of CPR.

Full CPR: Infant

- Using the compression and ventilation techniques from the previous skills, deliver chest compressions at a rate of 100-120 per minute followed by ventilations, using a ratio of 30:2 as a single rescuer for a minimum of two minutes.
- Using the compression and ventilation techniques from the previous skills, deliver chest compressions at a rate of 100-120 per minute followed by ventilations, using a ratio of 15:2 as a two-rescuer team for four minutes.
- Switch roles, and continue for an additional two minutes of CPR.

Person	One Rescuer	Two Rescuers	How to Compress	Depth
Adult	30:2 ratio	30:2 ratio	Two hands stacked	5-6 cm (2-2 1/2 inches)
Child	30:2 ratio	15:2 ratio	Heel of one hand or two hands stacked	5 cm (2 inches) or 1/3 chest depth)
Infant	30:2 ratio	15:2 ratio	Two or three fingers (1 rescuer); two thumbs (2 rescuers)	3.5 cm (1 1/2 inches) or 1/3 chest depth)

NOTE: The rate of compressions for all age groups is 100-120 per minute.

SKILL: Resuscitation with a BVM

Objectives:

- Provide emergency oxygen as part of a team to a nonbreathing or inadequately breathing injured diver using a bag valve mask.

Follow these steps to use a BVM to resuscitate a nonbreathing or inadequately breathing injured diver. This skill requires two rescuers.

Remember S-A-F-E.

Rescuer One

The first rescuer begins single-rescuer CPR as soon as possible and continues while the second rescuer prepares the oxygen equipment. When the oxygen equipment is ready, Rescuer One ventilates the injured diver by compressing the ventilation bag about one-third of the bag volume.

- Bag compressions should be slow and gentle, lasting about one second for the ventilation phase. Allow the chest to fall completely before beginning each new ventilation.
  - Watch the stomach for signs of distension to prevent regurgitation.
- Each ventilation should last about one second. Deliver two ventilations, allowing for a one-second exhalation in between.
- Deliver chest compressions between ventilations.

Rescuer Two

The second rescuer prepares the oxygen equipment, while the first rescuer performs CPR. When the equipment is ready, the second rescuer should do the following:

- Connect the BVM tubing to the constant-flow barb on the oxygen regulator.
- Turn on constant flow to initial setting of 15 lpm and allow the reservoir bag to inflate.
- Seal the mask in place using head-tilt, chin-lift method, pulling the diver’s jaw up and into the mask.
- Maintain the airway.
- Monitor the oxygen supply.
- Activate your emergency action plan.
- Call EMS (if you haven’t already) and DAN.



## SKILL: Using an MTV

### Objectives:

- Provide emergency oxygen as part of a team to a non breathing or inadequately breathing injured diver using an MTV and oronasal mask.

Follow these steps to use an MTV to resuscitate a nonbreathing or inadequately breathing injured diver. Two rescuers are required for this skill.

### Remember S-A-F-E.

#### Rescuer One

The first rescuer begins single-rescuer CPR using an oronasal resuscitation mask as soon as possible and continues while the second rescuer prepares the oxygen equipment. When the oxygen equipment is ready, Rescuer One ventilates the injured diver by carefully pressing the resuscitation button while observing the chest and quickly releasing the button.

- Watch for the chest and abdomen to rise.
  - Ventilations should take about one second.
- Release the resuscitation button as soon as the chest begins to rise. Deliver two ventilations, allowing for a one-second exhalation in between.
  - Leaving one hand gently on the center of the chest can help to assess that ventilations are adequate and not excessive.
- Watch for distension of the stomach.
- Deliver chest compressions between ventilations.

#### Rescuer Two

When the equipment is ready, the second rescuer should do the following:

- Test the safety valve to ensure that it functions properly.
- Press the ventilation button, then block the oxygen outlet of the MTV with their hand.  
The oxygen flow should stop and the gas should be released.  
NOTE: If the safety shutoff does not work, do not use the MTV.
- Connect the oronasal mask to the MTV adapter.
- Position the mask over the mouth and nose of the injured diver.
- Seal the mask in place using the head-tilt, chin-lift method, pulling the diver's jaw up and into the mask.
- Maintain the airway and hold the mask in place while the first rescuer pushes the ventilation button on the MTV and delivers chest compressions.
- Monitor the supply of oxygen attentively, and be prepared to resume rescue breathing if the supply is exhausted.
- Activate your emergency action plan.
- Call EMS (if you haven't already) and DAN.

## Cardiopulmonary Resuscitation

## Chapter 20: Use of an Automatic External Defibrillator (AED) during CPR

### Objectives

1. Why are AEDs recommended?
2. What are the considerations for using an AED on children or infants?

### Use of AEDs During CPR

The heart has an inherent electrical system that stimulates heart muscle contractions. As these electrical impulses fire and the muscles contract, blood is pumped from the heart to either the lungs or systemic circulation via arteries.

When something upsets these electrical impulses and breaks the heart's rhythm, sudden cardiac arrest (SCA) may occur. The most common life-threatening rhythm disturbance (arrhythmia) that occurs during an SCA is ventricular fibrillation (VF). Fibrillation refers to disorganized and ineffective muscular contractions. When this occurs in the ventricles — the chambers responsible for pumping blood to the lungs and body — circulation essentially stops, and a person will die.

The most effective way to reestablish a normal heart rhythm is with defibrillation. While CPR helps to oxygenate blood and circulate it throughout the body, CPR cannot reestablish a normal heart rhythm. Only defibrillation can do that.

Defibrillation sends an electric shock through the heart and essentially hits a “reset” button. The electric shock overrides the misfiring rhythm and allows the body's natural pacemaker to restore a normal rhythm.



Prior to the advent of AEDs, the use of defibrillators required a lot of training, and only highly trained professionals could use defibrillators. Fortunately, AEDs available to the general public are simple to use and reduce the time from initial collapse to initial shock delivery. As noted in Chapter 17, bystander use of an AED significantly improves outcomes in observed public cardiac arrests. Take time to notice AED locations in stores and other areas you frequent so you will know where to find one in the event one is needed.

All AEDs provide audible user prompts and an easily recognizable light indicating when to deliver the shock. Turn on the AED, and follow the directions provided by the unit. In the skills-development section, your instructor will introduce you to the process using an AED training unit.

CPR combined with the use of an AED provides the highest rate of survival. When defibrillation is provided in conjunction with CPR within the first few minutes after VF begins, the person's chances of survival increase. Survival rates drop about 7 to 10 percent for every minute a person is in VF without CPR.<sup>17</sup> The longer a person remains in an unstable rhythm, the lower the chances of successful defibrillation.

It is recommended that the lone rescuer retrieve any readily available AED unit while concurrently using a cell phone to activate EMS, thereby reducing the time for emergency care arrival and providing for quick deployment of the AED. Use the phone's speaker function and keep it close, allowing for constant contact with EMS dispatch while you initiate care.

When a second rescuer is available, perform CPR while the other person locates and sets up the AED unit. Interrupt CPR only after the AED pads are in place so the unit can evaluate the individual's heart rhythm.

To utilize an AED, the person's chest must be bare. Place the AED pads on reasonably dry skin, following the diagrams on the pads — one on the upper right chest and the other wrapped around the lower left side of the rib cage. If the pads are switched, the AED will still work.

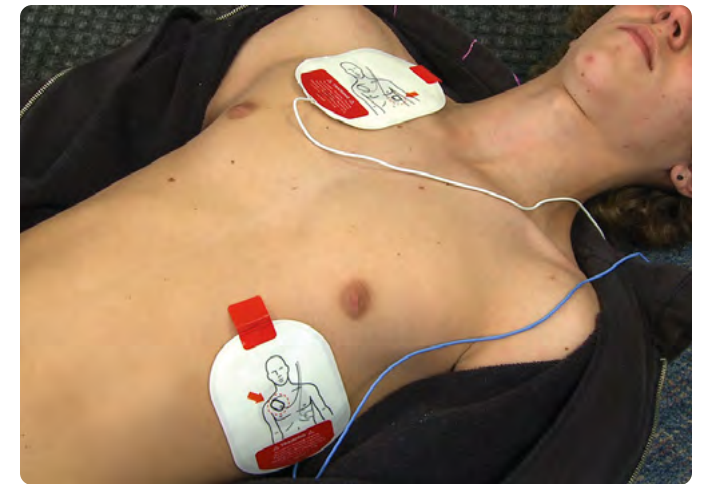
Software within the AED performs heart-rhythm analysis and advises the rescuer if a “shockable” rhythm is detected. If a nonshockable rhythm is detected, the unit will provide a “no shock advised” message. The rescuer should then continue CPR uninterrupted until EMS arrives or another rescuer takes over.

If a shockable rhythm is detected, the AED unit will prompt rescuers to clear the area (“Do not touch the patient”) and then prompt them to press the flashing button (or other action specific to the device) to deliver a shock. Once the AED delivers the shock, immediately resume chest compressions. The heart still needs the support of chest compressions, so resume them right away after a shock is delivered. There is no lingering charge from the use of an AED that will cause harm to the rescuer. Continue CPR for two minutes or until the AED unit advises it is analyzing the heart rhythm again.

The unit may advise for additional shocks, so be prepared to deliver multiple shocks based on the AED prompts.

## AED Pad Placement

AED use requires placement of the pads on the chest in a manner that allows the current administered during the shock to travel through the heart muscle. On an adult, place one pad on the right side of the chest below the clavicle (collar bone) and the other pad on the left side of the chest wall under the person's arm (see photo). Placing the left pad too far forward on the chest wall may allow the current to bypass the heart. Illustrations on the pads will aid in correct placement. If the pad positions are switched, the AED will still work.



AED pads should be placed on children the same way they're placed on adults. Use pediatric pads if they are available. If an adapter is not available, however, use the AED with adult pads at full power.

There is no clinical evidence of damage to the heart tissue from the use of an AED, so use on infants is approved. As with children, use an adapter to reduce the amount of current flow. In the absence of an adapter, however, using an AED may still be helpful. On an infant, place the pads in the center of the chest and in the center of the back.

## Cautions

While AEDs can be used in wet environments, they should not be used in standing water. Move an ill person away from pools of water if necessary.

Metal surfaces, as may be encountered on a dive boat, do not require special consideration as they do not pose a hazard to the ill person or the rescuers providing care. However, exercise caution to ensure that neither the pads themselves nor their conducting gel are in contact with the metal surface. In all circumstances, providers should not be in contact with the ill person during shock delivery. [Part 4: The Automated External Defibrillator: Key Link in the Chain of Survival](#)

If supplemental oxygen is being used in the person's care, discontinue its use, turn off the oxygen flow and move away from the person. Once the shock has been delivered, resume use of oxygen.

### Note:

While AEDs can be used in an aquatic setting (near water or where water is on or around the person), it should not be used in standing water. You must dry the chest before placing the pads on the individual. Place AED pads on the person's bare chest according to the diagrams on the pads.

Troubleshooting

AEDs typically are trouble-free, but when problems occur they frequently involve the pads. When the AED unit detects problems, it will provide prompts to check for issues such as poor pad placement or attachment. Chest hair or wet skin may interfere with pad adhesives, so be sure the chest is free of excessive moisture. It may be necessary to shave off heavy chest hair for adequate pad contact.

The vibrations caused by running boat engines may make it difficult to use an AED on a moving boat.

Maintenance

Check the AED status indicator daily. If the battery is low, replace it with a new or freshly recharged one. Do not use an AED with a low battery.

AED pads have expiration dates. Check components regularly, and replace items as necessary.

Carefully handle pads using the provided tabs or the place where the wires attach. If the pads appear damaged or if wires are loose, a new set of pads may be required for the AED to operate properly.

Be aware that rules and regulations concerning AED use vary from region to region. Check for laws that may apply in your area, or ask your DFA Pro Instructor about possible restrictions on AED use where you live or work.

Review Questions



1. The use of an AED is often helpful but may decrease the chance of survival.  
a. True  
b. False

2. For every minute of delay until the use of an AED, survival rates decrease by  
a. 3-5%  
b. 7-10%  
c. 12-15%  
d. 20-25%

3. All cardiac arrests can benefit from the shock delivered by an AED.  
a. True  
b. False

4. The charge from a delivered shock should be allowed to dissipate before touching the person to resume CPR.  
a. True  
b. False
5. AEDs with adult pads may be used on infants and children.  
a. True  
b. False

6. AED pad placement on adults is  
a. on the right chest and left side  
b. on the center of the chest and center of the back  
c. under both arms, centering the heart between them

7. AED pad placement on infants is  
a. on the right chest and left side  
b. on the center of the chest and center of the back  
c. under both arms, centering the heart between them

Review answers are on Page [251](#).

### Objectives

1. What is the most common cause of choking in adults?
2. How can a partial airway obstruction be identified?
3. How should a rescuer respond to a partial airway obstruction?
4. How can a complete airway obstruction be identified?
5. What action should be taken if a choking victim becomes unconscious?
6. When can a finger sweep be used?
7. What is the maximum time suctioning may be used on an adult? On an infant?

Foreign bodies are the main cause of blocked airways and choking. The most frequent culprit in adults is food. In children it may be toys, coins, nuts or other small objects. Airway obstruction prevents normal airflow into the lungs and may result in respiratory arrest and eventually cardiac arrest.

Airway obstruction may be partial or complete. A choking victim may suddenly become silent or grasp at their throat — this is the universal sign for choking. Ask the person, **“Are you choking?”** People who are able to move air will usually cough to dislodge the object and may not require an intervention.

Of greater concern is the severe obstruction, when a person is unable to breathe at all and



can only nod their head to your question. They cannot cough or speak. This person is unable to move air and will become unconscious without intervention. If possible, provide assistance before unconsciousness occurs. Remember to ask permission to assist a conscious, choking person before providing care.

### First Aid for Choking Adults and Children

In the case of a partial or mild airway obstruction (e.g., the person can speak, cough, make sounds), the rescuer should encourage the choking victim to cough but should do nothing else.

If the person shows signs of a severe airway obstruction and is conscious, there are three major methods to clear an obstructed airway in adults.

- Abdominal thrusts
- Back blows
- Chest compressions

All have been shown to be effective with no single method more effective than another. Multiple techniques may be required to clear an obstructed airway. No clear evidence of an effective order of use has been demonstrated. Utilize the method of choice or whichever method is regionally preferred. A combination of techniques may be required to relieve an obstructed airway.

Each technique does present potential risks:

- Abdominal thrusts have been associated with rupture of internal organs.
- Chest thrusts may cause rib and sternal fractures.
- Back blows may lodge the foreign body tighter in the trachea<sup>18</sup>.

**Always ask permission to assist before providing care.**

#### Abdominal Thrusts:

Stand behind the person, and put both arms around the upper part of the abdomen.

- Clench your fist, and place it between the navel and bottom tip of the sternum with the thumb side of your fist against the choking victim's abdomen.
- Grasp your fist with your other hand, and pull sharply inward and upward.
- Repeat until the object is expelled or the person loses consciousness.



**Chest Thrusts:**

- Stand behind the individual encircling their chest, placing your arms directly under their armpits.
- Form a fist and place the thumb side of your fist on the middle of breastbone (avoid the xiphoid process or margins of the rib cage).
- Grasp your fist with your other hand and deliver 5 quick forceful thrusts.
- Continue the series of chest thrusts until the obstruction is relieved.



**Back Blows:**

- Stand to the side and slightly behind the victim.
- Support the chest with one hand and lean the victim forward.
- Give up to five sharp blows between the shoulder blades with the heel of your hand.
- Check to see if each back blow has relieved the airway obstruction.



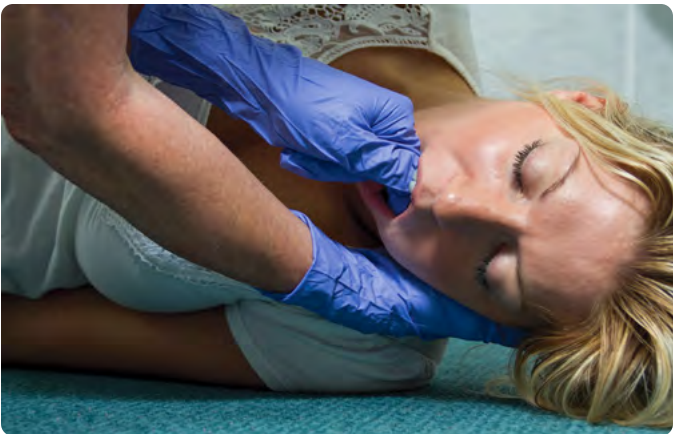
Continue applying FBAO techniques until the obstruction is relieved. Rotating techniques is acceptable.

If the person at any time becomes unconscious:

- Carefully lower the individual to the ground.
- Activate EMS.
- Begin CPR (chest compressions followed by rescue breaths).
- Look in the mouth for the obstruction before each pair of breaths. Use a finger sweep to remove any visible objects.

**Finger Sweep:**

When you can see solid materials in the airway, use a gloved finger to remove the foreign matter. Do not perform a finger sweep if you cannot see an obstruction or foreign object in the mouth. If the removal of a foreign object enables spontaneous breathing, continue to monitor the person and call EMS. If spontaneous breathing doesn't start with the removal of foreign material, initiate CPR.



**First Aid for Choking Infants**

Infants have very small airways that can easily become obstructed. Because they often explore with their mouths, aspiration of small objects is a very real concern.

To dislodge an object from a responsive infant's airway, begin by placing the infant face down on your forearm, supporting the infant's head with the hand of the same arm. Allow the infant's legs to straddle your arm, and keep the infant's head lower than their body. Deliver five back blows between the infant's shoulder blades. Immediately turn over the infant by sandwiching them between your forearms, continuing to support the head and keep it low. Deliver five chest compressions using the same two-finger technique as in CPR. Check the infant's mouth for the dislodged object. If it's not visible, turn over the infant, and repeat the back blows and chest thrusts until the object is successfully dislodged.



If the infant becomes unresponsive, initiate CPR, beginning with chest compressions. Look in the mouth for the obstruction before each pair of breaths.

As with all life-threatening emergencies, activate EMS as soon as you recognize a problem. Even if the object is successfully removed without EMS assistance, medical evaluation is recommended.

**Victims of Drowning: Aspiration of Water**

Aspiration of water can be suspected in cases of drowning. It is usually only a small amount, however, and its removal is not part of first-aid treatment as it is usually a much smaller volume than expected. There is no need to clear the airway of aspirated water before starting CPR.

Regurgitation of stomach contents is common during drowning resuscitation and can make it difficult to maintain a clean and open airway. Using the appropriate force and volume for ventilations will reduce the chance of regurgitation. Therefore, proper ventilation technique can be critical. Whenever regurgitation occurs, turn the person on their side using the recovery-position technique, and wipe or suction vomitus using a finger sweep or suction device.

**Suctioning**

Suctioning to remove foreign matter can aid in clearing the airway, but it should not interfere with other definitive care. Limit use of a suction device to 15 seconds on an adult, 10 seconds on a child and 5 seconds on an infant to avoid depletion of oxygen supplies in the airway. Prolonged suctioning can result in decreased oxygen, leading to further complications.

Once the airway is clear, return the person to their back, and resume CPR or rescue breathing if indicated.



- The most common cause of airway obstruction and choking in adults is:
  - the tongue
  - food
  - dentures
- With infants and children, airway obstruction and choking can also be caused by
  - food
  - foreign bodies (toys, coins, nuts)
  - fingers
- Grasping the neck is a common sign made by choking victims.
  - True
  - False
- If you suspect that someone is choking,
  - look in the mouth
  - check for responsiveness
  - ask, "Are you choking?"
  - ask a doctor
- In which of the following circumstances is permission to assist a choking individual not required?
  - a responsive choking adult
  - a choking adult who has become unconscious
  - a choking child or infant with a parent present
- With complete airway obstruction, the person will be unable to \_\_\_\_\_ but might nod their head in response to your question. If the person is unable or has a limited ability to move air, they may soon lose \_\_\_\_\_.
  - yell for help, their breath
  - talk, their breath
  - breathe/cough/speak, consciousness
- In the case of a partial airway obstruction, the rescuer should encourage the choking victim to cough but should do nothing else.
  - True
  - False
- If the choking victim becomes unconscious, the rescuer should
  - drop the person in the hope that the fall will dislodge the foreign body
  - ease the person to the ground, remove the foreign body if visible, and start CPR
  - ease the person to the ground, initiate supplemental oxygen therapy
- An obstructed airway in a responsive infant should be cleared with back blows alternating with chest compressions.
  - True
  - False
- What must you do when a person regurgitates?
  - Roll the person on their side, and wipe or suction out the mouth.
  - Blow vomit back into the stomach.
  - Remove gloves, and wipe away vomit with bare hands.
- Suctioning for adults, children and infants respectively should be limited to
  - 15 seconds, 10 seconds, 5 seconds
  - 2 minutes, 1 minute, 30 seconds
  - 20 seconds, 10 seconds, 5 seconds
  - 30 seconds, 15 seconds, 10 seconds

Review answers are on Page [251](#).



### Objectives:

- Demonstrate proper technique for abdominal thrusts, back blows, and/or chest thrusts for management of an obstructed airway in a conscious adult. The chosen method should be consistent with regional recommendations.
- Demonstrate proper technique for management of an obstructed airway in an infant.

### Abdominal Thrusts

In the case of a mild airway obstruction, encourage the choking victim to cough, but do nothing else. If the person shows signs of a severe airway obstruction and is conscious, ask permission to assist then use one or more of the following techniques:

- Stand behind the choking victim, and put both arms around the upper part of the abdomen.
- With one hand, locate the person's navel.
- Clench your other hand into a fist, and place it just above your first hand between the navel and the bottom of the sternum with the thumb end of your fist against the choking victim's abdomen.
- Grasp your fist with your other hand, and pull sharply inward and upward.
- Repeat until the object is expelled or the person loses consciousness.



Chest Thrusts

- Stand behind the individual encircling their chest, placing your arms directly under their armpits.
- Form a fist and place the thumb side of your fist on the middle of breastbone (avoid the xiphoid process or margins of the rib cage).
- Grasp your fist with your other hand and deliver 5 quick forceful thrusts.
- Continue the series of chest thrusts until the obstruction is relieved.



Back Blows

- Stand to the side and slightly behind the victim.
- Support the chest with one hand and lean the victim forward.
- Give up to five sharp blows between the shoulder blades with the heel of your hand.
- Check to see if each back blow has relieved the airway obstruction.



Continue applying FBAO techniques until the obstruction is relieved. Rotating techniques is acceptable.

If the person at any time becomes unconscious:

- Carefully lower the individual to the ground.
- Activate EMS.
- Begin CPR (chest compressions followed by rescue breaths).
- Look in the mouth for the obstruction before each pair of breaths. Use a finger sweep to remove any visible objects.

Obstructed Airway in Infants

- Hold the infant face down on your lower arm with your hand supporting the infant's head and with the infant's legs straddling your arm. The infant's head should be lower than his body.
  - Use your thigh to help support your arm with the infant if desired.
- Deliver five back blows between the infant's shoulder blades.
- Place your other forearm over the infant along his back, cupping his head with your hand, "sandwiching" the infant between your arms.
- Turn over the infant, and quickly check for the obstruction. If visible, remove with a finger sweep.
- If the obstruction is not visible, deliver five chest compressions using the same technique as for infant CPR.
- Check for the obstruction. If visible, remove with a finger sweep.
- If not visible, use the above technique to turn over the infant, and deliver five back blows.



SKILL: Foreign-Body Airway Obstruction

Objectives:

- Demonstrate the appropriate technique and duration for suctioning on an adult or child manikin and an infant manikin.

When fluids or soft solids are present in the upper airway, suctioning may aid in clearing the airway so effective ventilations can be accomplished.

Suctioning an Adult or Child Airway

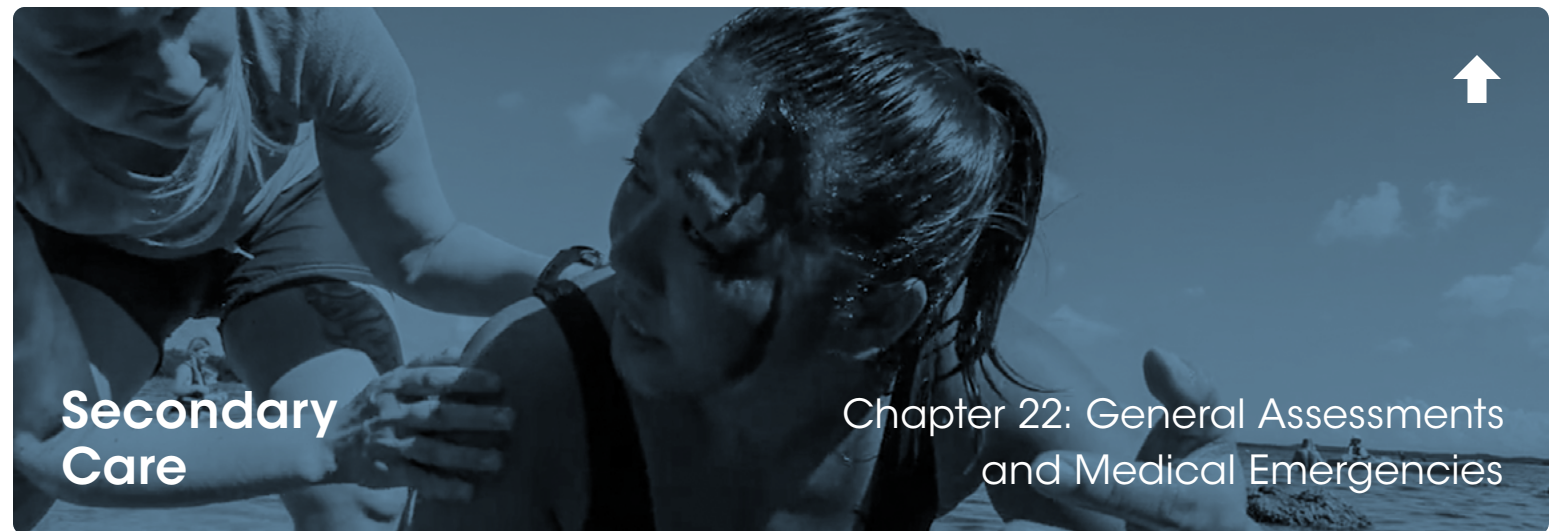
(Use a size-appropriate, rigid suction catheter.)

- Place the person on their side.
- Estimate the distance from the front of their mouth to their throat.
  - Use your fingers to measure from the corner of their mouth to their ear lobe.
  - Transpose the distance onto the catheter. This is the maximum allowable distance for insertion.

- Use a cross-finger technique to open the person’s mouth if needed.
  - Using one hand, place one or more fingers on the front teeth of one jaw and the thumb on the front teeth of the other jaw.
  - Push the teeth apart with a scissorlike action.
  - Use this method to hold open the mouth while suctioning.
- Insert the suction tip along the roof of the mouth to the back of the mouth and top of the throat.
  - Do not insert the suction tip any farther than previously estimated.
- Activate suctioning mechanism.
  - Limit suctioning to no more than 15 seconds.
- Visually inspect the mouth and airway for visible obstructions.
  - Remove any visible obstructions with a gloved finger, or repeat suctioning.
- Attempt to ventilate the person.

#### Suctioning an Infant

- Open the infant’s mouth with a similar technique as for adults and children, or use a jaw thrust as with two-person infant CPR.
- Depress the suction bulb before inserting the tip in the infant’s mouth.
  - Suction the mouth and then the nose.
  - Limit suctioning to no more than five seconds.
- Remove the suction bulb from mouth or nose, and depress it away from the infant to clear it.
- Visually inspect the mouth and airway for visible obstructions.
  - Removed any visible obstructions with a gloved finger, or repeat suctioning.
- Attempt to ventilate the infant.



## Secondary Care

## Chapter 22: General Assessments and Medical Emergencies

### Objectives

1. How is first aid distinguished from basic life support?
2. What is a secondary assessment?
3. What is asthma?
4. What are the signs and symptoms of a heart attack?
5. What are hypoglycemia and hyperglycemia?
6. What is the primary first aid for a seizure?
7. What is the primary first aid action for poisoning?
8. What is the preferred first aid for exertional dehydration?
9. What restrictions should be observed by someone who may have suffered a concussion?
10. What action provides the best chance for survival of an avulsed tooth?

First aid is medical care for injuries or illnesses that are not immediately life-threatening. Because this action occurs after an initial assessment for urgent needs, it is referred to collectively as secondary care. Before initiating care, perform a general assessment.

### General First Aid Assessment

- State of health: Obtain a general impression of the person’s health and well-being.
  - Are they in physical distress or pain?
- Observe respiratory effort, chest expansion, respiratory rate and use of accessory muscles.
- Notice if the skin is pale or red and flushed.

## History

When talking to an injured or ill person, gather and record a history of the event(s) that led to the injury. If it was a traumatic event, determine the mechanism of injury, if possible. This information helps determine the potential severity of the injury. It may also reveal other injuries that are not immediately detectable. Also ask about previous injuries to the same area that may confuse your findings.



The mnemonic **S-A-M-P-L-E**, which was introduced earlier in this course, is repeated here for emphasis in its role in secondary assessment. It is used to help you remember what information to gather when taking a history.

**S-A-M-P-L-E** stands for:

- Signs/Symptoms
- Allergies
- Medications
- Pertinent medical history
- Last oral intake
- Events leading to the current situation

While conducting the history interview, observe how the person appears overall. For example, note if their breathing is difficult or if they are having trouble speaking. Do they appear flushed or sweating more than you would expect?

## Illness Assessment

Not all concerns facing a dive professional will be the result of a dive injury. Emergencies may result from unexpected trauma or underlying disease. In a medical emergency, determine the person's complaints and when symptoms began. Examples of common concerns include the following:

- Breathing difficulties
- Chest pain
- Abdominal pain
- Altered level of consciousness

The conditions described below represent a short list of common emergencies that dive professionals may encounter. A brief description of interventions is included.

## Asthma

Asthma is a noncontagious respiratory illness characterized by airway narrowing and enhanced bronchial thickening. People with asthma are more prone to abrupt airway narrowing if exposed to particular triggers, such as dust, pollen, pet dander, exercise, cold, etc. Most people who have asthma are aware of their condition and have medications that can help reverse symptoms of chest tightness or shortness of breath. Asthma medications are commonly administered with a metered-dose inhaler, and symptom relief can be rapid.

A prolonged asthma attack with severe symptoms can be a life-threatening situation requiring prompt medical attention. Severe symptoms include labored breathing, wheezing, bluish skin tones, and tripod positioning. (Tripod positioning is when a standing or sitting person leans forward, supporting their upper body with their hands on their knees or another surface. This position can indicate respiratory distress.) When severe or prolonged symptoms occur, activate EMS immediately. Try to calm the person to reduce their breathing workload and anxiety. Assist the person with their prescribed inhaler if necessary. (An inhaler should not be given to someone for whom it is not prescribed.)

## Heart Attack

A heart attack — acute myocardial infarction (AMI) or acute coronary syndrome (ACS) — is the term used to describe the symptoms associated with blockage of the arteries that supply the heart. If the heart attack is severe enough to cause the heart to stop functioning or stimulate a life-threatening arrhythmia, first responders may need to initiate CPR and use an AED. When a person is suffering from a heart attack but is still conscious and breathing, your role is more supportive.

In this situation, keep the person in a position of comfort, activate EMS, and monitor their heart rate and respirations. Do not do anything else until EMS has been activated unless you need to begin CPR. EMS may direct you to administer one adult (325mg) aspirin. Crush it or have the ill person chew it for 30 seconds before swallowing for faster absorption. Note that use of an enteric-coated aspirin will delay absorption.<sup>19</sup>

Some people with a history of heart problems carry nitroglycerine, which is available as either pills or a sublingual (under the tongue) spray. You may need to assist the person with taking their own prescription, but do not attempt to give nitroglycerine to a person who doesn't have a prescription. When assisting someone with nitroglycerine, do not handle the pills with bare hands because the medication can be absorbed through the skin. Nitroglycerine is administered under the tongue to be absorbed, not swallowed. It is administered every five minutes for a total of three doses. Do not administer more than three doses, regardless of the person's condition.

**Not all heart attacks are painful**, and there are many different variables to look for when it comes to heart conditions. Symptoms vary between men and women as well as among individuals with preexisting medical conditions. Common signs and symptoms were described in Chapter 17, Cardiopulmonary Resuscitation.

**Note:**

The term “massive heart attack” is often used to describe a sudden cardiac arrest. The term “heart attack” may refer to pain secondary to a blocked artery that feeds the heart. As a result of blood-flow restriction, an area of the heart muscle may die, but this does not necessarily result in death of the individual.

**Diabetic Emergency**

Diabetes is a disease that affects normal blood-sugar control. When blood-sugar (bloodglucose) levels are markedly elevated (hyperglycemia) or low (hypoglycemia), people can become symptomatic.

Blood glucose comes from the breakdown of dietary carbohydrates found in foods such as rice, cereals, grain, potatoes, fruits and sweets. Insulin, a hormone made in the pancreas, facilitates cellular uptake of blood glucose. When insulin is either made in insufficient quantities or is ineffective (in the case of insulin resistance), blood-sugar levels will rise, and hyperglycemia may result.

Hyperglycemia may require medical intervention but rarely requires emergency treatment from the first aid provider. The person with diabetes experiencing hyperglycemia will usually be capable of checking their own blood sugar and administering their own insulin if needed. A first aid provider should not administer insulin as this can easily make the condition worse.

For people with diabetes who require insulin injections, use of insulin without adequate dietary intake will cause a drop in blood-glucose levels that may lead to hypoglycemia.

If someone with diabetes suddenly feels unwell or starts behaving uncharacteristically, consider having them check their blood-glucose level with a glucometer (a blood-glucose measuring device — standard equipment for all diabetics). Most diabetics will recognize their symptoms, but if they are unable to think clearly, they may need your help. Confusion, altered behavior, excessive sweating or tremors in someone with a history of diabetes can quickly lead to a serious medical emergency that requires advanced medical care as quickly as possible. Some people will wear medical-alert tags to inform rescuers that they have diabetes.

Hypoglycemia is an acute condition requiring rapid intervention. Interventions by a first aid provider should be limited to assisting with ingestion of foods with high sugar concentrations such as glucose tablets or 20 g of carbohydrates such as candy (quantity varies), jelly beans (15-20), fruit leathers (two strips) or orange juice (200 mL; 3/4 cup). If the diabetic is responsive enough to swallow, 15 ml (1 tablespoon) of honey or corn syrup or 200 ml (3/4 cup) of orange juice may be given.<sup>20</sup> It may take 10-15 minutes for the symptoms of hypoglycemia to resolve, so waiting to activate EMS is suggested. If symptoms do not resolve in that time frame, administer additional high sugar concentrations as noted previously and call EMS. If you are in doubt about the condition of a person who has diabetes, give sugar. However, never administer insulin without a medical directive. (Usually this would be done by EMS if required.)

Once a diabetic who is experiencing hypoglycemia has had something to eat or drink, stay with him to ensure that his condition and mental status improve. If his mental status deteriorates, it may become necessary to call EMS and continue to support until help arrives.

Signs of Hypoglycemia	Signs of Hyperglycemia
hunger	increased thirst
tremors or seizures	headaches
anxiety	difficulty concentrating
sweating	blurred vision
dizziness or lightheadedness	frequent urination
sleepiness	fatigue (weak, tired feeling)
confusion and/or changes in level of consciousness	
difficulty speaking	
nervousness	
weakness	

**Stroke**

Stroke is the leading cause of long-term disability and the third leading cause of death in the U.S. Strokes are a medical emergency that can result in permanent neurological injury, disability and death. They result from either blood-vessel blockage (usually from a blood clot or thrombus) or from blood-vessel rupture that causes bleeding (hemorrhage).

Strokes can manifest with sudden loss of motor function (ability to move one half of the body), inability to understand or formulate words, or loss of a visual field. Many strokes are not associated with headache. Most strokes come on suddenly and are painless — the person suffering from one may be unaware of its occurrence.

In the absence of head trauma, stroke should be suspected when neurological symptoms (those affecting the nervous system) suddenly appear. The faster acute injury is detected and EMS alerted, the greater the chances that medical treatment will reduce injury and disability.

Signs of stroke include the following:

- Facial droop
- Inability to raise or move an arm
- Slurred, garbled or nonsensical speech

If any of these signs are present, call EMS immediately.

The F-A-S-T mnemonic described in Chapter 11, Neurological Assessment, may help you quickly identify a possible stroke and reinforces the need for immediate activation of EMS.

F

Facial droop

A

Arm weakness

S

Speech difficulty, sudden severe headache

T

Time (note the time, and call EMS immediately)

**Remember: F-A-S-T first, then call EMS.**

- Facial droop. Facial droop occurs on one side of the face (either the left or right side).
- Arm weakness. Assess arm weakness by asking the injured person to raise both their arms in front of them. Ask the person to hold that position for about 10 seconds. Watch for lowering of an arm.
- Speech. Stroke is frequently associated with speech difficulty or reduced vocal clarity.
- Time. Rapid recognition and activation of EMS is critical, as timely intervention can dramatically influence outcome and recovery time.

Activate EMS at the first sign of stroke. Depending on the person’s condition, BLS may be necessary as airway management can become compromised.

**Seizures**

Seizures (also known as fits or convulsions) result from a sudden massive electrical discharge within the brain. Seizures may present as brief trancelike states (petit mal seizures) or dramatic full-body convulsions (grand mal seizures). Epilepsy is a disorder that results from surges in electrical signals in the brain, causing recurrent seizures. Generalized seizures affect both cerebral hemispheres (both sides of the brain). They cause loss of consciousness for either brief periods or for several minutes. A common type of generalized seizure is the tonic-clonic or grand-mal seizure. Seizures may also be focal and involve only one limb.

Generalized seizures often start with a brief cry followed by a fall to the ground. Alternating stiffening (tonic phase) and jerking (clonic phase) movements of the arms, legs and face characterize a seizure. The period following a generalized seizure is known as the postictal phase. During this period people may be unresponsive, in a deep sleep, weak, disoriented or combative. This phase usually resolves within 30 minutes.

As a first aid provider, there isn’t much you can do for a seizing person, nor is there much you need to do. During a seizure your first priority should be to move objects away from the seizing person that may be struck or cause injury. Protect but do not attempt to restrain an individual during a seizure, and avoid placing anything in the person’s mouth.

Once the person has stopped actively convulsing, conduct your initial assessment, and ensure an open airway. Continue to monitor the person for changes. Next, take a history, and establish whether the person has a seizure disorder. If not, attempt to determine any other conditions that may have caused the seizure. This information will be useful for EMS.

Conditions associated with seizure predisposition include the following:

- |   |  |
|---|--|
| • High fevers (primarily in young children experiencing spiking fevers) | • Shock                                  |
| • Infections, including meningitis or encephalitis                      | • Hypoxia/hyperoxia                      |
| • Poisoning, including drugs or heavy metals                            | • Drug or alcohol overdose or withdrawal |
| • Hypoglycemia  | • Intracerebral bleeding (i.e., stroke)  |
| • Head trauma   | • Certain complications of pregnancy     |

**Poisoning**

A poison is any substance that is harmful to your body if too much is eaten, inhaled, injected or absorbed (through the skin). Any substance, including medications, can be poisonous if too much is taken.<sup>21</sup>

Common signs of poisoning include the following:

- Nausea/vomiting
- Abnormal blood pressure
- Headache
- Abdominal pain
- Dilation or constriction of pupils
- Altered mental status
- Shortness of breath
- Seizures
- Injury to skin
- Irregular heart rate
- Diarrhea



Any time you suspect poisoning, call 911, another local emergency number or a poison control center. (The number for the U.S. Poison Control Center is +1 (800) 222-1222; international poison control centers can be found at [WHO Directory of Poison Centers](#).) Stating the poison type (type of medication, drug, etc.), approximately how much was used and current symptoms will help guide management. A person’s medical status can worsen rapidly, so all suspected poisonings should be evaluated in a hospital.

Once EMS has been activated, your primary role is to monitor breathing and be prepared to perform BLS in the event the person’s airway become compromised, they lose consciousness or stop breathing, or evidence of circulation disappears.

Provide EMS or the treating medical facility with the substance to ensure appropriate treatment. If the substance is not available, attempt to find out the name, chemical composition or list of ingredients, and bring that to the hospital.

If the poison is a liquid that was absorbed through the skin or came into contact with broken skin, irrigate all affected parts of the body with water for 20 minutes or until EMS arrives. If the poison is a powder, brush off any residual powder (use exposure protection) before irrigating the exposed area. Immediately treat an eye injury due to any chemical exposure (liquid or powder) by flushing the eye with tap water for 15 minutes or until EMS arrives.

All poisoned individuals need to see a physician, even if it appears that all signs of a problem have been controlled and the emergency is over.

## Exertional Dehydration

Vigorous exercise with profuse sweating, especially in hot, humid environments, can lead to dehydration and loss of electrolytes. In the absence of shock or confusion, oral rehydration is a reasonable first aid approach (as long as the person can swallow).

Attempt rehydration with 5-8 percent carbohydrate-electrolyte solutions (commercially available sports drinks). Plain water is an alternative but is not as effective. If the individual has heat-related symptoms, refer to Chapter 23, Temperature-Related Injuries.



## Concussion

Concussion is a mild traumatic brain injury that results in symptoms such as feeling stunned or dazed, dizzy or unsteady. Headache, visual disturbances, confusion and memory loss are also symptoms of concern following a head injury. The range of symptoms can make recognition of concussion difficult. The potential for long-term consequences makes any decision about response critical. Anyone who experiences any of these symptoms after a blow to the head should not be allowed to sleep until they have been evaluated by a health care professional. Defer use of mechanical machinery, driving, cycling, participation in sport activities or use of any electronic equipment including computers, cell phones, and tablets until after evaluation and clearance by a health care provider. The most critical post-concussion time frame is 3-5 days. This period can make the difference between a 30 day recovery versus a year or more.

## Dental Avulsion

Traumatic loss of a tooth can damage both the tooth and the supporting structures in the mouth. The greatest chance for survival of the tooth is reimplantation within an hour. Otherwise, store the tooth in one of the following solutions, and seek immediate dental care:

- Egg white
- Whole milk
- Coconut water
- Injured person's saliva (but not in the person's mouth)

If available, the following solutions may be used:

- Hank's Balanced Salt Solution
- Ricetral
- Propolis

## Review Questions



1. A general first aid assessment includes assessing
  - a. overall impression of the individual's health and well-being
  - b. respiratory effort
  - c. presentation of skin color
  - d. all of the above
2. Asthma
  - a. is a noncontagious respiratory illness
  - b. is airway narrowing that makes breathing difficult
  - c. can be treated by metered dose inhalers
  - d. can be life-threatening if severe and prolonged
  - e. all of the above
3. All heart attacks are painful.
  - a. True
  - b. False
4. Hypoglycemia is a condition
  - a. in which blood sugars are low
  - b. that should be treated with additional insulin
  - c. that can be reversed by eating and/or drinking foods with high sugar content
  - d. both a and c
5. **F-A-S-T** stands for Face, Arms, Smile, Time.
  - a. True
  - b. False
6. During a seizure, the rescuer's primary concern is to move objects that may cause injury if the person should hit them.
  - a. True
  - b. False
7. In the event of suspected poisoning,
  - a. determine what was ingested
  - b. determine how much was taken
  - c. note current symptoms
  - d. call the local poison control center or EMS
  - e. all of the above
8. Plain water is the preferred first aid measure for exertional dehydration.
  - a. True
  - b. False
9. Someone who appears to have suffered a concussion can resume their regular activities regardless of how they may feel.
  - a. True
  - b. False
10. An avulsed tooth can be stored in
  - a. egg white
  - b. whole milk
  - c. the injured person's saliva
  - d. all of the above

**Review answers are on Page 251.**



## Secondary Care

## Chapter 23: Temperature – Related Injuries

### Objectives

1. What is hypothermia?
2. What is the first aid response to hypothermia?
3. What special consideration must be taken into account for hypothermia?
4. What is hyperthermia?
5. What are four methods of heat transfer, and how can they benefit the hyperthermic individual?
6. What are the signs and symptoms of heat exhaustion and heat stroke?
7. What is the first aid response to hyperthermia?

The human body has a limited tolerance for temperature extremes. Prolonged unprotected exposure may raise or lower core body temperatures and cause health concerns that require prompt attention. The body maintains a relatively stable core temperature, which represents a balance between heat production and heat loss. The normal core body temperature is 36 to 37°C (97 to 99°F).

### Hypothermia<sup>17</sup>

When external temperatures are too low or the body’s heat production is inadequate relative to the external demands, core temperatures can drop. Hypothermia (hypo = less than normal + thermia = generation of heat) is defined as core temperatures below 35°C (95°F).

**MILD** hypothermia is classified as a body core temperature of 32-35°C (90-95°F). Expected symptoms include shivering, lethargy and apathy. Motor skills may also be compromised.

**MODERATE** hypothermia occurs with body core temperatures of 28-31°C (83-89°F). At this point the shivering stops, cognitive function is markedly reduced (stupor), and heart and respiratory rates tend to slow.

**SEVERE** hypothermia occurs when body core temperatures go below 28°C (82°F). At this point, coma and unconsciousness are likely, and people may appear dead.

### Cold-Water Immersion

Water has the ability to conduct heat away from the body 20-27 times faster than air. As such, cold-water immersion should raise the suspicion of potential hypothermia and prompt rewarming efforts.

Localized injuries such as frostnip and frostbite are possible in cold water diving. These injuries are the result of vasoconstriction due to cold exposure. Common areas of injury are fingers, toes, nose and ears. Skin in the affected areas may be discolored, and pain or tingling may be present.

### Frostnip

Frostnip is treated by getting the affected person out of the cold, removing wet clothing and applying heat. Even a warm hand over the affected area will help rewarm the area. do not rub tissues showing signs of frost nip.

### Frostbite

Frostbite is a much more serious condition in which tissues actually freeze. Length of exposure to the cold is a factor in frostbite. Remove clothing, and immerse affected areas in a warm water bath; do not rub tissues. Once rewarmed and dry, place dry dressings between exposed digits and seek medical evaluation.

**Do not attempt to rewarm tissues affected by frostnip or frostbite when there is an imminent risk of refreezing.**

### Rewarming Strategies

When hypothermia is suspected, prevent further heat loss, and initiate rewarming strategies.

Remove the person from the cold, and place them in a dry, warm environment away from wind. Remove wet clothing, and replace with dry, warm coverings to include the head, and activate EMS. Monitor breathing and heart rate, and be prepared to perform CPR if either becomes dangerously slow or stops and the person becomes unconscious.

In addition to the steps described above, rewarming can also include the use of warm water bottles or heating pads applied to the chest, neck and groin to optimize core warming.

Symptom severity and the person’s mental status will largely determine the course of further treatment. Anyone presenting with a history of confusion, lethargy, unconsciousness or stupor



Handle hypothermic people gently and carefully, as rough handling may cause cardiac arrhythmias such as ventricular fibrillation.

should receive prompt medical attention. Calling EMS may enable faster recovery (with more aggressive rewarming techniques) and appropriate monitoring.

Hypothermia can cause cardiac arrhythmias and subsequent unconsciousness, a condition that may stabilize with rewarming. This condition has led to an axiom within emergency medical circles that “patients aren’t dead until they’re warm and dead.” Therefore, resuscitation efforts are often performed for prolonged periods with hypothermic people and especially so with children who have been saved after prolonged cold-water immersions.

### Special Consideration: Core Temperature After-Drop

The term “core temperature after-drop” refers to a reduction in core temperature subsequent to rewarming and is characterized by clinical deterioration.<sup>17</sup> Current theory for this phenomenon reasons that as peripheral tissues warm, vasodilation allows cooler blood from the extremities to circulate back into the body core. This may result in additional core cooling and cardiac arrhythmias. Rewarming efforts aimed at core temperature elevation minimize the chances of the after-drop phenomenon.

When treating moderate to severe hypothermia, focus on rewarming strategies, activate EMS, and be prepared to initiate CPR. Minimize or, better yet, eliminate any exertion by the individual during or after care until evaluated by medical personnel.

## Hyperthermia

Hyperthermia occurs when the body is overheated and the normal cooling mechanisms are overwhelmed (hyper = above normal + thermia = generation of heat).

The body’s natural cooling mechanisms include sweating and peripheral vasodilation. Sweating enables evaporative heat loss, and peripheral vasodilation (seen as flushing) brings blood to the body’s surface, which enables cooling through evaporative heat loss and other cooling mechanisms described below. Personal factors or individuals at elevated risk of hyperthermia include the following:

- Infants and children
- Obesity
- People over 65 years of age
- Exertion/exercise
- Dehydration
- Health issues such as diarrhea that predispose to dehydration
- Divers wearing drysuits or heavy wetsuits for cold-water diving during hot weather
- Divers wearing drysuits for contaminated-water activities during hot weather

The severity of hyperthermia can range from mild to life-threatening. Signs, symptoms and appropriate first aid will vary depending on the degree of overheating and the individual’s condition.

The next sections describe the progression of hyperthermia severity and the appropriate care for each level.

### Heat Rash

Heat rash — commonly seen around the neck, groin, elbow creases and beneath breasts — looks like small pimples and is caused by excessive sweating. While seen in all ages, it is most common in young children. Treatment is simple and involves cooling and keeping areas dry. This rarely requires medical attention and usually resolves on its own.

### Heat Cramps

Heat cramps are muscle spasms resulting from excessive fluid and electrolyte loss. They are often associated with strenuous activity and may be a sign of heat exhaustion. Immediate first aid measures include the following:

- Stop all activity, and rest in a cool place.
- Drink clear liquids, preferably with electrolytes (sports drinks).
- Do not return to strenuous activity for several hours.
- If symptoms do not resolve within about an hour, seek medical attention.

### Heat Exhaustion

Heat exhaustion occurs as a result of excessive fluid and electrolyte loss. Those most prone to heat exhaustion include the elderly, people taking diuretics (medications that cause fluid and electrolyte loss) and people working or exercising in hot environments where fluid and electrolyte loss are most likely to exceed the rate of replacement.

Warning signs of heat exhaustion include the following:<sup>23</sup>

- Heavy sweating
- Fatigue
- Nausea/vomiting
- Weakness
- Headache
- Fainting
- Muscle cramps

Untreated, heat exhaustion can progress to heat stroke and should receive prompt attention. If symptoms are severe, call EMS immediately, and perform cooling measures until they arrive.

Immediate first aid measures include the following:

- Remove the person from the heat source.
- Keep them at rest.
- Place the person in a cool environment.
- Remove unnecessary clothing.

- Replace fluids and electrolytes — oral intake is usually safe
- Cooling methods: evaporation, conduction, convection and radiation
  - Sponge the head, neck and torso.
  - Place the person near an air-conditioning vent or fan.

### Heat Stroke

**Heat stroke is a life-threatening condition** in which the body’s temperature exceeds its ability to effectively regulate cooling. Core temperatures may exceed 41°C (106°F).

Signs and symptoms of heat stroke may include the following:

- Rapid pulse
- Red, hot and usually dry skin
- Strange behavior
- Hallucinations
- Confusion
- Seizures
- Coma and death

Immediate first aid measures include the following:

- Remove the person from the heat source
- Activate EMS
- Keep the person at rest
- Place the person in a cool environment and on a cool surface
- Remove unnecessary clothing
- Cooling methods: evaporation, conduction, convection and radiation
  - Apply cold packs to the head, neck, armpits and groin
  - Cover the person with water-soaked towels or blankets (keep coverings wet with additional cool water)
  - Place the individual near an air-conditioning vent or fan
- Replace fluids and electrolytes (intravenous fluids are usually advised because airway management may be compromised)

Continually monitor the person for airway compromise, seizure, unconsciousness or cardiac arrest.



### Note:

Symptom onset may be rapid and requires aggressive cooling and immediate activation of EMS.

### Cooling Measures

There are four primary mechanisms for heat loss: conduction, convection, evaporation and radiation. The process of breathing can also result in heat loss, but this process is passive and doesn’t affect the first responder. When trying to cool someone with hyperthermia, the use of multiple methods simultaneously will have the greatest effect.

**Conduction** is the transfer of heat from a warmer object to a cooler object when the two objects are in direct contact. An example of conductive heat loss occurs when backpackers sleep on cold ground.

- Cooling methods: Sponge around the head and neck, or immerse in a tepid (lukewarm) bath or shower. Refrain from ice-water immersion because this causes peripheral vasoconstriction and may be counterproductive.

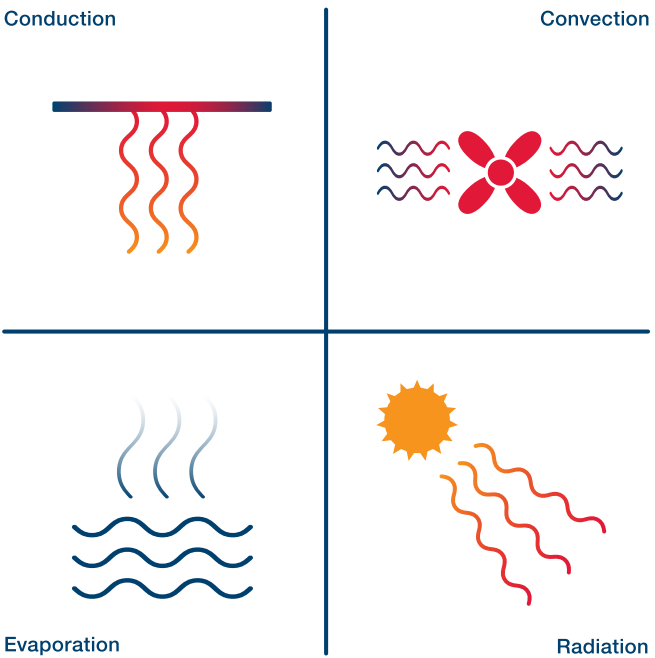
**Convection** is heat loss that occurs in response to the movement of fluid or gas. This method of cooling is experienced by wind chill or an indoor fan.

- Cooling methods: Use a fan, air conditioning vent or exposure to wind. It works best if combined with a cool mist spray to utilize evaporative heat loss.

**Evaporation** is heat absorbed by sweat that is then released or removed from the body when liquid phase-changes to gas as part of evaporation.

- Cooling methods: Sponge with cool water, or use mist to maintain skin moisture. Key areas are the head, neck and torso.

**Radiation** is the transfer of electromagnetic energy (primarily in the infrared spectrum) between two objects of different temperatures. The temperature difference between objects will determine the direction of heat transfer. For example, fire radiates heat and will warm a cooler room. When body temperature is higher than the surroundings, our heat will generate ambient warmth.



- Cooling methods: Remove from direct sunlight, place in the shade or a cool room, and remove heavy or unnecessary clothing.

Seek immediate medical attention in the following situations:

- Symptoms are severe
- A history of heart problems or high blood pressure exists
- Symptoms worsen or last longer than one hour

Continually monitor the person for airway compromise, seizure, unconsciousness or cardiac arrest.

## Secondary Care

## Chapter 24: Slips, Falls and Secondary Assessment: Fractures and Splinting

### Objectives

1. How can slips and falls be prevented?
2. What is a secondary assessment?
3. What general guidelines should be used when conducting a secondary assessment?
4. What is the role of a splint?

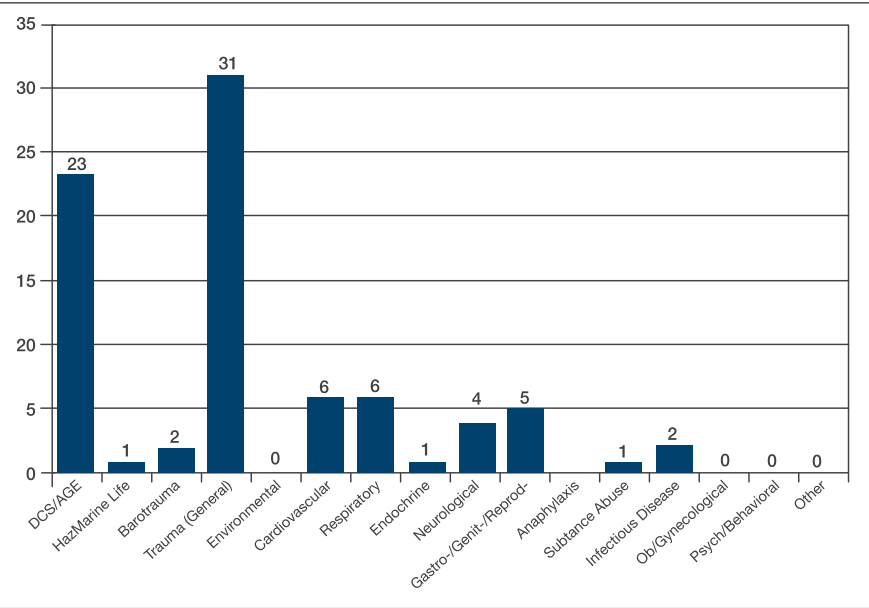
### Review Questions

1. The first step in rewarming is to prevent further heat loss.
  - a. True
  - b. False
2. Management of hypothermia may include
  - a. removal from the cold
  - b. removal of wet clothing
  - c. use of blankets and heat packs
  - d. calling EMS
  - e. all of the above

3. Heat stroke is a medical emergency that requires aggressive cooling and activation of EMS.
  - a. True
  - b. False

Review answers are on Page [251](#).

Diving is naturally associated with wet surfaces, which present the potential for mishaps. Traumatic injuries, such as those caused by slips and falls, consistently rank highly among the reasons people call the DAN Emergency Hotline. This category includes fractures, lacerations and fingers caught in dive boat ladders.



Diagnostic categories of evacuations coordinated by DAN Medical Services in 2012

Taking precautions to avoid these injuries as well as knowing how to handle them when they do occur is therefore an important aspect of dive accident preparation.

Prevention

Slips and falls associated with surfaces that are frequently wet or slippery can be minimized with proper drainage, rubber matting, nonskid surfacing and the use of warning signs.

Stairs and riser treads should be uniform and maintained in good repair. Handrails may be required in some jurisdictions. OSHA standards as well as state and local regulations may apply.

Secondary Assessment

Should someone fall but not incur a lifethreatening injury, it is best to leave the injured person in the position they were found and conduct a secondary assessment to identify possible injuries that may not be readily apparent. Fractures are often associated with falls and can cause considerable pain and limb deformity. Talk to the injured person to determine if they have any pain or particular discomfort, and focus on those areas.

General Guidelines

Before you begin a secondary assessment, remember to be S-A-F-E and protect yourself from bodily fluids with personal protective equipment. Ask for permission before initiating your assessment, and advise the person that the exam requires limited touching. Pay close attention to their response to your examination, and note any areas where pain or discomfort occurs. Signs of injury should prompt EMS activation. If at any point a life-threatening injury is noted, stop the assessment and activate EMS if not already done.



Conducting the Assessment

Use your eyes and hands to find any abnormalities or possible problems. Start at the head, watching for signs of injury or blood and any areas that cause apparent pain.

Gently palpate (touch) the entire scalp and face.

Inspect the person's nose and ears for blood or fluid.

Palpate the person's neck. The mechanism of injury will give you a good idea about whether a head or neck injury is likely.

Move in front of the person, and shade their eyes from the sun or lights. Do this one eye at a time to see if the eyes dilate in response to the shade.

If the injury is related to scuba diving, feel the front of the neck for air bubbles and a crackling sound coming from underneath the skin. This sign indicates subcutaneous emphysema, which is caused by air bubbles escaping from the lungs and chest cavity, or it can indicate a lung overexpansion injury. If this sign is present, call EMS if you have not already done so.

Next, palpate the person's collarbone to check for deformities or discoloration. Press your fingers along each collarbone individually to assess movement or reaction to your examination.

Examine the chest by placing both hands on either side of the rib cage, and ask the person to take a deep breath. Note any open wounds. If you see bubbling, apply direct pressure to the wound to stop air from moving in and out.



Divide the abdomen into four quadrants with the navel as the center point. Gently press on each quadrant in turn to check for any areas that are sensitive, stiffened, hard or painful. If the person complains of pain in any particular area, press on that area last.

Next, place a hand on either side of the person's pelvis, and gently push straight down and then in from both sides. Note any instability or painful responses.

Finally, palpate down the legs and arms by gently squeezing to feel if bones beneath the skin and muscle are displaced. Areas of obvious deformity do not require palpation, as pain and further injury are possible. Attempt to stabilize the injured limb to limit movement and pain if EMS will be delayed (more than 10 minutes).

Test for retained nerve and motor control by asking the person to wiggle their fingers and toes.



## Fractures

There are two general categories of fractures: open and closed. A closed fracture means the bone does not puncture the skin. A deformity may or may not be visible. Open fractures occur when the broken bone punctures the skin. The bone may be observed or may have retreated back under the skin, but the open wound is still present. Open fractures are at high risk for bone and tissue infections. They should be covered with sterile dressings as soon as possible, and the limb should be immobilized. Although such wounds will bleed, avoid excessive pressure.

Check pulses, capillary refill and sensation in any injured limb. Be sure movement of the fingers and toes is possible and the person has normal sensation distal to the injury. Repeat these checks every 15 minutes after you apply a bandage to ensure that circulation hasn't been impaired.

Apply a splint any time you think one might be helpful, but do not attempt to realign or push bones back into place. Pad the injured area to provide both security and comfort, and prepare to evacuate the injured person to the nearest appropriate medical facility.

## Dislocations

Dislocations are a disturbance in the normal position and function of a joint. Forceful trauma often causes these types of injuries. Once a joint is dislocated, even after relocation by medical personnel, it usually takes less force to dislocate the same joint again. It is common for ligament injuries to accompany dislocations. Sometimes other soft tissues, like muscles, blood vessels and nerves, are also adversely affected. A joint can become partially or fully dislocated and then return to its normal function and position spontaneously, which is known as subluxation. Other times, the joint can remain entirely out.

As you assess the affected joint and the anatomy distal to the injury, advise EMS immediately if you note diminished circulation or sensation.

Treatment of a dislocation is like that of a strain, sprain or break. Do not attempt to realign or relocate the dislocated joint. Instead, splint the dislocation in place as you would a broken bone.



## Splinting

Splints reduce movement and physical stress to injured limbs. If EMS is readily available, protect and stabilize the injured limb, and wait for help. If you are in a remote location or if emergency services are delayed, splints can both ease pain and protect the limb from further injury. A properly applied splint will not only secure the injured area but will also immobilize the joints above and below the injury. For example, if splinting a forearm, immobilize both the wrist and elbow.



You can use just about anything to immobilize an injured limb. Commercial splints may be made for a specific purpose or be designed to have a variety of applications. Splinting materials can also be improvised. Prior to splint application, remove all jewelry, and ensure you can see the entire injured area. This may involve cutting away clothing. Keep the injured area in the same position. Do not attempt to realign (reduce) the bones or straighten the limb. Immobilize joints on either side of the fracture to prevent further injury.

### Note:

Once the splint is in place, continue to monitor circulation and sensation every 15 minutes.

## Review Questions



- Slips and falls can be prevented by
  - keeping walkways as dry as possible
  - providing drainage, rubber matting or rough surface concrete
  - using wet-surface warning signs
  - all of the above
- The purpose of a secondary assessment is to identify injuries that may not be readily apparent.
  - True
  - False
- General guidelines that should be used when conducting a secondary assessment include
  - S-A-F-E, standard precautions, asking permission to help
  - keeping the injured diver in the position found, realigning any limb deformity as quickly as possible
  - disregarding any complaints of pain due to the fall
  - calling EMS immediately
  - a and d only
- A splint is used to
  - immobilize the joints on either end of an injured limb
  - ease pain
  - protect the limb from further injury
  - all of the above
  - a and c
- When a bandage or splint has been applied, circulation and sensation should be checked every
  - 5 minutes
  - 10 minutes
  - 15 minutes
  - 20 minutes

Review answers are on Page [251](#).

## SKILL: Secondary Assessment



### Objectives:

- Demonstrate the technique for a head-to-foot secondary assessment using a gentle touch and caring manner.

### Remember S-A-F-E.

- Ask permission to conduct an assessment.
- Note any areas that cause pain or are uncomfortable to the person.
- Palpate the person's head and face for deformities or signs of injury.
  - Determine if there are any broken bones under the skin.
  - Watch for any fluids or blood.
  - If the individual experiences pain, stop the assessment, and notify EMS if you have not already done so.
- Visually inspect the person's nose and ears for blood or fluid.
- Palpate the person's neck.
  - The mechanism of injury will give you a good idea about whether a head or neck injury is likely.
- Shade the person's eyes from the sun or lights, then remove your hands while observing their pupils for reaction to the changing light exposure.
  - Determine if they dilate in response to the shade.
- If the injury is related to scuba diving, gently palpate the front of the neck for air bubbles and a crackling sound coming from underneath the skin.
- Inspect the person's collarbone for injuries or discoloration.
  - Gently slide the fingertips of your index and middle fingers, one on each side of one collarbone, to check for movement or reaction to your examination. Repeat this on the other collarbone.
- Examine the chest.
  - Place your hands on either side of the rib cage, and ask the person to take a deep breath.
  - Note any open wounds.
  - If you see bubbling, apply direct pressure to the wound to stop air from moving in and out.
- Divide the abdomen into four quadrants using the navel and midline of the torso as dividing points.
  - Gently press on each quadrant in turn.
  - Note any areas that are sensitive, stiffened by the person, hard or painful.
- Place a hand on either side of the person's pelvis, and very gently push in and down.
  - Note any instability or painful response.
- Palpate the arms and legs, checking the bones beneath the skin and muscle.

## SKILL: Splinting

### Objectives:

- Apply a splint to a simulated injured limb, immobilizing the joints on either side of the injury. Use of either a professional splint or improvised splint is acceptable.
- Apply the splint, keeping the injured limb in the position it was found. Do not attempt to straighten it.
- Be sure to remove rings or other jewelry from the affected extremity.
- Place splinting material either along or on each side of the injured limb. Place the splint so the joints both above and below the site of injury are immobilized.
- Use padding (gauze, towels, clothing, etc.) to fill in voids under the splint and to provide additional support to the injured limb.
- After the splint is in place, check circulation by squeezing the nail beds and looking for the pink color under the nails to return quickly after pressure is released. If color does not return in three seconds or less, loosen the bandage and rewrap.
- Continually reassess the individual, and monitor for signs of shock.
- Activate EMS if not already done.

## Burn Categories

### Superficial Burns (first-degree burns)

- Tissue injury is limited to the epidermis (outermost layer of the skin)
- Characterized by redness (erythema) and minimal swelling such as in a sunburn
- Mild discomfort
- Commonly treated on an outpatient basis



### Partial-Thickness Burns (second-degree burns)

- Involves the epidermis and variable depths of the dermis (skin layer below the epidermis)
- Often occurs with scalding injuries and severe sunburns
- May present as blisters and blanched skin; may appear glistening/wet
- Most painful of all burns
- Requires medical evaluation and ongoing care especially if hands, feet, face, genitals or buttocks are affected
- Deeper burns may take three to four weeks to heal
- Deeper burns may require excision/debridement (removal of dead tissue)



### Full-Thickness Burns (third-degree burns)

- Involves epidermis, all layers of dermis and extends down to subcutaneous tissue
- Appears dry, leathery and insensate (without sensation in the area most affected), often without blisters
- May appear waxy or charred
- Presents with variable degrees of pain
- Can be difficult to differentiate from deep partial-thickness burns
- Commonly occurs when clothes catch on fire
- Always requires emergency medical care



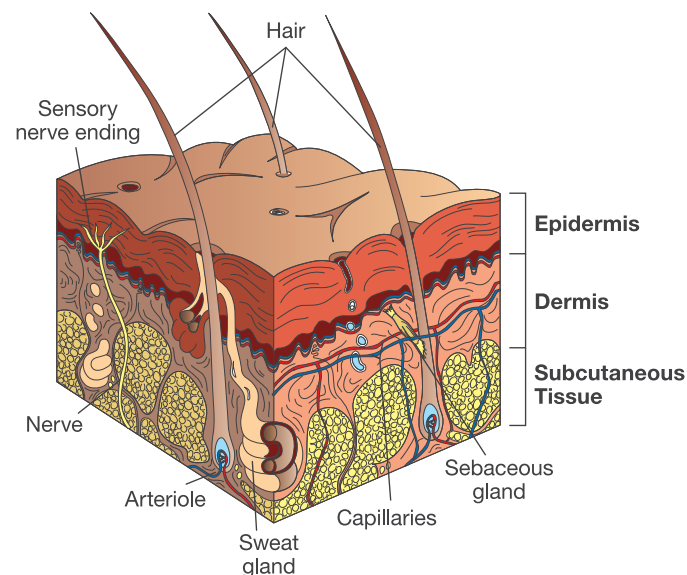
### Objectives

1. How are burns categorized?
2. What is a superficial burn?
3. What is a second-degree burn?
4. What is a third-degree burn?
5. What is the general first aid treatment for burns?
6. How should chemical burns be treated?
7. What is a fourth-degree burn?

Burns refer to tissue damage caused by heat, chemicals, electricity, sunlight or radiation.

Thermal injury from hot liquids, steam, building fires, flammable liquids and chemicals are the most common causes. As with all cases of severe injury, continuously monitor the person, and treat for shock if any signs of that condition become apparent.

Burns can disrupt the protective function of skin and result in fluid loss and increased risk of infection. They can cause swelling, blistering, scarring, shock and even death. Burns are named or categorized based on the depth of tissue involvement.



Fourth-Degree Burn

- Full-thickness burn extending to muscle or bone
- Commonly the result of high-voltage electric injury or severe thermal burn
- Requires hospital admission



First Aid Provider Response to Burns

Determination of burn depth is not a primary concern of a first aid provider. Of immediate importance is removing the person from the source and stopping further injury. To stop further burning, use cool or very cold but not freezing running water or saline for at least 10 minutes, but refrain from prolonged immersion. It may take more time and water than anticipated to halt burn progression. Cooling measures applied too aggressively or for too long can cause more tissue damage and may lead to hypothermia.<sup>11</sup>

Refrain from applying ointments, lotions or antiseptics. Topical antibiotic ointments or creams **should be used only under the direction of a physician.**

Avoid the use of ice or butter on burn wounds because these measures will not help and may cause more tissue damage. In addition, medical staff will want to inspect the wounded area and will have to remove any applied product.

If there are blisters, keep them intact, and refrain from releasing blister fluid. Removal of blistered skin increases the risk of infection (as the primary skin barrier is removed) and will also expose tender tissue, resulting in additional pain. Blisters that have broken should be left in place and protected with an appropriate dressing and bandage.

If the burn was caused by a semisolid or liquid such as tar, grease or oil, flush the area with water to cool the tar or anything that has burned to the skin (such as clothing) and stop the burning process. Refrain from attempts to remove substances such as tar because you may cause additional tissue damage. These burns can be severe, so seek medical attention or call EMS.

Dry chemicals such as lye, pool chemicals such as solid chlorine granules or tablets, and certain detergents require additional diligence. These chemicals will react with the water, causing further or potentially deeper burns. Therefore, the FIRST step in treating dry chemical burns is to brush off the dry chemical and carefully remove any jewelry and clothing that may have become contaminated, taking care to not spread the chemical onto yourself or anyone else. After the dry chemical has been brushed off, flush with copious amounts of water. Be aware that any residual dry chemical that was not brushed off will begin to react, will most likely be painful and potentially causing further burning. Flush with copious amounts of clean water for at least 15 to 20 minutes. Seek medical evaluation as soon as possible.

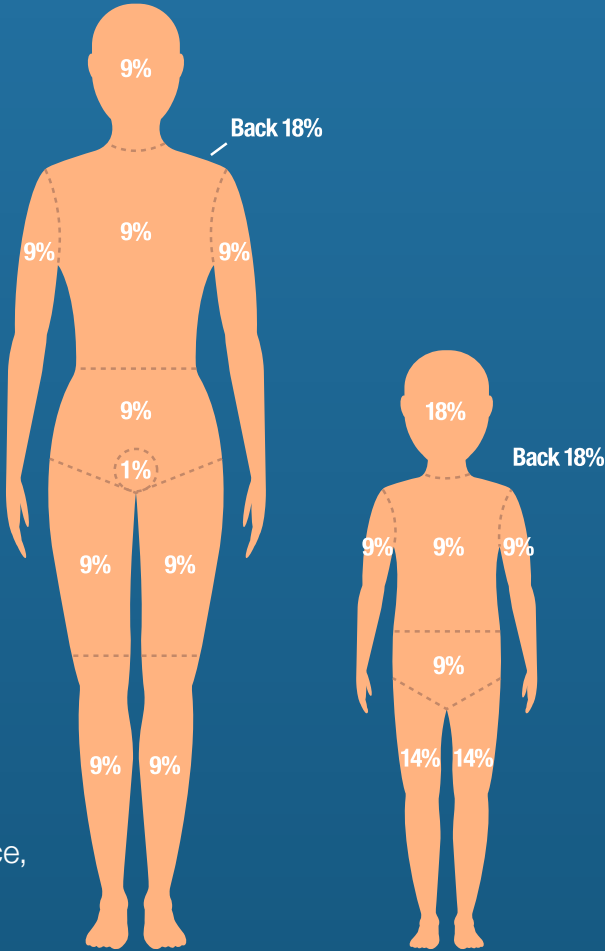
Depending on the circumstances and extent of injury, always remain ready to provide airway support and BLS. Burns to the face are associated with smoke inhalation and may cause upper-airway damage that compromises airway patency. Any signs of breathing difficulty should prompt activation of EMS if they have not already been notified. People with extensive burns or difficulty breathing should be placed in a semi-reclining position and monitored continuously.

Advanced Concepts

The Rule of Nines is a method health care providers use to help determine how much of a person is burned and to help in treatment.

For an adult:

- Head and neck 9%
- Anterior trunk (front of body) 18%
- Posterior trunk (back of body) 18%
- Each Arm (including the hand) 9% (total of 18%)
- Each leg (including the feet) 18% (total of 36%)
- Genitalia 1%



For a child:

- head and neck 18%
- anterior trunk 18%
- posterior trunk 18%
- arms (including hands) 9% each
- legs (including feet) 14% each

If a person has more than 9% of their body burned, they should be referred to a specialized burn center. Other reasons to refer to a burn center are:

- The person is a child
- Burned areas are in key areas such as the face, hands, feet, genitals or major joints
- Chemical burns
- Electrical burns
- Third- or fourth-degree burns

After you have ensured that the individual is stable, breathing easily, removed from the source and the burning process has been stopped or slowed, cover the injured area with a dry sterile dressing. If available, use burn specific dressings such as adaptic or iodoform gauze (petroleum impregnated and nonadhering) over the injured area as a primary dressing, followed by dry gauze. This will enhance the person’s comfort and make dressing changes more tolerable. If burns involve vital areas such as the face, hands, joints or genitals, seek immediate medical attention.

Burns of the Fingers and Toes

If the burn involves the hand, foot, fingers or toes, remove all jewelry on the affected extremity. When dressing burned fingers or toes, ensure digit separation with the use of gauze padding if the digits can be easily separated. Seek medical evaluation of these burns.

Facial Burns

Burns to the face may affect vital structures such as the eyes, ears or airway. Medical professionals should assess injuries to these areas. If the eyelids are burned, refrain from opening, and seek immediate medical attention.

Chemical burns to the face and eyes require immediate action. Call EMS and continuously flush affected area with cold water for about 20 minutes.

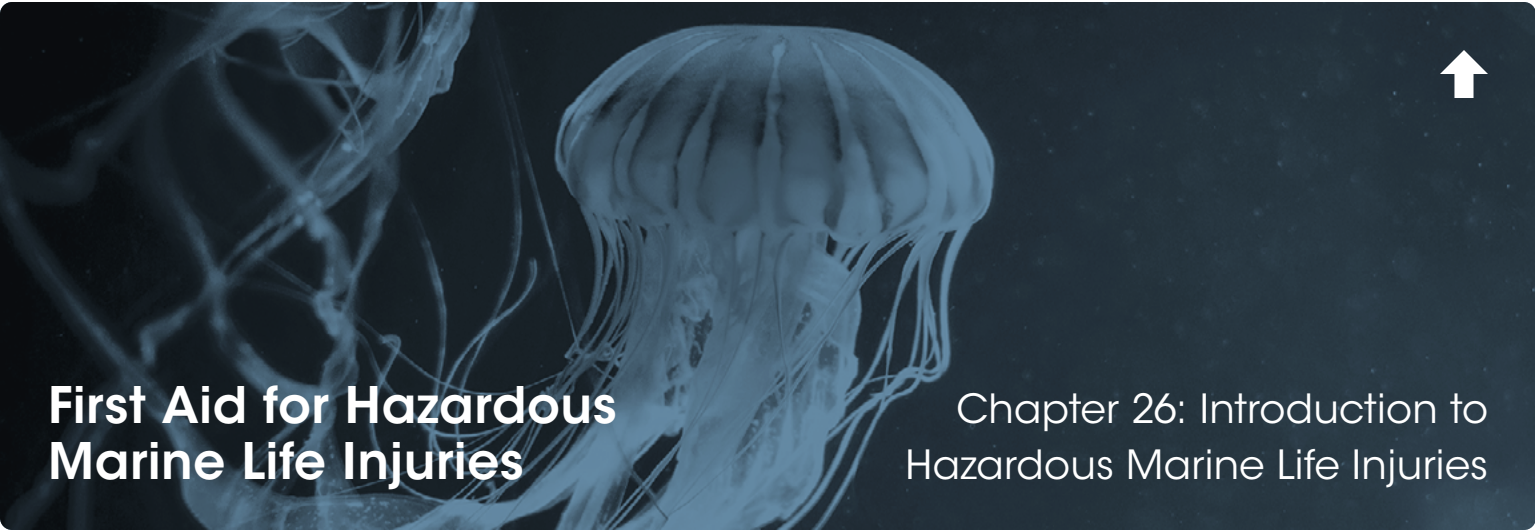
Review Questions

1. Superficial burns are severe and involve all skin layers.  
a. True  
b. False

2. Immediate first aid for burns includes removal from the source and the application of cool water to stop the burning process.  
a. True  
b. False

3. In the event of chemical burns to the face or eyes, continuously flush the area with cool water for approximately 20 minutes, and call EMS.  
a. True  
b. False

Review answers are on Page 251.



**Objectives**

- 1. What are the three general categories of marine life injuries?
- 2. What is an envenomation?
- 3. What is the usual trigger for marine animal bites?
- 4. What is the primary cause of seafood poisoning?
- 5. What protective measures should a first aid provider utilize?

Hazardous marine life injuries fall into one or more of the following three categories:

- 1. Envenomations
- 2. Traumatic injuries
- 3. Seafood poisonings

Appropriate first aid will depend on the type and source of injury. Signs and symptoms will vary and are influenced by several factors, including the type of injury, differences in individual reaction, treatment provided and treatment delays. Additional factors may include the person’s underlying health status and the type, potency and quantity of injected or ingested venom or toxin or the extent of tissue trauma.

**Envenomations** — Envenomation is the process by which venom or toxin is injected into another creature by means of a bite, puncture or sting. Fish (e.g., lionfish) use venom as a defense mechanism. Injuries result from direct contact with spines or fins. Such encounters often occur as a result of inadvertent contact while entering or exiting the water or when handling marine life. Envenomations are rare but can be life-threatening and may require rapid response by first aid providers. Common signs of envenomation along with the appropriate first aid procedures are described later in this chapter.

**Traumatic injuries** — Bites account for most of the trauma associated with marine life injuries. Fortunately, bites are extremely rare and are usually due to defensive reactions by the animal or from misidentification of a diver’s body part (such as a finger) as a food source. Bites may occur when divers feed animals such as moray eels, barracudas and sharks. Bites are almost always accidental and rarely life-threatening.

**Seafood poisonings** — Food poisoning occurs as a result of ingestion of food or liquids contaminated with harmful bacteria, parasites, viruses or toxins.

**Taxonomy**

Taxonomy is the scientific system used to organize life and indicate natural relationships between different organisms. The table below provides examples of this system through the phylogenetic organization of some common organisms. The first column identifies the primary taxonomic categories. The remaining columns provide examples of how this system is applied to different organisms (human, E. coli, kidney bean, shiitake mushroom). The final row, “scientific name,” combines the genus and species and is included for clarity but might not be found in standard tables. While this information may seem daunting it can facilitate understanding of how marine injuries and their treatments are grouped. Similiar first aid techniques will be applied across what may otherwise seem like unrelated organisms.

**Note:**  
When describing the larger group to which an organism belongs, we will often reference the order.

Table 1. Taxonomy or phylogenetic lineage of four common organisms

Taxonomy	Human	E. coli (bacteria)	Kidney bean	Shiitake mushroom
Domain	Eukaryota	Prokaryota (Bacteria)	Eukaryota	Eukaryota
Kingdom	Animalia	Monera	Plantae	Fungi
Phylum	Chordata	Proteobacteria	Magnoliophyta	Basidiomycota
Subphylum	Vertebrata		Magnoliophytina	Agaricomycotina
Class	Mammalia	Gammaproteobacteria	Magnoliopsida	Agaricomycetes
Subclass	Eutheria		Magnoliidae	Agaricomycetidae
Order	Primates	Enterobacteriales	Fabales	Agaricales
Suborder	Haplorrhini		Fabineae	
Family	Hominidae	Enterobacteriaceae	Fabaceae	Marasmiaceae
Subfamily	Homininae		Faboideae	
Genus	Homo	Escherichia	Pisum	Lentinula
Species	sapiens	coli	sativum	edodes
Scientific name	Homo sapiens	Escherichia coli	Pisum sativum	Lentinula edodes

Table 2 shows the primary members of vertebrate and invertebrate families associated with human injury.

Table 1. Taxonomy or phylogenetic lineage of four common organisms

Vertebrates	Invertebrates
<b>Scorpionfish and stonefish</b> Phylum: Chordata Class: Actinopterygii (ray-finned fish) Order: Scorpaeniformes Suborder: Scorpaenidae Pterois spp. Scorpaena spp. Suborder: Synanceiidae Synaceja spp.	<b>Cnidarians (jellyfish, corals and anemones)</b> Phylum: Cnidaria Class: Hydrozoa Millepora spp. (fire coral) Physalia spp. (Portuguese man-of-war) Class: Cubozoa (box jellyfish) Chironex fleckerii Chiropsalmus spp. Carukia and Malo spp. (Irukandji) Class: Scyphozoa (true jellyfish) Class: Anthozoa (anemones and corals)
<b>Stingrays</b> Phylum: Chordata Class: Chondrichthyes Order: Myliobatiformes Family: Urotygonidae	<b>Mollusks</b> Phylum: Mollusca Class: Gastropoda Conus spp. (cone snails) Glaucus spp. (blue ocean slug) Class: Cephalopoda (octopuses and squids) Hapalochlaena spp. (blue-ringed octopus)
<b>Sea snakes</b> Phylum: Chordata Class: Reptilia Order: Squamata Suborder: Serpentes Family: Elapidae Subfamily: Hydrophiinae	<b>Echinoderms (urchins, starfish and sea cucumbers)</b> Phylum: Echinodermata Class: Echinoidea (sea urchins) Class: Asteroidea (starfish) Acanthaster planci (crown-of-thorns) Class: Holothuroidea (sea cucumbers)
	<b>Sponges</b> Phylum: Porifera
	<b>Bristle worms</b> Phylum: Annelida

**Standard Precautions**

When treating any marine-life injury, the safety of the first aid provider is important. The use of protective barriers is essential to preventing injury to the rescuers while they are providing care. When removing stinging debris such as jellyfish tentacles or controlling external bleeding from an open wound, protective barriers are of particular importance. Before providing care, don nonlatex medical-style gloves. Use protective eyewear or masks if they are available.



1. The three general categories of marine-life injuries include envenomations, traumatic injuries and seafood poisoning.

a. True

b. False
2. Envenomation is a process facilitated by bites, punctures or stings.

a. True

b. False
3. Marine animal bites are usually fatal.

a. True

b. False
4. Seafood poisoning occurs as a result of contaminated food or liquids.

a. True

b. False
5. Standard precautions include the use of

a. nonlatex medical-style gloves

b. surgical-style masks

c. protective eyewear

d. all of the above

Review answers are on Page [251](#).



First Aid for Hazardous Marine Life Injuries

Chapter 27: Envenomations and Toxins



Objectives

1. By what mechanisms do envenomations occur?
2. Why do most envenomations occur?
3. What factors may affect an individual’s response to envenomations?
4. What are the first aid steps for venomous fish injuries?
5. For which three injuries is the pressure immobilization technique recommended?
6. What are the general first aid guidelines for jellyfish stings?
7. What are the general first aid guidelines for treating injuries resulting from contact with marine life?

The risk of marine envenomation can be greatly reduced by avoiding deliberate contact with marine life. It is important to remember that it is of equal priority to protect the marine life from harm as it is to protect yourself. Just because something is not venomous does not mean you should touch it. Even a small poke just to see how the polyps of a coral feel can be incredibly detrimental to these vulnerable creatures. It is in our best interest to admire marine life from a distance so it can be preserved for others to see and we can remain safe, too. Granted, not all encounters are avoidable. Be sure to learn about specific species in your area to watch out for, like jellyfish with long and nearly invisible tentacles.

Recognition of Venomous Marine Life and Treatment of Injuries

The mechanisms of marine envenomations include stings, spines, bites and barbs. Most of these injuries result from the animal’s defensive actions or accidental contact. Our physical reactions to these encounters are dependent upon several factors, including venom potency, volume injected and the area involved. Underlying factors such as the individual’s health status, sensitivity to venom and delays to first aid and treatment all have an impact on the extent of an person’s response.

Envenomations may also cause allergic reactions; in severe cases, an exaggerated reaction may cause airway narrowing. First-responder responsibilities always include basic life support, which may be as simple as maintaining an open airway or as involved as performing CPR. The signs and appropriate first aid procedures for severe allergic reactions are described later in this handbook.

Regardless of the type of venomous marine animal injury, appropriate first aid is intended to minimize the effects of injury. After each animal class description in this chapter is a short injury summary with a brief description of appropriate first aid. Detailed categorical first aid is provided at the end of individual sections. The categorical information is duplicated on the DAN First Aid for Hazardous Marine Life Injuries slates.

**Note:**

All wounds acquired in or subjected to a marine environment carry the risk of infection with the bacteria that causes tetanus. The U.S. Centers for Disease Control and Prevention (CDC) recommends a tetanus booster every 10 years (subsequent to completing the initial series). Repeat boosters are advised when high-risk wounds occur more than five years since your last tetanus booster. Deep puncture wounds are a risk factor for tetanus infection and should always receive thorough cleaning and medical evaluation, which may include a tetanus booster (Td or Tdap).

## Part 1: Vertebrates

Vertebrate animals are characterized by the presence of backbones and spinal columns. Examples include fish, amphibians, reptiles, birds and mammals. Envenomations from fish species include localized trauma in the form of puncture wounds and lacerations.

While the extent and nature of each injury is unique and will vary depending on the animal, the essential approach to first aid is consistent. General signs and symptoms plus generic first aid follows. Treatment specific to a particular animal is listed with its description below.

### Lionfish, scorpionfish, stonefish

Phylum: Chordata  
Class: Actinopterygii  
Order: Scorpaeniformes  
Suborder: Scorpaenoidei



These fish have characteristic physical attributes and for this course are separated into two different groups. One is very extravagant and represented by well-known organisms such as lionfish or zebrafish. The other group is well-camouflaged (or mimetic, indicating attempts to mimic their surroundings) and includes stonefish, scorpionfish and leaf fish.

Members of this order are found in oceans all over the globe. Typically nocturnal, these fish are voracious predators. Generally docile, they allow curious divers to closely approach, which enhances the risk for accidental contact. Venom is rapidly injected through needlelike spines located along the dorsal, pelvic and anal fins.

Puncture wounds can be painful, with rapid swelling (edema) and subcutaneous bleeding. Pain can last for several hours, edema typically resolves in two to three days, and the tissue discolorations can last up to four or five days.

Rare but serious signs include cyanosis, bradycardia (slow heart rates), hypotension and respiratory failure. In extreme cases, compartment syndrome and tissue necrosis may occur.

**Note:**

Skeletal muscle is wrapped in a tough, fibrous sheath called fascia, which forms a muscle compartment. As fascial tissue doesn't readily stretch, tissue trauma or envenomation that causes bleeding or edema within the compartment may result in elevated compartment pressures. Compartment syndrome describes a situation in which pressures within a muscle compartment have elevated enough to compress nerves and blood vessels. If pressures rise enough to choke off blood flow both in and out of the area, tissue death from lack of oxygenation within the compartment can occur. Compartment syndrome most often involves the forearm or lower leg.

**Note:**

Aquariums and dive operations diving with or around venomous species should have an emergency action plan that includes coordination with the local hospitals regarding antivenom options.

### Summary: Lionfish, stonefish, scorpionfish and other Scorpaena

- Envenomation results from direct contact/puncture.
- Reactions to mimetic species tend to be more serious.
- Edema can become rapidly significant.
- Pain may be severe.
- Deep puncture wounds can become infected.
  - Tetanus can result from these wounds.
- First aid involves cleaning the wound, controlling pain (heat) and applying topical antibiotics.

Stingrays

Phylum: Chordata  
Class: Chondrichthyes  
Order: Myliobatiformes  
Suborder: Myliobatoidei



Stingrays are usually shy and are closely related to sharks. They do not typically represent a risk to divers unless threatened, startled or stepped on.

Stingrays feed on sandy seabeds and are responsible for thousands of minor injuries worldwide in tropical regions. Most injuries occur in shallow water due to foot traffic where stingrays reside. Fatalities due to stingrays are infrequent, and occurrences are not consistently tracked.

Stingrays are armed with a serrated bony barb on their tail. When threatened or stepped on, stingrays will strike, and the barb can easily penetrate or cause deep and painful lacerations. A typical wetsuit offers limited protection. These types of wounds carry a particularly high risk of serious infection.

Venom glands are located at the base of the barb. The venom is a variable mixture of substances, none of which are specific to the animal; therefore the creation of a specific antivenom is not possible. The initial concern with stingray injuries is the trauma and pain from the barb puncture wound. The risk of infection is a serious concern that requires monitoring of the injury.

Summary: Stingrays

- Injuries are rarely fatal.
- Pain is scorching in nature and can be out of proportion to the injury.
- Wounds can become infected easily.
  - Tetanus and other forms of soft-tissue infections can result from these wounds.
- First aid involves controlling bleeding, cleaning the wound and controlling pain (heat).
- Definitive medical care may include surgical wound debridement, antibiotics and tetanus vaccination.

Treating Venomous Fish Injuries

Signs and symptoms

- |   |   |
|---|---|
| <ul style="list-style-type: none"><li>• Puncture or laceration</li><li>• Blisters around the puncture site</li><li>• Patches of purple or black skin coloration</li><li>• Intense pain</li><li>• Swelling<ul style="list-style-type: none"><li>— Can lead to compartment syndrome</li></ul></li></ul> | <ul style="list-style-type: none"><li>• Other<ul style="list-style-type: none"><li>— Nausea</li><li>— Vomiting</li><li>— Shock (rare)</li><li>— Respiratory arrest (rare)</li><li>— Cardiac arrest (rare)</li></ul></li></ul> |
|---|---|

First aid (lionfish, stonefish and stingrays)

- Wash the area thoroughly with soap and fresh water. (Tap water is fine.)
- Remove foreign material.
- Control bleeding (if present).
- Pain control: Immerse the affected area in hot (not scalding) fresh water (upper limit 45°C/ 113°F) for 30 to 90 minutes (repeat as needed).
- Apply topical antibiotic ointment or cream, if available.
- Apply bandaging as necessary.
- If necessary, administer pain-control medications.
- Seek professional medical evaluation, as medical management may include sedatives, tetanus vaccination and antibiotics. Advanced life support may be required in rare instances.

Note:

The use of heat to the affected area is effective for pain control and can be repeated as needed. Cold packs can also be used and may provide relief and reduce or minimize swelling.

Advanced Concepts

Thermolysis describes the use of heat (often by immersion of the affected area in hot water) to break down substances (thermo meaning heat, and lysis meaning breakdown or destruction). For venoms comprised primarily of proteins, this may denature them and reduce their potency.

Protein denaturation, however, may not necessarily be limited to venom and may also injure healthy tissue in the affected area. Each case is unique and requires some estimation of the depth to which the venom was injected. If the inoculation occurs in deep tissues, heat at the surface of the skin will rapidly diffuse, and deeper tissues will not acquire the temperatures necessary to denature foreign proteins. In addition, vasodilatation caused by exposure to elevated temperature may expedite the onset of absorption and of systemic effects. Thermolysis is not recommended in first-aid circumstances since temperatures high enough to denature venom proteins can also cause severe burns. If attempted, minimize the risk of local tissue damage by testing the water on yourself first. Use the hottest temperatures you can tolerate, and avoid scalding. Do not rely on the individual's personal assessment, as intense pain may impair their ability to discriminate between "hot but tolerable," "too hot" and "way too hot."

Sea snakes

Phylum: Chordata  
Class: Reptilia  
Order: Squamata  
Suborder: Serpentes



Sea snakes are highly venomous airbreathing animals that are well adapted to marine life and are related to land species such as cobras and coral snakes. They have a paddle-shaped tail, and an adult sea snake can reach 90-135 cm (3-4.5 feet) in length. They are adept and graceful swimmers and have been known to reach depths of up to 40 meters (130 feet) or more. Their habitat includes the Indian and Pacific oceans.

These animals are rarely a threat to divers or swimmers. They are often curious and may approach divers in a fast and deliberate manner that can be construed as aggressive. The best way to handle these situations is to remain calm and swim in a different direction. Armed with small fangs (2-3 mm), most of their bites do not result in envenomation.

Multiple bites with tiny jagged lacerations are suggestive of venom inoculation. Sea snakes can produce an average of 10-15 mg of venom — a sobering thought when 1.5 mg is enough to kill an average adult human.

Sea snake venom rarely contains large quantities of tissue-toxic compounds, therefore bites will rarely cause localized pain. Their venom, however, does contain neurotoxic components, which can cause paralysis. Venom may have muscle-specific toxic effects that can result in a serious condition known as rhabdomyolysis, which can cause loss of kidney function and require medical intervention. Symptoms usually appear within two hours after the bite; more serious poisonings may present sooner. A bite victim should be kept under observation in a medical facility. If a bite victim remains symptom-free for more than eight hours, envenomation is unlikely, but continued medical supervision may still be warranted.

Snakebite-associated fatalities are unknown among divers, but fatal bites have occurred among Southeast Asian fishermen during attempts to disentangle sea snakes from fishing nets.

Very few sea-snake species spontaneously venture onto land. When they do, they are typically clumsy and move slowly. Despite this, they should be treated with respect and left alone.

Summary: Sea snakes

- Prevent bites by avoidance — don't antagonize the animal.
- Bites can be painless and difficult to detect.
- Most bites do not result in envenomation.
- Neurotoxic venom may cause the following:
  - Difficulty speaking and swallowing
  - Weakness
  - Progressive flaccid paralysis
  - Respiratory distress/arrest
  - Cardiac arrest due to respiratory depression
  - Death
- First aid includes pressure immobilization of wounded limbs, limiting movement of the injured diver and hydration.
- Seek medical attention if bitten (antivenom may be available).

Treating Venomous Fish Injuries

Signs and symptoms

- Small lacerations or punctures
- Bleeding
- Painless bite site
- Retained material in the wound

Early neurological warning signs

- Difficulty swallowing (dysphagia)
- Drooping of the upper eyelid (ptosis)
- Dilatation of the pupils (mydriasis)
- Double vision (diplopia)
- Difficult or painful speech (dysphonia)
- Tongue twitching (lingual fasciculations)

First aid (sea snakes)

Initial treatment is symptomatic, and the first aid responder must focus on four primary tasks:

- Continuously monitor injured person's vital signs.
- Use pressure immobilization technique on affected limbs. Limit all movement as much as possible.
- Keep person hydrated.
- Transport to a hospital capable of advanced life support and possibly antivenom administration.

Advanced Concepts

Antivenom (or antivenin or antivenene) is a serum product cultivated from animal blood and given therapeutically to neutralize the effects of venomous bites and stings. Antivenom is generally specific to particular venom and works by introducing venom-specific antibodies that help to minimize venom activity.

- For optimal effectiveness, antivenom should be injected within four to eight hours following a bite or sting.
- Since antivenom is cultivated from the blood of animals, it is important to know a person's allergy history. Allergic reactions to antivenom are not uncommon (serum sickness) and may be mitigated by the use of antihistamines.

**First aid – Pressure Immobilization Technique**

The pressure immobilization technique should be used only as an interim aid while getting the injured individual into advanced medical care. It is not universally effective but has been reported to delay systemic envenomation.

An elastic bandage (versus roller/crepe gauze) is recommended but should not be applied too tightly. Peripheral pulses and circulation should be checked to ensure adequacy. A suggested reference for wrapping pressure is the pressure used to wrap a sprain.

Once applied, the bandage and splint should not be removed until the injured person is in definitive medical care. Antivenom must be immediately available when the bandage is released to prevent increased risk from a systemic venom bolus.

The immobilization component of the technique does not apply to just the injured limb. The injured person should stay as still as possible because movement of other limbs will contribute to venom circulation. If an injury indicates the need for this technique, constant monitoring of breathing and circulation should also be implemented.

Advanced Concepts

Sea snakes and other marine creatures have highly toxic venom to overcome the difficulties they face securing prey. Fish are cold-blooded animals with a slow circulatory system to disseminate venom. When these animals strike, they need a highly effective poison to subdue their prey.

Advanced Concepts

Acute renal (kidney) failure may occur secondary to rhabdomyolysis (muscle protein breakdown). To minimize this effect, active hydration, supplemented by IV fluids under medical supervision, and immobilization, to minimize muscular activity, are the cornerstones of first aid and medical management.

Review Questions

1. Envenomations may occur via

a. stings

b. spines

c. bites

d. barbs

e. all of the above
2. Envenomations may occur due to

a. accidental contact

b. defensive action

c. both a and b
3. The health status of the injured person, sensitivity to the venom and delays in receiving first aid have an impact on their response to the injury.

a. True

b. False
4. A venomous fish injury should be treated by

a. washing the area

b. removing foreign material

c. controlling bleeding

d. managing pain

e. all of the above
5. Pressure immobilization is recommended for which vertebrate injury?

a. stingray punctures

b. lionfish stings

c. sea snake bites

Review answers are on Page 251.

# Bonus Content

## Snake Morphology: What do their shape and physical features tell us?

**Venomous vs. nonvenomous:** There are a few physical characteristics that enable differentiation between most venomous and nonvenomous snakes, whether terrestrial or marine. It is important to emphasize that these features should be used only as a general guideline and that handling or approaching snakes should be done only by or under the direction of herpetology experts.

**Head/neck/body:** Most venomous snakes have a clearly defined neck that differentiates the head from the body. In contrast, nonvenomous snakes such as colubrids do not. The heads of many venomous snakes are roughly triangular, while the heads of nonvenomous snakes tend to be more spoon-shaped.

**Elliptical pupils:** Most venomous snakes have elliptical pupils, while nonvenomous snakes have round pupils.

**Loreal pit:** Venomous snakes have loreal pits, while nonvenomous snakes do not. The loreal pit is a depression between the nostril and the eye. It is a highly effective sensory organ that enables certain snakes to perceive the body heat that radiates from its prey.

**Ridged or keeled scales:** Most venomous snakes have keeled scales that give them a rough-to-the-touch appearance. In contrast, nonvenomous snakes typically have a smooth appearance with flat and often shiny scales.

**Body/tail:** With some venomous snakes it is possible to identify where the body and its internal organs end and the purely muscular tail begins. This feature may not be obvious or possible to see when the animal is coiled or hidden.

**Note:** *There is one important exception to these general rules. Elapids (cobras, coral snakes and sea snakes) follow all the same features and resemble harmless nonvenomous snakes.*

### Head Shape and Fang Location

Whether terrestrial or marine, snakes are characterized not only by name and family but also by skull shape and location of their teeth and fangs (or absence thereof). All snakes will fit into one of four different groups.

**Aglyphous** (prefix a- meaning “lack of” and glyph meaning “fangs”). These snakes do not have fangs; they have jaws full of teeth that are similar in shape and size and are not connected to venom glands. Two-thirds of all snakes belong to this group. Most aglyphous snakes are nonvenomous. Pythons are aglyphous.

*(Continued on the next page.)*

*(Continued from the previous page.)*

**Opisthoglyphous** (prefix opistho- meaning “back”). Opisthoglyphous snakes are found in the family Colubridae. Their classification stems from the “backof-the-mouth” location of their fangs. These specialized teeth have an open groove that allows venom to flow down the backside of the tooth into the bite. Due to the location of these fangs, it is relatively hard for these snakes to open their mouths wide enough for their fangs to be a threat to humans. Most of these snakes typically feed on amphibians, small rodents as well as other snakes (ophiophagous). While some human deaths have been documented, these snakes typically pose little risk to humans.

**Proteroglyphous** (prefix pro- or protero- meaning “forward”). This form of dentition is unique to elapids, the most toxic of all snakes. These snakes have a shorter upper jaw with few teeth except for a large fang on each side, which points downward and curves around the venom channel, forming a true hollow needle. Because of the location of these fangs and their relative shortness (only a few millimeters), these snakes have to momentarily hang onto their prey to inject venom.

**Solenoglyphous** (prefix soleno- meaning “pipe” or “channel”). This form of dentition is unique to vipers such as rattlesnakes and other members of the Crotalinae subfamily. This group of snakes has the most advanced venomdelivery mechanism. The upper jaw supports a hollow fang on each side, which can be as long as half the length of the animal’s head. Fangs are retractile, folding backward, and these animals can open their mouths to almost 180 degrees, which means that when they attack, their fangs can thrust forward toward their prey. Though the venom of these animals poses a different type of toxicity than that of proteroglyphs, the effectiveness of the venom-delivery mechanism enables them to inject large quantities very quickly.

## Part 2: Invertebrates

Invertebrates are animals without backbones and compose more than 98 percent of Earth’s animal species. Injuries arising from contact include envenomation and localized tissue trauma (cuts and scrapes). The mechanisms of envenomation are stings and punctures. As with venomous-vertebrate animals, individual invertebrate animal groups have unique features that affect signs and symptoms as well as first aid.

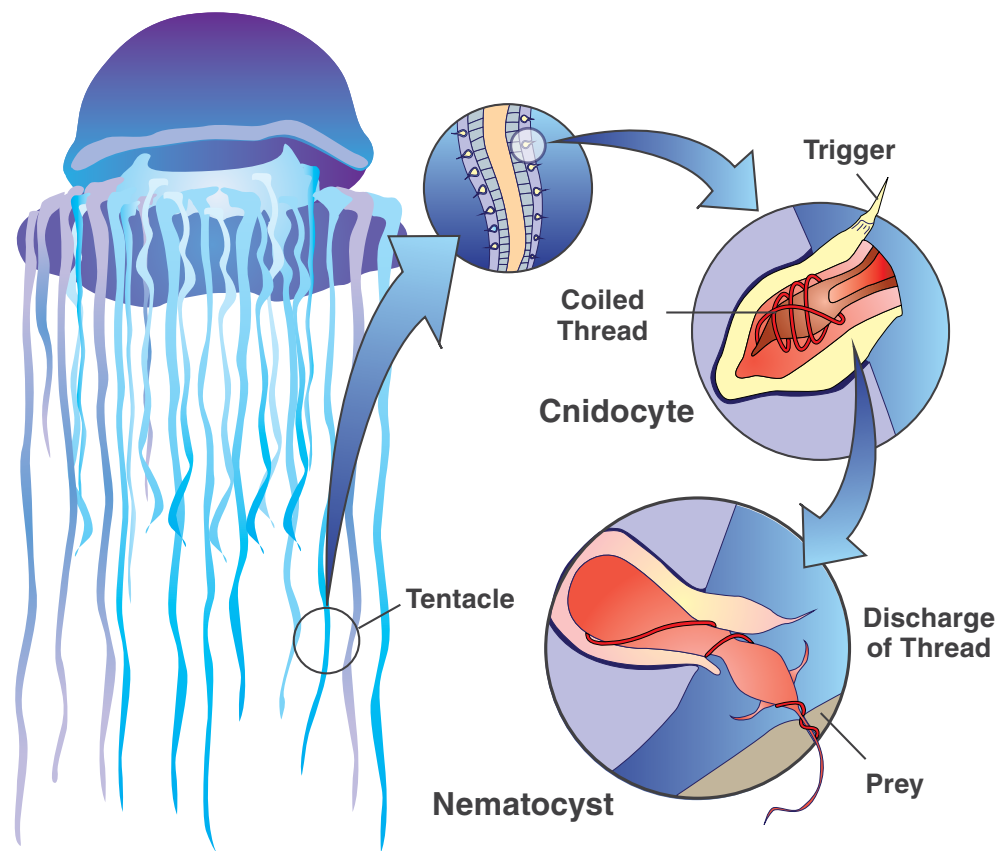
### CNIDARIANS

#### Jellyfish, corals, anemones and hydroids

Phylum: Cnidaria

Most marine envenomations are the result of interactions with cnidarians. These organisms contain tentacles with numerous stinging cells called nematocysts. These ingenious harpoonlike devices excel at venom delivery.

The majority of cnidarians are actually harmless to humans; only a handful pose a risk to people. In general, first aid treatment remains the same for all organisms. Some species, however, may require additional interventions. Be aware that treatment protocols vary in different parts of the world. (See note for Portuguese man-of-war later in this section.)



### Jellyfish

Phylum: Cnidaria

Subphylum: Medusozoa

The most frequent and severe cnidarian injuries are the result of interactions with jellyfish. Injuries result from direct contact and are usually localized to the affected area. Though these encounters may be painful, most are not life-threatening and result in only mild to moderate skin irritations. Stings can be avoided with proper exposure protection.



### Box jellyfish

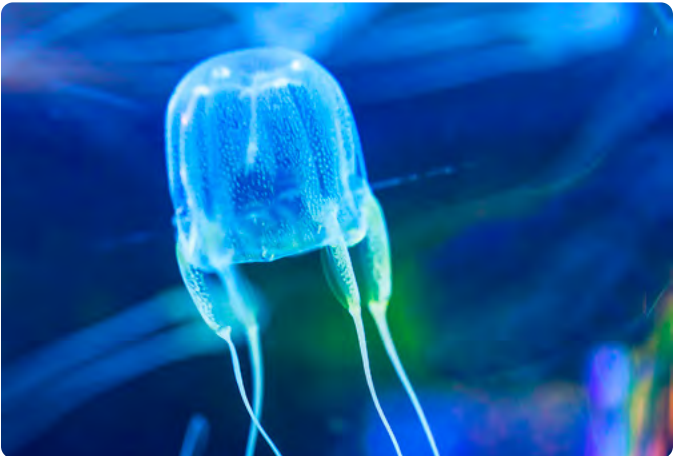
Phylum: Cnidaria

Class: Cubozoa

Order: Chirodropida

Family: Chirodropidae

Box jellyfish, also known as “sea wasps,” are considered the most venomous of all creatures and contribute to for more human fatalities than any other marine organism. According to health authorities in Queensland, Australia, where the highest number of cases are recorded, box jellyfish have been responsible for at least 63 recorded deaths in Australian waters since 1884.



Rapid toxin absorption affects the cardiovascular system and can lead to death from cardiac arrest in as little as three minutes — scarcely enough time for any rescue response. Prevention, therefore, is a key measure. Even a lightweight dive skin can provide adequate protection.

#### Signs and symptoms

- Immediate, extreme pain
- Significant localized welts and discoloration of skin
- Rapid progression of symptoms — May lead to death within minutes



■ Distribution of the box jellyfish

**Note:**

There is a specific antivenom (bovine origin) for box jellyfish.

## Irukandji jellyfish

Phylum: Cnidaria

Class: Cubozoa

Order: Carybdeia

Family: Carybdeidae

Irukandji syndrome is a condition caused by tiny box jellyfish, *Carukia barnesi* and *Malo kingi*. Fortunately, fatalities are rare, but stings are nonetheless extremely painful and can cause systemic symptoms that should prompt immediate medical attention.



First described in northern Australia, reports of Irukandji-like syndromes have also come from Hawaii, Florida, French West Indies, the Caribbean, Timor-Leste and Papua New Guinea.

Irukandji syndrome occurs within five to 45 minutes following contact.

### Signs and symptoms

- Moderate pain initially
  - Progresses to extreme pain throughout the body
- Excruciating muscle cramps
- Restlessness
- Severe hypertension
- Anxiety and a feeling of impending doom
- Rarely fatal

Life-threatening manifestations such as fluid in the lungs (pulmonary edema), hypertension or heart failure may also occur and can be fatal if not treated.

## Portuguese man-of-war

Phylum: Cnidaria

Class: Hydrozoa

Order: Siphonophora

Family: Physaliidae



Portuguese man-of-war are floating cnidarians that use their sail-like gas bladder to catch wind currents that propel these animals along the surface of the open ocean. The gas bladder, known as a pneumatophore, is filled with atmospheric gases, and it may contain up to 90 percent carbon dioxide (CO<sub>2</sub>).

There are two species: the larger Atlantic or Portuguese man-of-war and its smaller IndoPacific relative known as bluebottle. The Atlantic species is found from south Brazil through the Gulf of Mexico and all along the eastern United States. Further east, they are found around South Africa and as far north as the Mediterranean and Scotland. While the Pacific species is typically found in Australia, the Indian Ocean and New Zealand, they have also been reported in the Hawaiian Islands.

Because of their propensity to cause systemic symptoms, these two species are considered among the most dangerous cnidarians. Their venom contains a powerful neurotoxin that can paralyze small fish and other prey.

Symptoms can persist up to 48 hours. Severe systemic symptoms are rare but may require advanced life support including mechanical ventilation and advanced cardiac life support. The first responder must consider evacuation to a higher level of care if symptoms worsen or the overall condition deteriorates.

### Signs and symptoms

- Localized pain
- Localized redness
- Pain with breathing
- Back pain and abdominal cramps
- Anxiety

**Note:**

Multiple studies have supported the use of vinegar as an effective measure to prevent further firing of jellyfish nematocysts in tropical waters. Removal of tentacles further reduces venom injection. Finally, use heat packs to manage pain and decrease venom activity. These steps are supported specifically by the American Heart Association (AHA) and the Australian Resuscitation Council (ARC) in conjunction with Australia-New Zealand Council on Resuscitation in their latest guidelines.

An exception is *Physalia* spp. (Pacific Portuguese man-of-war or bluebottle). The ARC strongly discourages the use of vinegar for these species because some studies report that vinegar stimulates massive nematocyst discharge. This is ongoing research and as changes occur, updated information will be shared.

**Bonus Content**

Despite its appearance, the Portuguese man-of-war technically is not a jellyfish; it's a siphonophore. These differ from jellyfish in that they are not actually single organisms but a colony of specialized polyps or zooids. One type of polyp fills itself with gas and forms the pneumatophore; three others take up the roles of defense (dactylozoid), reproduction (gonozooid) and feeding (gastrozoid). Their tentacles, covered with stinging dactylozooids, can reach up to 50 meters (165 feet) in length.

**Bonus Content**

There are two species of nudibranchs (gastropods or sea slugs) that are known to feed on Portuguese man-o-war. These sea slugs not only devour the tentacles, but they also somehow manage to use the man-of-war's venom in their own defense. The venom is collected in specialized sacs (cnidosacs) at the tip of their thin "featherlike fingers" (branchia), which enables them to potentially produce a sting equally powerful to the man-of-war upon which it feeds.

**Fire coral**

Phylum: Cnidaria  
Class: Hydrozoa  
Order: Capitata  
Family: Milleporidae

Fire coral (*millepora* spp.) are stinging cnidarians and present as branching yellow-green or brown limestonelike formations in tropical and subtropical seas. These formations have tiny pores through which cnidocytes protrude. Due to the jagged nature of these formations, envenomation is often associated with local tissue trauma, which may require aggressive and thorough irrigation and bleeding control. Wound edges can become necrotic.



**Anemones, hydroids and other corals**

Phylum: Cnidaria  
Class: Anthozoa

While related to jellyfish and equipped with cnidocysts (stinging cells), these organisms are typically harmless to humans. In some particularly sensitive individuals, contact may produce a mild skin irritation (dermatitis). Treatment is geared toward symptom relief.



Hard corals typically do not represent a threat. The biggest hazards are mechanical injuries such as cuts and scrapes, which are at risk for serious infections.

Soft corals, sea feathers and gorgonians are nonvenomous, and any contact that results in injury should require only thorough cleaning with soap and fresh water and treatment of symptoms. If necessary, remove any foreign material.

**Note:**

The routine use of home remedies, such as meat tenderizer or urine, for marine-life injuries is not recommended. These techniques have limited efficacy and may cause additional tissue irritation.

Treating Cnidarian Injuries

(Jellyfish, corals, anemones and hydroids)

Signs and symptoms

- Pain (may be excruciating with some species)
- Intense burning and itching
  - Fire-coral injuries may be associated with abrasions or lacerations, which may enable additional toxin entry and also increase the risk for infections.
- Localized swelling
- Nausea, vomiting, dizziness
- Blister formation (may be delayed for days with some species)
- Shock (rare)

First aid

The following describes a general first aid approach for species of different classes of cnidarians. Since nematocysts are microscopic structures that are mechanically activated, it is extremely important to avoid further envenomation while performing first aid.

- **Inactivation.** Irrigate the area with generous amounts of household vinegar (or 4 to 6 percent acetic acid solution). This does not reverse the effects of venom or control pain, but it helps prevent the discharge of unfired nematocysts.
- **Removal.** Visible tentacles or filaments should be carefully removed with the aid of fine tweezers or protective barriers. Gloves, stockings or other thin material can provide enough mechanical protection to prevent rescuers' envenomation during tentacle removal.
- **Wash/irrigate.** After liberal use of household white vinegar and removal of tentacles or filaments, wash the area with seawater or saline solution. Avoid rubbing or use of fresh water as these can stimulate nematocyst discharge.
- **Symptomatic treatment and control of bleeding.** Treatment usually consists of painkillers, anti-inflammatory medications and topical anesthetics. Local application of heat or cold can provide additional pain reduction. Reports indicate that the application of heat to the affected area may provide more effective pain relief than the use of cold, but cold packs should not be refused or avoided on this basis.

Summary: Cnidarians

(Jellyfish, corals, anemones and hydroids)

- Avoid contact (physical distance, neutral buoyancy, exposure protection)
- Thoroughly rinse wound with vinegar
  - Avoid the use of fresh water
- Remove foreign material; use barriers or tweezers
- Wash affected area with salt water or saline
- Control bleeding if present
- Immerse in hot water for pain control (ice packs can also be used)
- Medical attention and tetanus booster may be necessary

MOLLUSKS

Cone snails, blue-ringed octopuses

Of the nearly 85,000 recognized species of mollusks, only two are potentially harmful to humans: cone snails and blue-ringed octopuses.

Cone snails

Phylum: Mollusca

Class: Gastropoda

(Unranked): different clades

Family: Conidae

There are about 600 different species of cone snails. The shells of these mollusks are characteristically conical (cone shaped), and all of them are poisonous. Cone snails have a tiny harpoonlike structure that delivers potent neurotoxic venom. Injury occurs when handling, so handling should be avoided.



Advanced Concepts

Slow-moving but voracious night predators, cone snails require fast-acting venom to paralyze their prey. Several toxic compounds, collectively called conotoxins, form the unique characteristics of cone-snail venom. These toxins are composed of small peptides and carbohydrates whose primary target is the nervous system.

Initial signs and symptoms of envenomation vary widely. Stings from some species may initially be no worse than a bee sting, while others may cause severe systemic effects.

Signs and symptoms

- Immediate pain (mild to moderate)
- Mild edema and/or erythema (usually resolves within a few hours)
- Numbness/sensation changes (may persist for weeks)

Advanced Concepts

Venom toxicity appears directly related to an animal’s dietary habits and inversely proportional to their abundance. There are three primary dietary categories: fish eaters, less abundant (10 percent) and very venomous; shellfish eaters, more abundant (30 percent) but less venomous; and worm eaters, very abundant (60 percent) and the least venomous. The relative toxicity of venom makes sense, as fish are harder to subdue than worms.

Blue-ringed octopuses

Phylum: Mollusca  
Class: Cephalopoda  
Order: Octopoda  
Family: Octopodidae

The blue-ringed octopus is the only cephalopod that poses a real medical threat to humans. These small animals rarely exceed 8 inches (20 cm) in diameter and are commonly found in warm tide pools from Japan to Australia.



At rest they are patterned with distinctive brown bands on the body and arms. Their iridescent blue rings are expressed when the animal is disturbed or on the prowl. Their small size and distinct markings enable easy identification. Envenomation happens when the animal is handled.

Signs and symptoms

- |   |                        |
|---|------------------------|
| • Bite site might be painless and difficult to find | • Progressive weakness |
| • Confusion   | • Nausea and vomiting  |

Symptoms usually resolve within 24 hours and may be associated with generalized itching (pruritus), wheals/hives (urticaria) and joint swelling. Symptoms can progress quickly, so immediate medical evaluation and support is strongly advised. Injured people who live through the first 24 hours generally go on to make a complete recovery.

### Bonus Content

Like all other cephalopods, the mouth of the blue-ringed octopus is armed with a strong beak in the center of its body, right at the confluence of all its arms. This sharp beak resembles that of parrots. The bite is usually painless and leaves two small V-shaped puncture wounds oriented in opposite directions. The toxins, created by bacteria within its saliva, are extremely potent and may induce generalized weakness that can lead to paralysis and death. A single 0.9-ounce (25-gram) specimen possesses enough venom to paralyze at least 10 average-sized adults.

Treating Mollusk Injuries

Signs and symptoms

- |   |  |
|---|--|
| • Blurred or double vision  | • Progressive weakness                                 |
| • Difficulty speaking or swallowing (dysphagia)   | • Paralysis  |
| • Slurred speech, vocal hoarseness  | • Death (from respiratory depression due to paralysis) |
| • Numbness and fullness around the mouth, neck and throat (especially with blue-ringed octopus bites) |  |

### First aid

- Clean wound thoroughly with soap and fresh water.
- Remove any foreign material.
- Pressure immobilization technique is recommended for affected limbs. Limit all movement as much as possible.
- Immediately transport the injured person to a medical facility for monitoring and advanced medical support.
  - Do not wait for muscular paralysis to develop. Respiratory depression may require advanced medical support, including mechanical ventilation.
- Monitor breathing and airway.

Keep people with systemic symptoms under careful observation in a medical setting, and monitor for signs of respiratory depression for at least six to eight hours. Tetanus coverage is always recommended, and antibiotic therapy may be necessary. Monitor for infection. There is no available antivenom. Immersion in hot water may provide some relief but may also enhance venom distribution due to vasodilatation.

Summary: Mollusks

(Cone snails and blue-ringed octopuses)

- Avoid contact. Do not handle live specimens.
- Clean the affected area with soap and water
- Monitor breathing and airway
- Seek local emergency medical services immediately, and monitor the condition
- Cone snails: To control pain, immerse affected area in hot water

Advanced Concepts

Blue-ringed octopus venom was once known as maculotoxin but was later found to be identical to tetrodotoxin (TTX), a toxin found in Tetrodontids (pufferfish, triggerfish, porcupinefish, etc.), some cone snails and amphibian such as certain newts and dart frogs. TTX is considered more toxic than cyanide. (Read more about TTX in Chapter 28, Seafood Poisonings.) The venom also contains an enzyme that dissolves certain molecular structures in connective tissues, which increases its permeability and speeds venom dispersion and delivery. Even in serious envenomations, the bite site might be hard to detect. Injured people often do not realize they have been bitten until respiratory depression and paralysis set in. Symptom onset typically occurs within 10 minutes following a bite.

ECHINODERMS  
Sea stars, sea urchins and sea cucumbers

The phylum Echinodermata (Greek for “spiny skin”) is composed of about 7,000 species. While most echinoderms are poisonous, only a few members are capable of causing venomous injuries to humans.

**Bonus Content**

Echinoderms show a huge variety of shapes, sizes and colors, and all share certain common anatomical and structural features. One of them is five-spoke or pentaradial symmetry, easily identifiable in sea stars, sea urchin skeletons and sand dollars. There are exceptions to the five-spoke symmetry, with up to 14 arms in some varieties, such as the crown-of-thorns (acanthaster planci). Echinoderms are the only animals that possess a vascular system that utilizes water. This system consists of five radial canals; it facilitates respiration, nutrition and even locomotion by connecting hundreds of pairs of tubular feet (called pedicellariae). These extremely versatile “feet” are independently mobile, and by means of synchronized movements they can transport the animal around the sea bed. Synchronic traction can also be strong enough for gripping, and these pedicellariae have a sensory perception function as well.

Crown-of-thorns sea stars

Phylum: Echinodermata  
Class: Asteroidea  
Order: Valvatida  
Family: Acanthasteridae

Crown-of-thorns sea stars have a unique appearance and voracious appetite. Injuries occur as a result of contact with their spines. These species have a wide habitat and are found from the Red Sea to the Great Barrier Reef in Australia and the western tropical Americas. They are known for achieving plague-like populations and can cause severe bleaching to tropical reef ecosystems.



Advanced Concepts

Seasonal overpopulations of crown-of-thorns sea stars may cause massive coral bleaching. In some areas scuba divers have deliberately dismembered them in an attempt to curtail reef destruction only to find that each damaged limb has the capacity to fully regenerate the whole organism. Such efforts therefore only serve to increase the population and the risk of injuries to the involved divers as well as further reef destruction.

Sea urchins

Phylum: Echinodermata  
Class: Echinoidea

The primary hazard associated with sea urchins comes from contact with spines. Although not necessarily venomous, sea urchins have sharp spines that easily penetrate skin, wetsuits and shoes and are brittle enough to quickly break off once embedded. The brittle nature of these spines can also make removal difficult, as they tend to break off or disintegrate with traction. Although puncture wounds won't necessarily become infected, they may stimulate a foreign-body reaction. Spine injuries that involve joints may require surgery.



Prevention is key. Avoid physical contact with sea urchins unless you have the knowledge, equipment or experience to handle them safely.

If the species responsible for the injury is venomous, wounds quickly become intensely painful, erythematous and swollen. Systemic symptoms are rare and usually mild and self-limited.

Advanced Concepts

The flower urchin (toxopneustes pileolus) is the only urchin in which spines are not the problem, but its pedicellaria are. (See Bonus Content on Page 187.) If you see them in the Pacific or Western Americas, enjoy them, but do not touch.

Sea cucumbers

Phylum: Echinodermata  
Class: Holothuroidea

These seabed scavengers are found in every ocean. Their characteristic shape resembles that of a cucumber or large caterpillar, and their texture, size and color vary significantly.



Injuries associated with these animals may occur upon ingestion of certain species or from contact with holothurin — a toxic chemical released by sea cucumbers to deter potential predators.

Holothurin is water-soluble and heat stable. Contact with this toxin can cause mild to moderate skin irritation. Anecdotal reports mention cases of swimmers who complained of conjunctivitis (eye irritation) or even became blind after swimming where fishermen cleaned their catch prior to consumption. Fishermen have developed skin rashes after cleaning high volumes of these animals.

**Bonus Content**

When threatened, some sea cucumbers can expel their stomach contents or their whole stomach to provide an alternative meal to potential predators and give the slow sea cucumber time to escape.

Treating Echinoderm Injuries

Signs and symptoms

- Sharp, stinging pain
- Local swelling
- Redness (erythema)
- Tissue damage and/or spines protruding from skin
- Muscle weakness, nausea, vomiting and paresthesias (severe cases)

**First aid**

- Thoroughly wash the area with soap and fresh water (tap water is fine).
- Remove foreign material.
  - Seek medical attention if spines have entered joints.
- Monitor for signs of infection. (See additional information in Chapter 4.)
- Tetanus coverage is recommended.

The use of topical antibiotics or corticosteroids may help reduce discomfort and minimize the risk of infection. In areas where deep skin penetrations have occurred or joints are involved, seek immediate medical attention.

Summary: Echinoderms

(Sea stars, sea urchins and sea cucumbers)

- Avoid contact
- Clean the affected area with soap and water
- Seek medical attention if spines are deeply embedded or have entered joint spaces
- Tetanus coverage is recommended
- Monitor for signs of infection

OTHER PHYLA

Sponges and bristle worms

Irritations are the most common marine life injury and are also the easiest to avoid. These are rarely life-threatening and usually just require a thorough cleaning and close observation to prevent infection.

Common causes of these injuries include contact with rough surfaces such as coral, barnacles and rocks, sponges and various marine organisms. If the irritation, cut or abrasion shows signs of infection, seek medical attention.

Sponges

Phylum: Porifera

Sponges are one of the most primitive organisms. Of the approximately 10,000 known species, only 150 live in fresh water. Sometimes described as “living hotels,” these sessile organisms provide shelter for a large array of small creatures.



Aside from a few species that contain harmful toxins (noted below), contact dermatitis is the most characteristic presentation. Skin lesions may take two to three weeks to resolve.

Corticosteroids, antihistamines and antibiotics will not necessarily alter the course of acute injuries but may be used in an attempt to treat delayed reactions or persistent skin irritation.

Note:

There are 13 species of sponges reported as harmful to humans. Species include the Caribbean and Pacific fire sponges, the poison-bun sponge in the tropical West Atlantic and the red-beard sponge found along the eastern United States.

Envenomations can occur even after the sponge has been removed from the sea, provided it remains moist. Dry sponges are apparently harmless, but reports indicate that rehydration can reactivate toxins.

Bristle worms

Superphylum: Lophotrochozoa  
Phylum: Annelida  
Class: Polychaeta



Bristle worms are found in every ocean — from the deepest and coldest abyssal plains to the extremely high temperatures near hydrothermal vents to the shallowest tropical tide pools. Injuries typically result from accidental contact or deliberate handling. Such contact can result when the worm’s bristles, located along the sides of the animal, embed in the contact skin.

Symptoms usually last for several hours but may take several days to completely resolve.but may be used in an attempt to treat delayed reactions or persistent skin irritation.

Treating Sponge and Bristle Worm Envenomations

Signs and symptoms

- Sharp, stinging pain
- Localized redness, skin irritation
- Bleeding associated with cuts/scrapes
- Mild to severe itching
- Edema
- Burning and numbness
- Blisters

First aid

- Clean the affected area with soap and fresh water.
- Remove any foreign material.
  - Cellophane tape may aid in bristle removal.
- Leave blisters intact if present.
  - Keep the area clean, dry and aerated until the blisters dry out and eventually peel off.
- If eye contact occurs, flush with copious quantities of fresh water, and seek medical attention.
- Monitor for signs of infection.
- Steroid ointments may prove useful in reducing skin irritation.

Summary: Sponges and bristle worms

- Avoid contact (physical distance, neutral buoyancy, exposure protection)
- Thoroughly wash affected area with soap and fresh water
- Control any bleeding that may be present
- Monitor for infection

Review Questions

1. What are the four steps in first aid for jellyfish stings in the correct order?

a. inactivate, remove tentacles, wash area, treat symptoms

b. remove tentacles, wash area, treat symptoms, inactivate

c. treat symptoms, wash area, remove tentacles, inactivate
2. Pressure immobilization is recommended for which invertebrate marine-life injuries?

a. jellyfish stings

b. cone-snail barb punctures

c. blue-ringed octopus bites

d. b and c
3. First aid for contact injuries includes

a. controlling bleeding

b. washing area thoroughly

c. removing any foreign material

d. leaving blisters intact

e. all of the above

Review answers are on Page [251](#).

SKILL: Injury Management

Objectives:

- Demonstrate the proper technique in a scenario for managing
  - Spiny envenomations
  - Stinging envenomations
  - Contact injuries

Wound management should occur only after life-threatening conditions have been addressed. Cleaning wounds may promote healing and prevent infection.

Spiny envenomations (lionfish, stonefish, stingrays, sea stars, crown-of-thorns)

1. Wash area thoroughly with soap and fresh water.

2. Control bleeding if present.

3. Remove visible pieces of spine or other foreign material with tweezers or forceps.

4. Control pain.
  - Administer oral analgesics.
  - Immerse affected areas in hot water (45°C/113°F maximum) for 30-90 minutes. Do not burn the skin.

5. Apply topical antibiotic ointment/cream.

6. Bandage if necessary.

7. Seek evaluation by a medical professional (for tetanus vaccination or antibiotics).

8. Monitor for allergic reaction and/or infection.



Note:

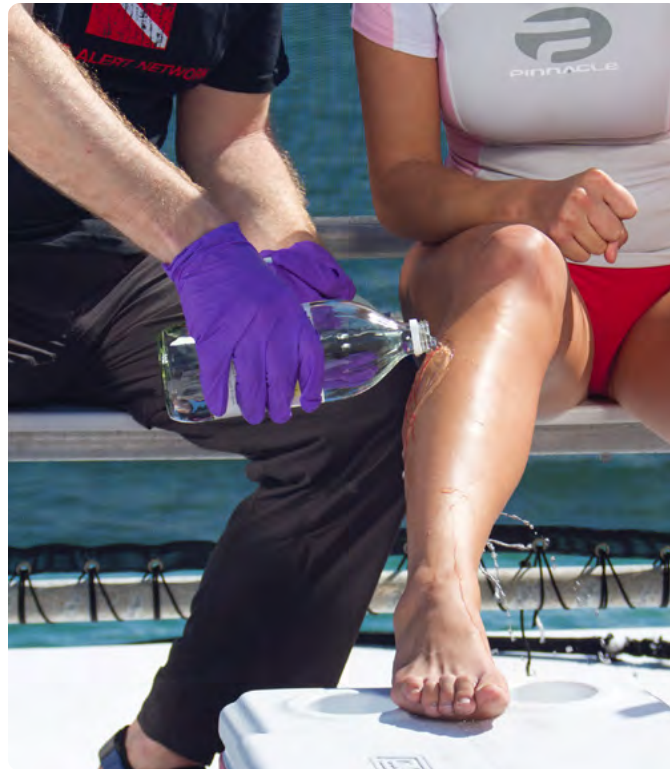
If a stingray spine is lodged in the injured person, it should be left in place (if possible) and secured from motion until the individual is brought to a medical facility.

Note:

Spines lodged deeply in soft tissues or in joints may require additional treatment by a health care professional.

### Stinging envenomations (jellyfish, corals, hydroids, anemones)

1. Irrigate with household vinegar or other mild acetic acid for 30 seconds. This neutralizes any unfired stinging cells still on the skin.
2. Remove the tentacles with forceps (tweezers) as necessary.
3. Irrigate with saline solution or seawater. Do not rub.
4. Control pain.
  - Oral analgesics (aspirin, Tylenol, Advil, etc.)
  - Immerse affected area in hot water (45°C/113°F maximum) for 30-90 minutes.
  - Anti-inflammatory agents (hydrocortisone)
  - Topical anesthetic agents (lidocaine)
  - Cold packs may also be effective.
5. Monitor for allergic reaction and/or infection.



### Contact injuries (sponges, corals, bristle worms)

1. Clean area with soap and fresh water.
2. Remove foreign material.
  - Cellophane tape maybe helpful to remove bristles.
  - Irrigate with syringe and catheter using clean water or saline solution to provide a steady stream of water that is forceful enough to dislodge debris and bacteria.
3. Remove any remaining visible debris with tweezers or forceps.
4. Control bleeding if present.
5. Leave blisters intact.
6. Apply steroid ointment if available.
7. Cover with sterile dressing and bandage.
8. If eye contact occurs, flush with fresh water.
9. Monitor for signs of allergic reaction or infection.



## SKILL: Injury Management

### Objectives:

- Demonstrate the proper technique for applying a pressure immobilization bandage.

### For wounds from sea snakes, cone snails and blue-ringed octopuses:

1. Thoroughly clean wound with soap and water.
2. Remove foreign material if present.
3. Place dressing or small pad over the bite or wound. Bandage in place.
4. Apply an elastic bandage firmly over the site starting at least 15 cm (6 inches) above the bite, and continue wrapping to at least 15 cm (6 inches) on the far side of the wound. (If there is insufficient space to wrap 15 cm (6 inches) above or below the bite, wrap as far as possible.)
5. Check for adequate circulation to the fingers or toes of the injured extremity.
6. Normal feeling, color and palpable pulse should be present.
7. Splint the extremity to limit movement.
8. Use a sling when the wound involves the upper extremity.
9. Do not delay transport to the nearest medical facility (for antivenom administration, tetanus vaccination, monitoring, IV hydration, respiratory support).
10. Do not remove bandage; let health care professionals do so.



### Note:

The pressure immobilization technique may delay absorption of venom from a bite or sting site into the general circulation. Marine animal injuries that may benefit from the use of the pressure immobilization technique include wounds from blue-ringed octopuses, sea snakes and cone snails.



# First Aid for Hazardous Marine Life Injuries

## Chapter 28: Traumatic Injuries

### Objectives

- 1. For what three reasons do marine animal bites occur?
- 2. How does the body respond to bleeding?
- 3. Why are marine animal bites of particular concern?
- 4. What is the primary method used to control most external bleeding?
- 5. When should a tourniquet be utilized?
- 6. How long should a tourniquet be left in place?
- 7. What are the signs and symptoms of infection?

Physical trauma denotes a wound or injury caused by some external force or agent. Trauma associated with marine life injuries results primarily from bites and scrapes, which manifest as punctures, lacerations, or abrasions. Most marine animal bites of humans result from the following circumstances:

- Animal feels threatened
- Humans mistakenly identified as prey
- Humans engaged in spearfishing or feeding

When bleeding occurs, the body has two mechanisms for limiting blood loss. The first is vasoconstriction (narrowing of blood vessels), which occurs in response to injury and helps to reduce blood loss. The second is platelet activation, which initiates blood clotting. For minor bleeding, this process works extremely well to stop blood loss with minimal support. When bleeding is more severe, direct pressure or additional interventions may be needed. First responders can aid the clotting process by applying direct pressure using an absorbent dressing.

### BITES

All bites are at high risk for infection and should receive prompt cleaning. Marine life known to bite humans include sharks, barracuda, moray eels and triggerfish. Marine mammals known to bite include seals, sea lions and otters. Injury severity depends on many factors, including bite location, size of the animal, extent of blood loss and treatment delays. First aid efforts should focus on bleeding control and reducing infection risk.

### Direct Pressure

- Direct pressure over a bleeding site is usually sufficient to control most bleeding. This is accomplished by using gloved hands or an absorbent pad or dressing. If the bleeding continues and seeps through the pad, add additional absorbent material on top of the original pad. Do not remove the original pad. Dressing removal may remove clotting blood and disrupt the clotting process. Continue to hold direct pressure until the bleeding stops.
- Secure the pad with a clean or sterile bandage. The bandage should be big enough to cover the pad, extending past the edge (1-2 inches if possible). Wrap the bandage from the distal side (farthest from the heart) of the wound site toward the heart.

### Note:

The direction of the bandage wrap is not critical to managing the injury. Wrapping the bandage from distal to proximal simply makes for a more secure bandage.

- The bandage should help maintain direct pressure but not prevent circulation. You can check circulation by squeezing the nail beds and looking for the pink color under the nails to return quickly after pressure is released. The normal pink color should return in 2-3 seconds. In cold conditions, color return may take slightly longer. If color does not return in a timely manner, loosen the bandage and rewrap.

### Hemostatic Dressings

A final option for controlling bleeding that is not responding to a tourniquet or is located in an area where a tourniquet cannot be used is a dressing impregnated with hemostatic agents. Impregnated dressings will often have a colored line (typically blue) through the length of the gauze for easy identification.

Remove any other dressing materials so the agents can have direct contact with the bleeding site. Cover the entire bleeding surface with the hemostatic dressing, and continue to apply direct pressure. Apply additional layers of hemostatic dressings if necessary. Hold dressings in place with a pressure bandage.

**Advise medical personnel that a hemostatic agent was used to assist with control of bleeding.** Retention of the dressing's packaging material may be helpful to emergency personnel. Hemostatic dressings should not be left in place more than 24 hours.

Wound Packing

In the case of penetrating wounds such as propeller injuries or knife wounds, bleeding is occurring inside the wound. Direct pressure on the external surface of the wound will not provide pressure at the source of the bleeding. For these wounds, dressing material should be packed into the wound and lateral pressure applied and maintained during the wound packing process. Hemostatic impregnated gauze, if available, is a good choice for this type of wound. If it is used, advise EMS personnel. It will require some modification in their care.

Tourniquets

If direct pressure fails to control massive bleeding, and the injury is on an arm or leg, the next step the next step may be to utilize a tourniquet. Tourniquets are a primary intervention when the bleeding is a massive bleed and is life-threatening.

A tourniquet is a wide band, at least 5 cm (2 inches), placed tightly enough around an arm or leg to stop blood flow. It must be applied with sufficient force to stop arterial bleeding, not just venous bleeding. Arteries are deeper in the body and therefore require forceful pressure to stop arterial flow. This is accomplished with the use of a windlass device (part of a commercial tourniquet or makeshift in an improvised tourniquet). Double check the effectiveness of a tourniquet by assessing distal pulses, which should not be present if the tourniquet is applied tightly enough. Some commercially available tourniquets do not use a windlass to tighten the tourniquet. These tourniquets utilize a ratchet mechanism that quickly applies pressure and is self-securing.

Note:  
Tourniquet placement may be determined by local regulations or protocols. Ask your DAN Instructor about the protocols in your area.

A tourniquet should be:

- Utilized only when direct pressure is not effective
- Well-padded (6-8 layers of a bandaging material)
- Placed 1-2 inches proximal to the wound or high on the limb when source of bleeding cannot be readily identified

A tourniquet should NOT be:

- Placed directly over knees, elbows or other joints. If there isn't room to place a tourniquet between a wound and a joint, place the tourniquet 1-2 inches proximal to the joint.
- Made of wire or rope. A narrow, excessively tight or insufficiently padded band may cause local damage to tissues in minutes.
- Utilized with injuries caused by venomous animals.

Applying a tourniquet

Before applying a tourniquet, inspect the wound to ensure pressure was being applied directly to the site of the bleeding. If not, attempt direct pressure once more.

Place a commercial tourniquet as noted above and secure it in place. Twist the windlass until bleeding stops, and secure it with the mechanism on the tourniquet.

Wrap an improvised tourniquet proximal to the wound, as noted above, several times, and secure it in place with an overhand knot. Place a stick or similar object on top of the knot, and tie a second overhand knot over it. Twist this "handle" just until the bleeding stops. Secure the handle in place by wrapping it with a second bandage.

Use a marker to write on the injured person's forehead "T" or "TK" (for "tourniquet") and the time the tourniquet was placed. This ensures subsequent caregivers are aware the tourniquet is there and how long it has been on. The tourniquet should not be removed until the injured person is under advanced medical care.

- Death of tissue below the tourniquet is possible after two or more hours. However, documentation exists of limb survival for extended periods after tourniquet placement.
- Tourniquets may cause pain in the extremity

First aid: Direct pressure

- Wash the wound thoroughly with soap and water (tap water is fine) as soon after the injury as possible.
- Apply dressing and direct pressure to wound.
  - Add additional dressings as necessary.
- Bandage the dressing(s) in place.
  - Extend the bandage 1-2 inches beyond the edge of the dressing, if possible.
- Check extremity circulation (capillary refill) to ensure bandage is not too tight.
- Seek medical evaluation. A tetanus booster may be required.
- Monitor for signs of infection.



### First aid: Hemostatic dressings

- Apply dressing directly to bleeding site, and apply direct pressure to the wound
  - Add additional dressings as necessary
- Bandage the dressing(s) in place
  - Extend the bandage 1-2 inches beyond the edge of the dressing, if possible
- Do not leave the dressing in place more than 24 hours
- Seek medical care
- Advise EMS or other medical personnel hemostatic impregnated gauze was used to control bleeding
  - Adjustments to their protocols will be necessary



### First aid: Wound Packing

- Pack dressing material to the depth of the wound
- Apply lateral outward pressure to the wound walls holding gauze in place on one side
  - while additional gauze is packed on the opposite side.
- Maintain lateral outward pressure on wound walls during the packing process.
- Hemostatic impregnated gauze, if available, is a good choice for this type of wound. If it is used, advise EMS personnel. It will require them to modify their care.



### First aid: Tourniquets

- Place the tourniquet 1-2 inches above (proximal to) the wound.
  - Improvised tourniquets require 6-8 layers of bandaging materials.
  - Tie an overhand knot.
  - Place a stick or similar object over the knot, and secure it with another overhand knot.
- Tighten the tourniquet until bleeding stops
  - For commercial tourniquets, twist the windlass and secure in clips
  - For improvised tourniquet, twist the rods or sticks and secure it in place with an additional bandage.
  - For ratchet-style tourniquets, pump the ratchet to apply pressure. It self-secures.
- Mark the injured person's forehead with a "T" and the time the tourniquet was placed.
- Leave the tourniquet in place until the injured person is under medical care.



## Special Circumstances

### Bandaging Joints

When applying bandages across joints, keep the limb in a comfortable position, and try to keep the joint immobilized to minimize further discomfort or bandage displacement.



Eyes

With eye injuries, it may be necessary to cover the injured eye to minimize pain and to provide comfort. To patch an eye, fold clean gauze over the closed eyelids, then place tape over the eyes with anchors at the forehead and cheek. Bandage both eyes in a manner that eliminate gaps at edges of bandage to prevent the injured eye from moving with the uninjured eye.



Wound Infections

The skin is our primary and most effective defense against infection. When this protective layer is breached, the introduction of bacteria, fungi, viruses and other organisms into tissue layers beneath the skin is enabled. The source of injury is important because organic material comes with higher risks of wound infections and delayed healing.

Thoroughly cleaning wounds with soap and fresh water soon after injury is a simple yet effective way to minimize infection risk. Delayed cleaning may enable microorganisms to replicate beneath the skin, resulting in infection. The presence of bacteria within a wound does not necessarily constitute infection; instead, this is often referred to as contamination.



When bacterial populations thrive and become large enough to interrupt healing or cause further tissue damage, then an infection has occurred.

Signs of infection appear within hours, days or even several weeks following injury. Inflammation is one of the cardinal signs of any infection, and the components typically present with an infection can be easily recalled using the acronym **P-R-I-S-H**.

Other signs of infection include the following:

- Pus and yellowish discharge
- Foul smell
- Swollen lymph nodes
- Fever
- Chills
- Nonhealing wounds

Marine-acquired wounds, particularly in people with compromised immune systems (who have diabetes, cancer or AIDS, for example) may require more aggressive treatment. If a marine-acquired wound is beyond your skills to manage or shows any signs of worsening, seek immediate medical attention.

P	Pain
R	Redness
I	Immobilization (loss of function)
S	Swelling
H	Heat

Advanced Concepts

Internal bleeding

Internal bleeding can be a life-threatening condition. It requires immediate medical attention from EMS or hospital personnel. It often results from blunt trauma, sudden deceleration injuries (such as a car collision), or certain bone fractures (e.g., femur or pelvis). The following may indicate internal bleeding:

- Rigid or swollen abdomen
- Vomiting or coughing blood
- Blood in urine
- Bloody or tarry stool
- Intense muscle pain
- Difficulty moving the related joints
- Fainting or dizziness
- Low blood pressure
- Signs of shock

To treat the injured person for internal bleeding:

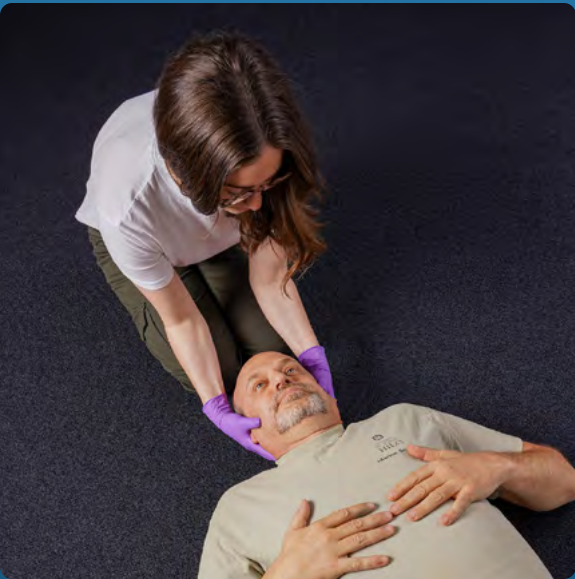
1. Open the airway if needed
2. Activate EMS (if not already activated)
3. Minimize movement of the injured person
4. Apply ice to the affected area (unless the internal bleeding is in the skull)
5. Evacuate to EMS as soon as possible



Advanced Concepts

Spinal Injury Management

If the injury mechanism is such that you suspect a spinal injury, your primary duty to the injured person is to deal with any immediate threats to their life. Perform CPR if necessary. If CPR is not necessary, your role is to keep the injured person calm and still. Activate EMS if you have not done so. If possible, kneel at the person's head and find a comfortable position to stay in for potentially a long time. Place your hands on both sides of the person's head to keep them immobile. Do not attempt to straighten or realign the head unless the airway is compromised. Be sure to talk to and reassure the person as you wait for EMS to arrive.



Advanced Concepts

Amputations

Sometimes a trauma involves the removal of a part of the body. Amputation injuries could range from a finger getting pinched in the hinge of a dive boat ladder to the severing of an entire limb. With an amputation, control bleeding as necessary using the techniques previously covered, including utilizing a tourniquet. Be ready to treat for shock or provide CPR if necessary.

If the amputation is incomplete and the skin, muscle or tendons are still attaching the body part, immobilize it using a splint and bulky gauze. Never detach an incomplete amputation.

If the amputation is complete, attempt to preserve the parts, no matter how damaged they appear to be. Wrap them in saline-moistened gauze, seal them in a plastic bag and place it in a container with ice. Do not place the amputated part directly on or in the ice. Ensure the amputated part is transported with the injured person.



Advanced Concepts

Open Chest Wound

Sometimes the injured person has a severe injury to their chest. Trauma to the chest can lead to a condition called pneumothorax, in which a leak in the lung causes air to collect. In diving this can be caused by rapid ascent or breath-holding during ascent. Another common cause of a pneumothorax is a blunt or penetrating wound to the chest; for example, slipping on the wet boat deck and hitting your ribs on the gunwale of the boat or accidental discharge of a spear gun. Sometimes this trauma generates a hole in the chest wall that allows air exchange between the chest cavity and the outside air. This kind of injury is called an open or a sucking chest wound.



If you have an open chest wound, tape an occlusive dressing around the injury by covering the hole with clear plastic (like a piece of clear plastic wrap or a sandwich bag) and taping the plastic on three sides. The incomplete seal allows exhaled air to escape, but the flap from the open fourth side will close to prevent external air from getting into the chest cavity. A transparent material is ideal so EMS can better see what is going on, but aluminum foil or a piece of a garbage bag will work if nothing else is available.

Similarly, an open neck wound can lead to the risk of a gas embolism in the brain. An occlusive dressing is appropriate in these conditions as well. A commercially-available product like HyFin® Vent Chest seals can work well in these circumstances.



## Bonus Content

**Moray eels** — Eels are generally passive marine creatures that often tolerate curious divers getting quite close but will defend their lairs against encroachment. Teasing or coaxing an eel from its home for a photo or to capture a lobster invites a bite. The teeth of an eel are angled backward to prevent the escape of their prey.

**Triggerfish** — Triggerfish have been called one of the most aggressive ocean fish, seeming to attack for no apparent reason. Due to their relatively small size, bites are usually more nuisance than threat.

**Octopus** — Injuries from octopus bites result from handling. The beak at the confluence of the arms results in a double V-shaped pattern with the “Vs” in opposite directions. Octopus bites are associated with pain and mild to moderate swelling.

**Stingrays** — Stingrays use the barb in their tail in defense of perceived threats. The puncture wounds and lacerations may result in bleeding and infection.

**Coral scrapes and cuts** — Surf and surge in shallow water or poor buoyancy control over reefs can result in scrapes and cuts of various degrees. Since bacteria and numerous tiny larvae live on these underwater formations, wound contamination should be assumed. Some infections resulting from coral-inflicted injuries can be quite serious. Taking precautionary steps to clean and debride a coral wound should be a priority once out of the marine environment.

1. Marine animals bite when
  - a. they feel threatened
  - b. humans are mistaken for food
  - c. humans engage in spearfishing or feeding
  - d. all of the above
2. Infection is of particular concern with marine animal bites.
  - a. True
  - b. False
3. Which of the following is the first course of action to control external bleeding?
  - a. direct pressure
  - b. tourniquets
  - c. hemostatic dressings
4. A tourniquet should be placed
  - a. if the wound exhibits massive arterial bleeding
  - b. if bleeding is not stopped by direct pressure over the wound
  - c. 1-2 inches above the wound
  - d. all of the above
5. A tourniquet should be removed after two hours regardless of continued bleeding.
  - a. True
  - b. False
6. Signs and symptoms of infection are
  - a. pus, redness, infection, sweating, hyperthermia
  - b. prickly feeling, rash, increased thirst, sweating, heat
  - c. pain, redness, loss of function, swelling, heat
7. Internal bleeding is a life-threatening condition that requires immediate medical attention.
  - a. True
  - b. False
8. If you suspect a spinal injury you should:
  - a. perform CPR if necessary, keep the injured person still, activate EMS, and stabilize the head
  - b. attempt to realign the neck to prevent paralysis
  - c. do nothing
  - d. Only realign the head if the airway is compromised
  - e. a and d
  - f. all of the above
9. For an open chest wound, the best treatment is:
  - a. pack the wound
  - b. use external dressing only
  - c. apply an occlusive dressing
  - d. do nothing
10. If an amputation is incomplete, you should cut the injured part away and store it in a cooler of ice.
  - a. True
  - b. False

Review answers are on Page [251](#).



Objectives:

- Demonstrate applying direct pressure to control bleeding on a simulated injured person.
- Demonstrate wound-packing technique, maintaining outward pressure on the lateral walls of the wound.
- Demonstrate bandaging to secure a dressing in place once bleeding has stopped on a simulated injured person.

To control bleeding:

- If possible, wash the area with soap and water as soon as possible.
- Cover the wound completely with a sterile or clean dressing, and apply pressure until the bleeding stops. Use additional layers of dressing if the dressing becomes soaked. Do not remove any layers of dressing materials because it may disrupt the clotting mechanism of the body.
- Pack dressing material to the depth of the wound.
- Apply lateral outward pressure to the wound walls, holding gauze in place on one side while additional gauze is being packed on the opposite side.
- Maintain lateral pressure on wound walls during the packing process.
- Once bleeding has stopped, use a conforming bandage, roller gauze or tape to secure the dressing, and make sure there aren't any loose edges.
- Remove all jewelry or constricting clothing on the injured appendage.
- Be careful not to interfere with circulation.
  - Check capillary refill on appendage nail beds to ensure adequate circulation.
  - Ask the injured person if any tingling or numbness is present.
  - Adjust bandage if necessary to ensure circulation.
- Monitor the pulse and motor function distal to the bandage before and after bandage application.
  - Continue to monitor for signs of infection.



Note:

- Bandage small wounds several inches on either side to ensure coverage and even pressure distribution.
- To bandage across a joint, maintain the area in a comfortable position, but try to keep the joint immobilized to minimize further discomfort or bandage displacement.

SKILL: Applying a Tourniquet

Objectives:

- Demonstrate applying a tourniquet to control bleeding on a simulated injured person.

To apply a tourniquet:

- Inspect the wound to ensure direct pressure was being applied directly to the site of the bleeding. If not, attempt direct pressure once more.
- Place the tourniquet 2.5-5 cm (1-2 inches) proximal to the wound.
- Secure the tourniquet
- Turn the windlass device to stop bleeding. Verify absence of pulse in the distal portion of the extremity.
- Secure the windlass.
- Simulate noting on the injured person's forehead use of a tourniquet and time of placement.
- In an actual injury, leave a tourniquet in place until the person is under medical care.



Critical Note:

When applying a tourniquet as part of skill practice for course requirements, the tourniquet does not need to be tightened to the point of distal pulse absence. For safety and to prevent localized injury, do not tighten a tourniquet during practice beyond the point your practice partner starts to feel changes in sensation.



# First Aid for Hazardous Marine Life Injuries

## Chapter 29: Seafood Poisonings

### Objectives

- 1. What is the primary cause of seafood poisoning?
- 2. What kinds of contaminants trigger seafood poisoning?
- 3. What are the three well-established types of seafood poisoning?
- 4. How can the risk of seafood poisoning be minimized?

Most human gastrointestinal complications that occur as a result of eating seafood are largely due to improper storage of caught fish. Poorly preserved seafood commonly alerts us of spoilage with a “fishy” odor resulting from the breakdown of certain fatty acids. Odor alone, however, does not determine whether food is safe to eat and is not associated with a particular toxicity.

Several marine species, primarily in the tropics, store specific toxins in their skin, muscles, viscera and/or gonads. Seafood poisoning occurs when ingested food or water is contaminated with certain types of bacteria, parasites, viruses or toxins.

### Advanced Concepts

The technical term for food poisonings resulting from ingestion of fish is ichthyosarcotoxism (pronounced ik'thé-ó-sar-kó-tók'sizm), meaning “poisoning from eating fish meat” (Greek ichthys = fish and sarx = meat or muscle). Though the term includes the Greek for “flesh” or “muscle,” it should be noted that this is a general term that includes but does not discriminate among poisonings resulting from ingestion of muscle tissue, viscera, skin or other organs and/or secretions. Paralytic shellfish poisoning (PSP) and other seafood poisonings resulting from ingestion of any seafood other than fish are therefore, by definition, not an ichthyosarcotoxism.

The four primary foodborne syndromes covered here are<sup>24</sup>

- Ciguatera
- Tetrodotoxin poisoning (or tetrodotoxism)
- Scombroid fish poisoning (also known as histaminoid syndrome)
- Paralytic Shellfish Poisoning (PSP)

Since there are few, if any, first aid procedures for these conditions, the emphasis is on prevention.

### CIGUATERA

Ciguatera can be a serious but rarely fatal self-limited disease that primarily affects the gastro-intestinal and neurological systems (and sometimes the heart) and is caused by ingestion of various species of tropical reef fish.

#### Cause

Certain dinoflagellates (planktonic protozoans) are thought to be responsible for producing ciguatoxins. These microscopic organisms live on algae and dead coral surfaces and are eaten by small reef fish. Their toxins are then transmitted from fish to fish through the food chain in a process of bioaccumulation. The process of ciguatoxin bioaccumulation starts when small marine herbivores feed on macroalgae on which dinoflagellates live. As small herbivores are eaten by larger predators, and these are then eaten by even larger predators, the toxin accumulates in the tissues of top predators such as barracudas, groupers and moray eels. Human poisoning occurs when any of the fish involved in this chain are consumed but particularly when the fish consumed is a large reef predator.

Toxicity depends on exposure and dose, with more severe cases occurring in people who have suffered previous exposure. Onset usually occurs within two to six hours after ingestion but may present as soon as 15 minutes later or as late as 24 hours later.

#### Common gastrointestinal signs and symptoms

- Abdominal pain and gastroenteritis
- Nausea, vomiting
- Diarrhea

These initial symptoms typically resolve without intervention within a few hours.

#### Common neurological signs and symptoms

- Numbness and tingling
- Lack of muscle coordination (ataxia)
- Vertigo

Symptoms may include skin itching, which can persist for weeks and worsen with activities such as exercise and alcohol consumption that increase skin temperature.

Musculoskeletal symptoms

- Joint pains
- Muscle pains and weakness

Decompression sickness should be considered as a differential diagnosis in people with a recent history of scuba diving.

Other signs and symptoms

One of the most well-known symptoms is the person’s inability to distinguish between hot and cold temperatures. This is known as temperature reversal.

More than 175 symptomatic manifestations have been described for ciguatera, which can make diagnosis difficult. Some 80 percent of injured people show varying degrees of neurological impairment in addition to gastroenteritis.

Fish species commonly associated with ciguatera

- Barracuda
- Snapper
- Moray eels
- Amberjacks
- Grouper
- Parrotfish
- Triggerfish

Ciguatera toxins rarely contaminate pelagic fish such as tuna, marlins, dolphin fish or other ray-finned fish. While the entirety of an affected fish will contain toxins, the highest concentrations are typically found in the liver, intestines and gonads. Ciguatoxin can be found throughout the world in the tropical reef belt between 35°N and 35°S latitude.

Note:

Affected meat does not have a characteristic appearance, smell or strange taste. Ciguatoxins are also heat stable, which means they are not affected by freezing, cooking or drying and are impervious to gastric (digestive) juices.

Advanced Concepts

Levels as low as 0.1 ppb (parts per billion; one drop in every billion drops of water) in consumed flesh can result in clinical poisoning. These low levels pose a major obstacle for the development of a simple detection method.

First aid

- Treatment is aimed at symptom control.
- Rehydrate if necessary.
- Support compromised heart or pulmonary function.

If ciguatera is suspected, seek medical evaluation. There is no effective treatment or specific antidote for ciguatera poisoning. The best course of action is prevention through education and avoidance of seafood in endemic or suspected areas.

Summary: Ciguatera

- Ciguatera is caused by a neurotoxin produced by microscopic organisms that contaminate reef fish.
- The bigger the fish, the more toxic the meat may be. Predators (such as barracudas, eels, groupers, etc.) contain more toxins due to bioaccumulation.
- Symptoms are primarily neurological (could mimic DCS) but rarely fatal.
- Affected fish appear, smell and taste normal (no fishy odor).
- Cooking does not alter toxin potency.
- Avoid eating large reef predators.
- Treatment focuses on symptom management.

## Bonus Content

The name ciguatera refers to a disease with some similar symptoms caused by a sea snail (known locally as a cigua) in the Spanish Antilles.

Historical perspective: There are reports from the times of Alexander the Great about prohibitions against feeding fish to soldiers to avoid ciguatera. Reports during the T'ang dynasty (618-907 AD) in China also indicate an awareness of this syndrome. The first known written report was in 1789 by Capt. William Bligh. He describes symptoms consistent with ciguatera after eating mahimahi, although this is an uncommon source. Capt. James Cook in 1774 on his expedition to the South Pacific aboard the Resolution described the poisoning in many of his crew members after eating fish from the islands near Vanuatu in the South Pacific.

Gambierdiscus toxicus is named after the location where it was discovered, the Gambier Islands in French Polynesia, a place where virtually all reef fish contained the toxin. Later research showed that other dinoflagellates could also play a contributing role in ciguatera, but G. toxicus appears to be the most toxic.

Four types of ciguatoxin have been identified. Ciguatoxins seem to lower the threshold for opening voltage-gated sodium channels in synapses in the nervous system, which results in depolarization of excitable cells. Ciguatoxin has also demonstrated anticholinesterase activity. Of note, the toxin remains unaltered within bodily fluids, and its toxicity can be transmitted both by vertical transmission (mother to baby) as well as through breast milk and semen. Because it does not cross the blood brain barrier (BBB), ciguatoxins affect only the peripheral nervous system, not the central nervous system.

## TETRODOTOXIN POISONING (OR TETRODOTOXISM)

Tetrodotoxin (TTX) is a strong neuromuscular blocking agent (blocks the transmission of impulses from nerves to muscles) that produces one of the most serious forms of poisoning. TTX is water soluble and heat stable, which means it is not broken down by the application of heat or by cooking.

Poisoning results from consumption of certain fish and invertebrates, most notably pufferfish, porcupinefish, ocean sunfish and triggerfish. Of note, TTX is not confined to marine environments. Poison dart frogs and some newts and worms may also contain this deadly substance.

TTX is usually found in the liver, intestines, gonads and skin of these animals; fatalities have been reported in as little as 15 minutes following ingestion.

Symptom onset ranges between 30 minutes to a few hours following ingestion.

### Initial symptoms

- Numbness of the lips and tongue
- A sense of lightness or floating
- Moderate gastrointestinal symptoms
  - Upper abdominal pain
  - Nausea
  - Vomiting
  - Diarrhea

### Second-stage symptoms

- Increasing paralysis
  - May initially manifest as difficulty walking

Final-stage symptoms

- Complete muscular paralysis (to include smooth visceral muscle)
  - Survivors describe having full consciousness but with the complete inability to move and the absence of all neurological reflexes — a description that matches stories told about Haitian zombies.

### First aid

- Management (both field and definitive medical) is symptomatic and supportive.
  - Symptoms can progress quickly; therefore activate EMS immediately upon symptom presentation.
- Mechanical ventilation may be necessary due to the injured person's inability to breathe on their own.

The goal is prevention through education. Avoid eating these species, and seek medical evaluation if TTX poisoning is suspected.

### Summary: TTX poisoning

- TTX poisoning is caused by a neurotoxin produced by certain fish and invertebrates (e.g., pufferfish, triggerfish, mola mola, Japanese fugu) from the order Tetradontiformes.
- It causes systemic paralysis, which can lead to death.
- Cooking does not alter toxin potency.
- Avoid eating these fish in any form or preparation.

Symptoms of TTX poisoning can progress rapidly, so activate EMS as soon as symptoms present.

### Bonus Content

Tetrodotoxin ingestion has a unique place within certain cultures.

In Japan, fugu is considered a delicacy and can be found in strictly controlled restaurants where specially trained and licensed chefs carefully prepare the fish for consumption. Those who enjoy this cuisine consider the expert chefs artists when they prepare this sashimi in a way that leaves just enough toxin to cause slight tingling sensations in the mouth. Drinking a mixture of fugu gonads with sake is a longstanding right-of-passage or sign of manhood for some. This practice is considered dangerous, as it is impossible to know the degree of toxicity or the possibility of a serious intoxication without a thorough analysis. Even under strict state control and strict licensure requirements, fugu is the leading cause of death from food poisoning in Japan.

TTX has been implicated as the possible causative agent of the Haitian voodoo “zombie potions,” as it is said it can cause a state of suspended animation.

### SCOMBROID FISH POISONING (OR HISTAMINOID SYNDROME)

Scombroid is caused by ingestion of fish containing high levels of histamine. Often confused with seafood allergy, the source of the “allergy chemical” histamine comes from the fish itself rather than from the person.

Histamine release within the fish is associated with inadequate refrigeration immediately following capture. Sun exposure or poor refrigeration enables bacterial invasion from intestinal bacteria. Once these bacteria invade the fish’s flesh, they convert histidine (an amino-acid precursor harmless in our digestive systems) into histamine — the chemical responsible for allergic signs and symptoms.

Potential sources belong to the family Scombroidae, which includes tuna, bonito, mackerel, mahi-mahi, and others such as anchovies, sardines and herrings. Scombroid poisoning accounts for 5 percent of food poisoning reported to the U.S. Centers for Disease Control and Prevention (CDC).

#### Note:

A key contributing factor to the prevalence of this condition is the absence of an associated flavor or taste. Some report a slight metallic or peppery taste, but otherwise the fish look, smell and taste normal.

Manifestations of scombroid are usually self-limited and resolve in about eight to 12 hours. Significant discomfort and serious manifestations are possible.

#### Symptom onset

- Rapid; commonly seen 10 to 30 minutes after ingestion

#### Symptoms

- Flushing
  - Manifests in the face, neck and upper chest
- Itchiness
- Eye irritation

#### Severe symptoms in rare cases

- Headaches
- Chills
- Vomiting
- Diarrhea
- Abdominal cramps
- Bronchospasm
- Hypotension

#### First aid

- Symptomatic treatment
  - Antihistamines such as diphenhydramine (e.g., Benadryl) and other medications in this class are commonly used for symptom control.
  - In cases of severe bronchospasm or hypotension, epinephrine may be indicated but is rarely required.
- Since histamine is not being released as a result of an allergic reaction, corticosteroids are ineffective.

#### Summary: Scombroid fish poisoning

- It is caused by eating species of scombroids (tuna, mackerel, mahi-mahi, jacks) that have not been properly refrigerated after being caught.
- Bacteria break down a component of the meat that releases histamine. Ingestion of large quantities of histamine-contaminated meat triggers an allergiclike reaction.
- It can be easily confused with and misdiagnosed as seafood allergy.
- Fish appearance, smell and taste are normal, perhaps with a slight peppery or metallic taste, but not unpleasant or foul.
- Cooking does not alter histamine and will therefore not prevent symptom occurrence.
- Avoid eating fish if you are unsure it was properly stored immediately after being caught. Storage temperatures should always be kept below 40°F (4.4°C) immediately after being caught and until preparation.

**Note:**

- Each of the seafood poisonings described have two consistent features:
- 1. They are NOT affected by cooking or method of food preparation.
  - 2. Seafood containing these toxins tastes, smells and looks normal.

**Prevention**

The disease is entirely preventable by immediately storing fresh fish in coolers or ice containers and away from direct sunlight. The CDC recommends temperatures below 4.4°C (40°F) at all points during the fish supply chain.

Paralytic Shellfish Poisoning (PSP), is a life-threatening condition that is associated with the consumption of seafood products contaminated with neurotoxins known as saxitoxins. Symptoms are purely neurological, and the onset is rapid, anywhere from 10 minutes to two to three hours. Duration of effects is generally a few days in non-lethal cases. Symptoms include tingling, numbness, and burning of the tissues around the mouth, ataxia (loss of control of body movements), giddiness, drowsiness, fever, rash, and staggering. Other symptoms can include abdominal pain, nausea, vomiting and diarrhea. The most severe cases result in respiratory arrest within 24 hours of consumption of the toxic shellfish. If the patient is not breathing or if a pulse is not detected, full CPR will be needed as first aid. There is no antidote. Supportive therapy under the direction of a physician is needed and survivors usually recover fully. PSP is prevented by large-scale proactive monitoring programs (assessing toxin levels in mussels, oysters, scallops, clams) and rapid closures of harvest in suspect or demonstrated toxic areas.

**Review Questions**

1. Contaminated seafood may taste and smell normal.

a. True

b. False
2. Seafood poisoning is triggered by

a. bacteria

b. parasites

c. viruses

d. toxins

e. all of the above
3. Seafood poisonings include:

a. ciguatera

b. scombroid

c. tetrodotoxin

d. all of the above
4. The most effective way to prevent seafood poisoning is to

a. only eat fish you have caught and cleaned yourself

b. store fish properly

c. cook fish thoroughly

d. eat fish that has a slightly fishy smell

Review answers are on Page [251](#).



**First Aid for Hazardous Marine Life Injuries**

**Chapter 30: Life Threatening Complications: Shock**

**Objectives**

- 1. What are the signs and symptoms of an allergic reaction?
- 2. What steps should be taken if an allergic reaction occurs?
- 3. What are the signs and symptoms of cardiogenic shock?
- 4. What steps should be taken if cardiogenic shock occurs?
- 5. What are the signs and symptoms of hypovolemic shock?

Shock is a life-threatening condition. Frequently this is because of a lack of blood perfusion to the body’s tissues. There are many types of shock, some of which are described in this chapter. There are many different triggers of shock, including allergies, cardiac conditions, and profuse bleeding. Regardless of the trigger, treatment is straightforward: management of the trigger and monitoring the person’s thermal state and food/liquid intake.

**ANAPHYLACTIC SHOCK**

Anaphylactic shock is a severe allergic reaction that may occur subsequent to envenomations. Life-threatening manifestations involve airway narrowing, which requires rapid activation of emergency medical services. As a first responder, you can help by supporting an open airway and by assisting the person with administration of allergy medications.

Most allergic reactions are fortunately less severe and are characterized by local skin reactions. Once you’ve ensured the person is breathing normally, thoroughly clean and rinse the affected area. In some cases allergy medications may be useful, but this requires familiarization or medical guidance.

Signs and symptoms (mild/moderate)

- Generalized itching (pruritis)
- Localized redness, swelling, raised rash that may change with time (urticaria/hives)
- Bloodshot, puffy eyes
- Facial swelling (eyes, lips)
- Localized or diffuse swelling (edema)

Signs and symptoms (severe)

- Airway narrowing
- Respiratory distress
- Cardiac arrest

**First aid**

- Anaphylactic shock is a medical emergency. Call **10177** or your local emergency medical services number immediately. Do not call DAN first.
- Assist the injured person with administration of allergy medications if prescribed for them personally. First-line medications include antihistamines. If airway narrowing or difficulty breathing is present, consider use of an epinephrine auto-injector if one is prescribed for the injured person.
- Monitor airway and breathing.
- Avoid giving the person anything by mouth.

CARDIOGENIC SHOCK

Cardiogenic shock refers to a reduction in the heart’s ability to circulate blood to the brain and vital organs. Causes include heart attack (myocardial infarction), unstable arrhythmias and envenomations, especially from box jellyfish. (Note: Stonefish venom may also have vasoactive effects that cause hypotension and may result in decreased blood flow to the brain and other vital organs.)

Signs and symptoms

- |   |   |
|---|---|
| <ul style="list-style-type: none"><li>• Hypotension (low blood pressure)</li><li>• Pale, cool, clammy skin</li><li>• Cold hands and feet</li><li>• Severe shortness of breath</li><li>• Weak pulse</li><li>• Chest pain (can radiate to the arms, shoulder, neck or back)</li></ul> | <ul style="list-style-type: none"><li>• Altered mental status</li><li>• Reduced urinary output</li><li>• Nausea and vomiting</li><li>• Unconsciousness</li><li>• Cardiac arrest</li></ul> |
|---|---|

**First aid**

- Cardiogenic shock is a medical emergency. Call **10177** or your local emergency medical services number immediately. Do not call DAN first.
- Have the person lie down on their back or in a position of comfort. Take necessary steps to maintain a normal body temperature.
- Check for signs of circulation; if absent, begin CPR.
- Keep the person warm and comfortable.
- Avoid giving the person anything by mouth.

HYPOVOLEMIC SHOCK

Hypovolemic shock results from a sudden decrease in circulating blood volume that causes a deficiency of blood supply to vital organs. Blood loss may be a result of internal or external bleeding. In the context of hazardous marine life injuries, the most likely cause is large animal bites (sharks, seals, eels), but acute blood loss can also occur due to nontraumatic events such as intestinal disease.

To control external bleeding, use universal precautions, and apply direct pressure. Universal precautions include barrier devices such as nonlatex medical gloves plus protective eyewear or a surgical-style mask if blood is being splattered.

Signs and symptoms

- |   |  |
|---|--|
| <ul style="list-style-type: none"><li>• Anxiety or agitation</li><li>• Pale, cool, clammy skin</li><li>• Confusion</li><li>• Generalized weakness</li></ul> | <ul style="list-style-type: none"><li>• Rapid breathing</li><li>• Decreased urine output</li><li>• Unconsciousness</li></ul> |
|---|--|

**First aid**

- Hypovolemic shock is a medical emergency. Call **10177** or your local emergency medical services number immediately. Do not call DAN first.
- Attempt to stop all external bleeding by applying direct pressure.
- Have the person lie down on their back or in a position of comfort. Take necessary steps to maintain a normal body temperature.
- Check for signs of circulation; if absent, begin CPR.
- Keep the person warm and comfortable.
- Avoid giving the person anything by mouth.



1. The signs and symptoms of allergic reaction include
  - a. itching
  - b. localized redness with swelling (hives)
  - c. swelling that affects the eyes, lips and possibly the airway
  - d. all of the above
2. In the event of an allergic reaction, the rescuer should
  - a. assist the injured person with any medications prescribed for them
  - b. monitor airway and breathing
  - c. immediately begin CPR
  - d. a and b only
3. Cardiogenic shock refers to
  - a. a decrease in blood volume
  - b. the heart's inability to circulate blood
  - c. an allergic reaction
  - d. all of the above
  - e. none of the above
4. The primary course of action for cardiogenic shock is to immediately call EMS and
  - a. be prepared to begin CPR
  - b. provide fluids to restore blood volume
  - c. both a and b
  - d. neither a nor b
5. Hypovolemic shock results in
  - a. cool, clammy skin
  - b. confusion
  - c. weakness
  - d. all of the above
6. Respond to hypovolemic shock by
  - a. contacting EMS
  - b. controlling any external bleeding
  - c. providing fluids to replenish blood volume
  - d. all of the above
  - e. a and b only

Review answers are on Page [251](#).



**Objectives:**

- Demonstrate the proper technique for assisting with an epinephrine auto-injector in a scenario.
1. Ensure airway and breathing.
  2. Assist in the delivery of allergy medications carried by the injured diver, such as antihistamines or an epinephrine auto-injector (e.g., EpiPen or Twinject). Administer such medication only if it is prescribed for the individual having the reaction.
  3. Activate EMS.



**Objectives:**

- Demonstrate the proper technique for managing shock by placing the victim on their back or in a position of comfort and taking steps to maintain normal body temperature in a scenario.
1. Assess scene safety.
  2. Support the airway and breathing if indicated.
  3. Activate EMS.
  4. Control external bleeding if present.
  5. Provide comfort and reassurance.
  6. Place the individual on their back or in a position of comfort.
    - Consider elevating the legs 6-12 inches if no neck, spine or pelvic injuries are suspected.
  7. Protect the person from cold or heat, and maintain normal body temperature.
  8. Monitor the level of responsiveness.



**Note:**

- Use extreme caution if providing fluids to someone in suspected shock. If in doubt, refrain from providing oral fluids, and activate EMS.
- Do not force a person (especially with a heart or breathing problem) to lie down. Place them in the most comfortable (sitting) position.
- Do not elevate the legs if it will make another injury worse.



**First Aid for Hazardous Marine Life Injuries**

Chapter 31: Avoiding Hazardous Marine Life Injuries

**Objectives**

1. What are the likely causes of injuries by marine life?
2. What dive practices can reduce the risk of injuries by marine life?

While hazardous marine life injuries can be life-threatening, most occur accidentally. Divers with poor buoyancy control or those swimming in rough water may accidentally grab fire coral or land on a stonefish. Both of these situations are avoidable through skill development and situational awareness.

If an animal acts aggressively, it is likely a defensive reaction to a perceived threat. Examples include putting your hand into a lobster hole only to find that it is also home to a moray eel or stepping on a stingray while putting on your fins in shallow water.

The best way to avoid hazardous marine life injuries during scuba diving activities is to practice perfect buoyancy control. This helps you avoid the sea bottom and accidental contact with coral and other animals.

In addition, follow these tips to reduce your risk of hazardous marine life injuries:

- Plan your dive, and know what hazardous marine life might be present.
- Pack a first aid kit. Be sure that the components have not expired.
- Wear appropriate exposure protection, including a hood, gloves and boots. While gloves protect you from potential injury, they may also increase the likelihood of touching the reef — as a result, some dive operators ban their use. Gloves should be worn, however, when wreck diving, diving in strong currents or when needed for thermal protection.
- Shuffle your feet, and wear thick-soled boots when entering water with a sandy or muddy bottom.
- Streamline your body and equipment to avoid fatigue.

- Improve awareness of your surroundings. Develop a sense of where you are in the water column. If you're busy looking at marine life or taking pictures, be sure to note your position and proximity to marine life.
- When taking pictures underwater, avoid using the reef for stabilization.
- Be passive in your interactions with marine life. Avoid feeding and petting animals, because this may lead to accidental injury.
- Avoid picking up shells. Some hazardous marine animals may live inside them and may defend their territory.
- Avoid carrying speared fish when diving in areas populated by sharks and other predatory marine life.
- Look up and around as you slowly ascend. Keep a careful watch if you're in jellyfishinhabited areas. Avoid holding onto the ascent/descent line without gloves; jellyfish and other stinging organisms may live on or get caught on the line.
- Avoid fish that are known to be potentially poisonous.

The hard truth is that the most hazardous marine life you are likely to encounter is yourself or your buddy. Far more injuries and fatalities occur to divers because of a lack of training, skills or experience than because of interactions with marine life.

## Review Questions

1. Marine life injuries can occur as a result of
  - a. accidental touching
  - b. poor situational awareness
  - c. perceived threats to the marine life
  - d. all of the above

2. Dive practices that can help minimize the risk of marine life injuries include
  - a. buoyancy control and streamlining yourself
  - b. use of exposure protection
  - c. not touching marine life
  - d. poor situational awareness
  - e. carrying speared fish
  - f. answers a, b and c

Review answers are on Page [251](#).

## Summary

Throughout this program the material has addressed factors that can contribute to dive accidents. We have covered and emphasized preventive measures. Practice these measures, and encourage others to embrace safe diving habits.

Dive accidents are rare; when they do occur, simple first-aid procedures are usually all that is required. Prompt action, however, is always important. Remember to protect yourself and other rescuers by completing a scene safety assessment and using protective barriers before rendering aid.

The priorities of care including personal protective equipment, should be constantly considered during an emergency. Lifethreatening conditions can emerge suddenly, even when the initial condition is mild. Absence of circulation and breathing, an obstructed airway, severe external bleeding and shock all require immediate interventions.

Remember, in the event of a dive accident requiring urgent care, activate emergency medical services in the area, administer oxygen, and call the DAN Emergency Hotline at **+27828106010**.

Keep in mind that even non-life-threatening injuries warrant monitoring, whether at the scene or after the return home. Watch for changes in the injured person's condition on site. Infections and other slower-developing signs and symptoms take time to show up and may not present until the diver has left the dive site.

Keep yourself prepared by practicing the skills learned in this course. Review signs and symptoms presented in the preceding chapters. Keep up to date on bloodborne pathogens training and any other training your organization may require. Check expiration dates on first aid supplies, and immediately replace any items used.

Finally, refresh your skills, and keep your certification current by participating in a recertification course at least every two years.



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- 1. B
- 2. E
- 3. A
- 4. C

Chapter 3.1, Page [19](#)

- 1. A
- 2. D
- 3. C
- 4. D
- 5. A

Chapter 3.2, Page [21](#)

- 1. A
- 2. D

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- 1. A
- 2. C
- 3. D

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- 1. A
- 2. C
- 3. B
- 4. B
- 5. A
- 6. D
- 7. B

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- 1. C
- 2. A
- 3. C
- 4. B
- 5. D
- 6. D
- 7. D
- 8. A
- 9. A
- 10. A

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- 1. D
- 2. E
- 3. D
- 4. C
- 5. A
- 6. A

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- 1. D
- 2. E
- 3. C
- 4. B

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- 1. A
- 2. E

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- 1. D
- 2. D
- 3. A
- 4. D
- 5. A

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- 1. E
- 2. A
- 3. B
- 4. B
- 5. A
- 6. A
- 7. A

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- 1. A
- 2. B

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- 1. A
- 2. A

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- 1. B
- 2. D
- 3. C
- 4. A
- 5. D

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- 1. A
- 2. E
- 3. E
- 4. A
- 5. D
- 6. B
- 7. D
- 8. B
- 9. A

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- 1. A
- 2. E
- 3. D
- 4. D
- 5. B
- 6. D
- 7. B

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- 1. E
- 2. A
- 3. A
- 4. A
- 5. A
- 6. B
- 7. A
- 8. A
- 9. B
- 10. A

Chapter 17, Page [118](#)

- 1. C
- 2. B
- 3. A
- 4. A
- 5. B
- 6. A
- 7. D
- 8. E

Chapter 18, Page [123](#)

- 1. B
- 2. B
- 3. A
- 4. C

Chapter 19, Page [134](#)

- 1. B
- 2. A
- 3. C
- 4. B
- 5. A
- 6. C
- 7. D
- 8. D

Chapter 20, Page [143](#)

- 1. B
- 2. B
- 3. B
- 4. B
- 5. A
- 6. A
- 7. B

Chapter 21, Page [148](#)

- 1. B
- 2. B
- 3. A
- 4. C
- 5. B
- 6. C

- 7. A
- 8. B
- 9. A
- 10. A
- 11. A

Chapter 22, Page [161](#)

- 1. D
- 2. E
- 3. B
- 4. D
- 5. B
- 6. A
- 7. E
- 8. B
- 9. B
- 10. D

Chapter 23, Page [168](#)

- 1. A
- 2. E
- 3. A

Chapter 24, Page [175](#)

- 1. D
- 2. A
- 3. E
- 4. D
- 5. C

Chapter 25, Page [182](#)

- 1. B
- 2. A
- 3. A

Chapter 26, Page [186](#)

- 1. A
- 2. A
- 3. B
- 4. A
- 5. D

Chapter 27.1, Page [195](#)

- 1. E
- 2. C
- 3. A
- 4. E
- 5. C

Chapter 27.2, Page [214](#)

- 1. A
- 2. D
- 3. E

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- 1. D
- 2. A
- 3. A
- 4. D
- 5. B
- 6. C
- 7. A
- 8. E
- 9. C
- 10. B

Chapter 29, Page [240](#)

- 1. A
- 2. E
- 3. D
- 4. B

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- 1. D
- 2. D
- 3. B
- 4. A
- 5. D
- 6. E

Chapter 31, Page [248](#)

- 1. D
- 2. F



DAN Oxygen Units

DAN Oxygen Units were specially designed with divers in mind. Each unit is capable of delivering high concentrations of inspired oxygen to injured divers.

Rescue Pak

The Rescue Pak is an affordable and compact oxygen system, ideal for areas where emergency medical services exist nearby or the distance to the nearest medical facility is short. It includes the following:

- Brass multifunction regulator
- Demand valve with hose
- M9 oxygen cylinder (248 liters)
- Nonrebreather mask with 6-foot tubing
- Oronasal resuscitation mask
- Pelican® 1450 waterproof case
- Optional MTV-100 with hose



Rescue Pak Extended Care

The Rescue Pak Extended Care, a popular choice among divers, is a self-contained kit that has all the necessary equipment to provide first aid for both breathing and nonbreathing injured divers. It includes the following:

- Brass multifunction regulator
- Demand valve with hose
- Jumbo-D oxygen cylinder (636 liters)
- Nonrebreather mask with 6-foot tubing
- Oronasal resuscitation mask
- Pelican® 1600 waterproof case
- Optional MTV-100 with hose



Dual Rescue Pak Extended Care

DAN’s dual-cylinder unit is ideal for offshore diving or for divers who desire a greater oxygen supply. It includes the following:

- Brass multifunction regulator
- Demand valve with hose
- Two Jumbo-D oxygen cylinders (636 liters each)
- Nonrebreather mask with 6-foot tubing
- Oronasal resuscitation mask
- Pelican® 1600 waterproof case
- Optional MTV-100 with hose



DAN also offers cylinders with a white shoulder for those regions that require that color designation for oxygen. If sold in a kit that includes a hose and demand or MTV, the hose is also white.

Charter Boat Oxygen Unit

DAN’s Charter Boat Oxygen Unit allows the use of larger oxygen cylinders, which allow for extended oxygen treatment. It includes the following:

- Brass multifunction regulator with CGA-540 connector
- Demand valve with hose
- Oronasal resuscitation mask
- Nonrebreather mask with tubing
- Wrench for CGA-540 connector
- Pelican® 1450 waterproof case



First Aid Backpack with Oxygen Option

Not only is this backpack fully stocked with first aid supplies, it also includes an adjustable padded pouch with Velcro backing, designed to fit a standard M9 oxygen cylinder. This is a portable, durable and practical unit with reflective strips and D-rings featured on the shoulder straps, and the waterproof cover is stored in the bottom compartment of the backpack. It includes the following items:

- Brass multifunction regulator
- M9 cylinder (248 liters)
- Demand valve with hose
- Oronasal resuscitation mask
- Nonrebreather mask with 6-foot tubing
- Dive safety slates
- Nitrile gloves
- Medications/Tools Pack
- Stop Bleeding/Shock Pack
- Wounds (Cuts) Care Pack
- Fractures/Sprain/Strain Pack



O2 Cardiac Complete

DAN's O2 Cardiac Complete allows responders to be prepared for almost any medical emergency. This unit meets U.S. Coast Guard standards for small passenger vessels and includes one Jumbo-D oxygen cylinder that delivers approximately 45-60 minutes of oxygen, a Philips HeartStart OnSite Defibrillator, and an assortment of first aid supplies stored conveniently in a waterproof Pelican 1600 case.



Other DAN Oxygen Unit options (as well as first aid kits) are available. Check the DAN store at [danship.co.za](https://danship.co.za) for additional configurations.

Appendix 2: Aquarium and Zoonosis Resources



Trauma Kit

DAN's Trauma Kit is designed to handle major traumas and emergencies in remote locations. This kit includes a wide assortment of pads, bandages, dressings, and other commonly used first aid supplies. The waterproof Pelican 1500 case keeps the firstaid supplies protected in even the most severe marine environments. Accessories such as a blood pressure cuff or stethoscope can be added to the kit to make this the ultimate first-aid kit for professional use.



[Association of Zoos and Aquariums, Infectious Diseases](#)

[U.S. Geological Survey National Wildlife Health Center, Medical Alert Wallet Card](#)

[Elasmobranch Husbandry: Conservation and ethical care of sharks, skates, rays and chimeras](#)

## Appendix 3: Contaminated Water Resources



Navy Experimental Diving Unit, Survey of Best Practices for Diving in Contaminated Water  
[Guidance For Diving In Contaminated Waters](#)

OSHA Code of Federal Regulations 1910.120, Hazardous Waste Operations and Emergency Response  
[Hazardous Waste Operations and Emergency Response](#)

OSHA Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities  
[OSHA's Hazard Identification Training Tool - Manual | Occupational Safety and Health Administration](#)

## Appendix 4: Additional Reading



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**abrasion** — a superficial scrape with loss of skin tissue in the form of small shreds

**acute** — rapid onset and/or short-term duration (as opposed to chronic)

**adaptic gauze** — nonadhering dressing

**agonal breathing** — an abnormal pattern of breathing characterized by gasping, labored breathing, accompanied by strange vocalizations and involuntary muscle twitching

**alveoli** — microscopic air sacs in the lungs where gas exchange with the circulatory system occurs

**ambient** — surrounding on all sides

**anesthesia** — general or local inability to feel to pain and other sensation induced by certain interventions or drugs

**anoxia** — absence of oxygen in the circulating blood or in the tissues

**anticholinesterase activity** — chemical activity that inhibits the cholinesterase enzyme from breaking down acetylcholine, increasing both the level and duration of action of the neurotransmitter acetylcholine

**antivenom, antivenin or antivenene** — a biological product used in the treatment of venomous bites or stings. Antivenoms are created by injecting small amounts of the targeted venom into an animal (typically horses, sheep, goats or rabbits) with the intention that the subject animal will develop antibodies against the venom’s active molecule. The plasma of the animals, containing the antibodies, can then be harvested from the animal’s blood and used to treat the envenomation.

**aorta** — the largest artery in the circulatory system, from which the main arteries carrying oxygenated blood branch out and subdivide into smaller and smaller vessels

**arterial gas embolism (AGE)** — gas bubbles in the arterial system generally caused by air passing through the walls of the alveoli into the bloodstream

**aphonia** — voice loss, inability to make sounds

**arrhythmia** — a problem with the rate or rhythm of the heartbeat

**arteriole** — small artery

**aspiration** — inhaling fluid or a foreign body into the bronchi and lungs, often after vomiting

**asymmetry** — disproportion between two or more like parts; lack of symmetry

**asymptomatic** — without symptoms

**ataxia (or ataxy)** — loss of coordination; inability to coordinate voluntary muscle movements; unsteady movements and staggering gait

**atelectasis** — the collapse of all or part of a lung

**atrium** — upper chambers of the heart. The right atrium received deoxygenated blood from the body and the left atrium receives oxygenated blood from the lungs

**audiovestibular** — of or pertaining to the auditory functions of the inner ear and the vestibule of the ear

**axon** — a long, slender projection of a nerve cell, or neuron, that typically conducts electrical impulses away from the neuron cell body

**barotrauma** — physical damage to body tissues caused by a difference in pressure between an air space inside (or beside) the body and the environment

**bioaccumulation** — the accumulation of substances in nature, organisms or the environment

**bloodborne pathogens** — infectious microorganisms in human blood that can cause disease in humans

**blood brain barrier (BBB)** — a separation between circulating blood and cerebrospinal fluid in the central nervous system. It occurs along all capillaries and consists of tight junctions around the capillaries that don’t exist in normal circulation.

**bronchi** — plural of bronchus, which is a division of the trachea

**bronchiole** — small branch of a bronchus that carries air to and from the alveoli

**bronchospasm** — bronchoconstriction, or the sudden narrowing of the smaller airways, of a constriction nature

**capillary** — microscopic blood vessels where the gas exchange takes place between the bloodstream and the tissues or the air in the lungs

**carbon dioxide (CO<sub>2</sub>)** — a waste gas produced by the metabolism of oxygen in the body

**carbon monoxide (CO)** — a highly poisonous, odorless, tasteless and colorless gas formed when an object burns with restricted access to oxygen. It is toxic by inhalation since it competes with oxygen in binding with the hemoglobin, thereby resulting in diminished availability of oxygen in tissues.

**cardiopulmonary resuscitation (CPR)** — an emergency procedure that is performed in an effort to manually preserve intact brain function until further measures are taken to restore spontaneous blood circulation and breathing in a person in cardiac arrest

**cardiorespiratory** — pertaining to the circulatory and respiratory systems

**cartilaginous** — pertaining to or composed of cartilage

**cerebral** — of, relating to or affecting the brain or cerebrum

**cerebrovascular accident (CVA)** — sudden death of some brain cells due to lack of oxygen when the blood flow to the brain is impaired by blockage or rupture of an artery to the brain; also referred to as a stroke

**chordata** — a major phylum in the kingdom Animalia characterized by the presence of a spinal cord. Phylogenetically, this phylum includes all vertebrates and some closely related invertebrates.

**chronic** — persistent or long-lasting (as opposed to acute)

**cilia** — long, slender microscopic hairs extending from cells and capable of rhythmic motion

**cirrhosis** — a consequence of chronic liver disease characterized by replacement of liver tissue by fibrosis, scar tissue and nodules, leading to loss of liver function

**CPR** — cardiopulmonary resuscitation

**cutaneous** — of, relating to or affecting the skin

**cyanosis** — bluish color of the skin due to insufficient oxygen in the blood

**debridement** — removal of dead, damaged or infected tissue to improve the healing potential of the remaining healthy tissue; surgical removal of foreign bodies from a wound

**decompression illness (DCI)** — dysbaric injuries related to scuba diving; DCI includes both decompression sickness (DCS) and arterial gas embolism (AGE).

**decompression sickness (DCS)** — a syndrome caused by bubbles of inert gas forming in the tissues and bloodstream that can evolve from ascending too rapidly from compressedgas diving

**defibrillation** — a therapeutic dose of electrical energy to an affected heart with a device called a defibrillator, which depolarizes a critical mass of the heart muscle, terminates the arrhythmia and allows normal sinus rhythm to be reestablished by the body’s natural pacemaker

**dehydration** — an abnormal depletion of water and other body fluids

**Diameter Index Safety System (DISS)** — intermediate pressure port where a hose attaches, leading to demand valve or other apparatus

**diaphoresis** — excessive perspiration, profuse sweating

**dinoflagellates** — microscopic unicellular organisms that share characteristics of both plants and animals and therefore do not fit into either kingdom; typically present in plankton, microscopic algae and microscopic bioluminescent organisms

**diplopia** — double vision; disorder of the vision in which one object is seen as two

**distal** — situated away from the middle of the body (as opposed to proximal)

**dorsal** — relating to the back (posterior) part of the body

**dura mater** — the outermost of the three layers of the meninges surrounding the brain and spinal cord

**dysesthesia** — distortion of any sense, especially of the sense of touch

**dysphagia** — difficulty swallowing

**dysphonia** — difficulty in phonation, or painful speech; typically a hoarse or weak voice; not to be confused with aphonia (inability to make sounds)

**dyspnea** — difficult, painful breathing or shortness of breath

**edema** — swelling caused by excess fluid in body tissues

**electrolytes** — minerals in your blood and other body fluids that carry an electric charge that affect the amount of water in your body, the acidity of your blood (pH), your muscle function and other important processes

**embolism** — a detached intravascular mass clogging capillary beds at a site far from its origin

**EMS** — emergency medical services

**epiglottis** — thin structure behind the tongue that shields the entrance of the larynx during swallowing, preventing the aspiration of debris into the trachea and lungs

**equilibrium** — the condition of a system in which competing influences are balanced

**erythema** — redness of the skin

**erythropoietin** — a hormone that is synthesized mainly in the kidneys and stimulates red blood cell formation

**esophagus** — portion of the digestive tract that lies between the back of the throat and stomach

**eukaryota** — from the Greek eu (“good” or “true”) and karyon (“nut” or “kernel,” which refers to the cell nucleus), meaning their cells have a true nucleus. Eukaryotes represent a complex form of biological evolution.

**facet** — a small, smooth, flat surface, as on a bone or tooth

**fasciculations** — a small and very localized involuntary sequence of muscle twitches; rapid muscle contractions and relaxations; not to be confused with seizures or grand mal

**first responder** — as used in the context of this course, an individual who arrives first on the scene and has first aid training that addresses the immediate need for care until EMS arrives or the person is transported to advanced medical care

**flexor** — a muscle that when contracted acts to bend a joint or limb in the body

**fossa ovalis** — oval depression in the wall of the heart remaining when the foramen ovale closes at birth (See patent foramen ovale.)

**ganglion** — a biological tissue mass, most commonly a mass of nerve cell bodies

**gastrointestinal** — refers to the stomach and intestines

**gradient** — a difference in pressure, oxygen tension or other variable as a function of distance, time, location or another continuously changing influence

**grand mal** — tonic-clonic seizure; a type of generalized seizure that affects the entire brain and causes massive muscular spasmodic convulsions (See seizures.)

**hemolytic** — that which causes hemolysis, dissolution of red blood cells

**hemorrhagic** — pertaining to bleeding or the abnormal flow of blood

**hemotoxic** — capacity of a toxin to destroy red blood cells, disrupt blood clotting and/or cause organ degeneration and generalized tissue damage

**histamine** — an organic nitrogen compound that is released during allergic reactions that triggers an inflammatory response. It also regulates other physiological responses and acts as a neurotransmitter.

**histaminoid** — similar to histamine

**histotoxic** — causes tissue damage

**hyperesthesia** — increased sensitivity to stimulation, particularly to touch

**hyperoxia** — excess oxygen or higher than normal partial pressure of oxygen

**hypoesthesia** — abnormally decreased sensitivity to touch

**hypotension** — excessively low arterial blood pressure; causes include blood loss, infection, poisoning, heart failure, neurological injury, endocrine disorders and medications

**hypovolemic** — a state of decreased blood volume

**hypoxemia** — inadequate oxygen content in the arterial blood

**hypoxia** — inadequate oxygen content

**incontinence** — absence of voluntary control of an excretory function, especially defecation or urination

**inert** — having little or no tendency to be metabolized or otherwise react chemically

**inflammation** — redness, swelling, pain or a feeling of heat in an area of the body; a protective reaction to injury, disease or irritation of the tissues

## Glossary continued

**intercostal muscles** — the muscles between the ribs that contract during inspiration to increase the volume of the chest cavity

**interneurons** — neurons that process signals from one or more sensory neurons and relay signals to motor neurons (connector neurons)

**intervertebral** — situated between two contiguous vertebrae

**intracerebral** — occurring or situated within the brain

**iodoform gauze** — sterile gauze treated with an antiseptic

**ischemia** — inadequate blood flow to a part or organ

**ischemic** — a decrease in the blood supply to a bodily organ, tissue or part caused by constriction or obstruction of the blood vessels

**isothermal** — of, relating to or indicating equal or constant temperatures

**jaundice** — a yellow color of the skin, mucous membranes or eyes

**laceration** — a jagged wound or cut

**larynx** — the organ of voice production, also known as the voice box; the opening from the back of the throat into the trachea (windpipe)

**lethargy** — the quality or state of being lazy, sluggish or indifferent

**lingual** — relating to or resembling the tongue

**localized** — restricted to the site of origin, without evidence of spread

**lpm** — liters per minute; a measurement of a flow rate of gas or liquid

**lymph** — a colorless fluid containing white blood cells, which bathes the tissues and drains through the lymphatic system into the bloodstream

**lymphatic** — pertaining to, containing or conveying lymph

**maxilla** — the principal bone of the upper jaw (The bone of the lower jaw is the mandible.)

## Glossary continued

**mediastinum** — the space within the chest located between the lungs, containing the heart, major blood vessels, trachea and esophagus

**meninges** — the system of membranes that envelopes the central nervous system

**metabolism** — the conversion of food into energy and waste products

**mimicry/mimetic** — protective resemblance; the resemblance that certain animals and plants exhibit to other animals and plants or to the natural objects among which they live; a characteristic that serves as their chief means of protection against enemies; imitation; mimesis; mimetism

**morbidity** — a disease or the incidence of disease within a population; also refers to adverse effects caused by a treatment

**morphology** — science of the form and structure of organisms (plants, animals and other forms of life)

**mortality** — death rate by a given cause within a population

**motor nuclei** — collection of cells in the central nervous system giving origin to a motor nerve

**mydriasis** — a prolonged or excessive dilation of the pupil of the eye

**myocardium** — the middle and thickest layer of the heart wall composed of cardiac muscle

**neurological** — having to do with the nerves or the nervous system

**neuromuscular** — the synapse or junction of the axon of a neuron and the motor end plate of a muscle; in vertebrates, the signal passes through the neuromuscular junction via a neurotransmitter, acetylcholine

**neurotoxic** — poisonous to the nerves or nerve cells

**nystagmus** — spontaneous, rapid, rhythmic movement of the eyes occurring when the eyes are moving or not moving

**occlude** — to close off or stop up; obstruct

**oronasal** — pertaining to the mouth and nose

**paralysis** — loss of ability to move all or part of the body

**paresthesia** — a sensation of numbness or tingling on the skin

**patent foramen ovale** — a hole in the septum (wall) between the right and left atria of the heart

**pelagic** — any water in the sea that is not close to the bottom or near to the shore is in the pelagic zone; from the Greek pélagos, which means “open sea”

**perfusion** — the passage of fluid (such as blood) through an organ or tissue

**pericardium** — a double-layered membranous sac surrounding the heart and major blood vessels connected to it

**peripheral** — related to or located in the outer boundary of the body

**pharynx** — portion of the airway at the back of the throat, connecting the mouth, nasal cavity and larynx

**phylogenetics** — the study of evolutionary relatedness among various groups of organisms

**pia mater** — the delicate innermost layer of the meninges, the membranes surrounding the brain and spinal cord

**platelet** — a round or oval disk found in the blood of vertebrate animals that is involved with blood clotting

**pleura** — membranes surrounding the outer surface of the lungs and the inner surface of the chest wall and the diaphragm

**pneumatophore** — one of the polyps of Physalia spp., which forms a gas-filled bladder that enables the organism to float along the ocean surface; also known as the marissa or sail

**pneumomediastinum** — the presence of air in the mediastinal soft tissues

**pneumothorax** — a collapsed lung

**postictal** — pertaining to the period following a seizure or convulsion

**postural** — position of the body or of body parts

**prescription** — a written order for dispensing drugs signed by a physician

**primary assessment** — assessment of the airway, breathing and circulation (pulse) in an ill or injured person; also known as the ABCs

**pro-inflammatory mediator** — a substance that indirectly mediates or triggers an inflammatory response

**prokaryote** — from the Greek pro (meaning “before”) and karyon (“nut” or “kernel”), referring to cells that have no real nucleus. They represent a more primordial form of life, less evolved than nucleated cells (eukaryotes).

**proprioceptors** — sensors that provide information about joint angle, muscle length and muscle tension

**prosboscis** — a hollow organ or tube attached to the head or connected with the mouth of various animals and generally used in taking food or drink

**protozoan** — a large group of single-celled, usually microscopic, nucleated organisms

**proximal** — nearer to the center of the body (as opposed to distal)

**pruritus** — an intense chronic itching sensation that can have various causes (allergies, infection, lymphoma, jaundice, etc.); poison ivy causes pruritus

**psi** — pounds per square inch; a measurement of pressure

**pulmonary** — having to do with the lungs

**quadriceps** — a large muscle in front of the thigh, the action of which extends the leg or bends the hip joint

**regurgitation** — expulsion of material from the mouth, pharynx or esophagus, usually characterized by the presence of undigested food or blood; vomiting

**respiratory arrest** — cessation of breathing

**resuscitation** — to revive from apparent death or from unconsciousness

**rhabdomyolysis** — disintegration of skeletal muscle

**seizure** — a convulsion; a sudden, involuntary movement of the muscles; typical of epileptic disorders

**sepsis** — a severe infection that affects the entire body

**sessile** — immobile or fixed in a particular place (e.g., the seafloor)

**sign** — any medical or trauma condition that can be observed

**siphon** — tubular organ through which water is ejected from the gill cavity of a cephalopoid; it serves as a locomotive organ by guiding and confining the jet of water

**subacute** — somewhat acute; between acute and chronic

**subcutaneous emphysema** — the presence of air or gas under the skin

**supersaturation** — the state of a solution when it contains more of a dissolved material than could be expected under normal circumstances.

**supine** — lying face up

**surfactant** — a substance produced in the lungs to reduce surface tension in alveoli and small airways

**symbiosis** — arrangement in which two similar organisms live together in what is usually a mutually beneficial manner; a cooperative arrangement (as opposed to parasitosis)

**symptom** — any nonobservable condition described by the patient

**symptomatic** — showing symptoms

**syncope** — fainting, swooning, temporary loss of consciousness generally caused by insufficient oxygen supply to the brain

**systemic** — affecting the entire body

**tachycardia** — rapid beating of the heart, usually defined as greater than 100 beats per minute

**Td, Tdap** — refers to different combination vaccines that provide immunization against tetanus. Tdap includes immunological coverage against three infectious diseases: tetanus (T), diphtheria (D) and pertussis/whooping cough (P). Td lacks the pertussis component.

**thermolabile** — heat sensitive; can be broken down with temperature

**thermostable** — the quality of a substance to resist irreversible change in its chemical or physical structure at a high relative temperature

**thorax** — the upper part of the trunk (main part of the body) between the neck and the abdomen that contains the heart, lungs, trachea and bronchi

**thrombotic** — having to do with intravascular coagulation of the blood in any part of the circulatory system, as in the heart, arteries, veins or capillaries

**thrombus** — a blood clot

**toxicology** — a branch of biology and medicine concerned with the study of the adverse effects of chemicals on living organisms; study of the signs, symptoms, mechanisms of action and treatments of poisonings

**toxinology** — the specialized area of science that deals specifically with animal, plant and microbial toxins; a branch of biology and medicine concerned with the study of the adverse effects of natural toxins or chemicals on living organisms

**trachea** — the air passage that begins at the larynx and ends as the beginning of the principal right and left bronchi

**transverse** — crossing from side to side

**trauma** — a serious injury to the body, as from violence or an accident

**ulcer** — a break in the skin or the surface of an organ; forms when the surface cells die and are cast off

**Valsalva maneuver** — the forced inflation of the middle ear by exhaling with the mouth closed and the nostrils pinched

**vasoconstriction** — narrowing of a blood vessel

**venomous** — secreting or transmitting venom (toxin)

**venous** — of, relating to or contained in the veins

**venous gas emboli** — inert gas bubbles in venous blood (that return to the heart and lungs)

**ventilation** — the exchange of gases between a living organism and its environment; the act of breathing

**ventral** — relating to the front (anterior) part of the body

- ventral horns** — the two roots of a spinal nerve that pass ventrally from the spinal cord and that consist of motor fibers
- ventricle** — thick-walled, muscular chamber in the heart that receives blood from the atrium, pumping it through to the pulmonary or systemic circulation
- ventricular fibrillation (VF)** — a condition in which there is uncoordinated contraction of the cardiac muscle of the ventricles in the heart, making them quiver ineffectually rather than contract properly
- venules** — small veins
- vertebrae** — the bones forming the spinal column
- vertigo** — a sensation of whirling motion, either of oneself or of external objects
- vestibular** — relating to a person’s sense of balance, orientation or equilibrium
- volume of distribution** — the volume in which the amount of drug would need to be uniformly distributed to produce the observed blood concentration



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Divers Alert Network Southern Africa (DAN-SA) is an international, nonprofit organisation dedicated to improving dive safety through research, education, medical information, evacuation support, products and services.

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