DIVING FIRST AID FOR PROFESSIONAL DIVERS

STUDENT HANDBOOK

DAN
SOUTHERN AFRICA

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This programme meets the current recommendations from the October 2015 Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care issued by the International Liaison Council on Resuscitation (ILCOR)/American Heart Association (AHA).

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DAN SOUTHERN AFRICA

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1 Diving First Aid For Professional Divers 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 and who may have to comply with health and safety regulations or other institutional requirements. This includes people who are employed as commercial divers, scientific divers, 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 programme is also well suited for dive professionals such as divemasters and dive instructors.

Dive accidents are rare, but they may require prompt, specific action. This course addresses topics required by health and safety guidelines, including blood-borne pathogens. Other topics include scene safety, oxygen administration, neurological assessment, CPR, as well as 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 (this 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 certification, 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 non-divers should be able to master the material.

1

Continuing Education
Continuing education is encouraged in the form of additional training courses, supervised practice sessions, reading current literature and refresher training. Your DFA Pro Instructor can provide information about these programmes.

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-development sections and participate in class discussions
- Boxes labelled "Note" provide explanations that are important for understanding the material just presented
- Boxes labelled "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.

2 Diving First Aid For Professional Divers Introduction

CHAPTER 2 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 organisation 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. You may, however, have an organisational duty of care if you are part of an organisational response team. This obligation does not extend to circumstances outside the organisation.

In circumstances outside your organisation, 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, be sure to provide care within your scope of training.

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 responsive, the victim should give permission before you provide care. Not asking for permission or forcing care against a victim'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 avoid infection)

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. However, these feelings 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 some care (even if not "perfect") is more effective 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. Tissues which are especially vulnerable, such as the brain, may start dying after four to six minutes. Therefore, the need for immediate action is crucial.

When providing care for an injured person, treat him, his family, friends and co-workers 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.

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, 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. Some rescuers may benefit from a critical-incident debriefing or professional counselling to help work through such concerns. Some companies will have resources available to assist with this intervention.

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CHAPTER 2 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. a and b
   e. all of the above

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 debriefing
   b. professional counselling
   c. both a and b

Review answers are on Page 242.

3 Basic Sciences Anatomy and Physiology Part 1: Respiration and Circulation

CHAPTER 3 OBJECTIVES

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

3

Oxygen (O_2) is essential for life. Within minutes of sustaining severe oxygen deficiency (hypoxia) or the absence of oxygen (anoxia), we may experience severe discomfort, unconsciousness or death.

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. The intake of oxygen and removal of carbon dioxide (CO_2) is the most critical part of a normal life.

CO_2 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 CO_2, not low levels of O_2, provide the primary ventilatory stimulus. The rapid elevation of dissolved CO_2 during short periods of breath-holding provides quick insight into the power of its influence.

The Respiratory System

The respiratory system comprises 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 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 oesphagus. The opening to the trachea is protected from food (solids and liquids) during swallowing by a flexible flap of tissue called the epiglottis. The oesphagus, located behind the trachea, is a conduit for food and fluids to enter 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.

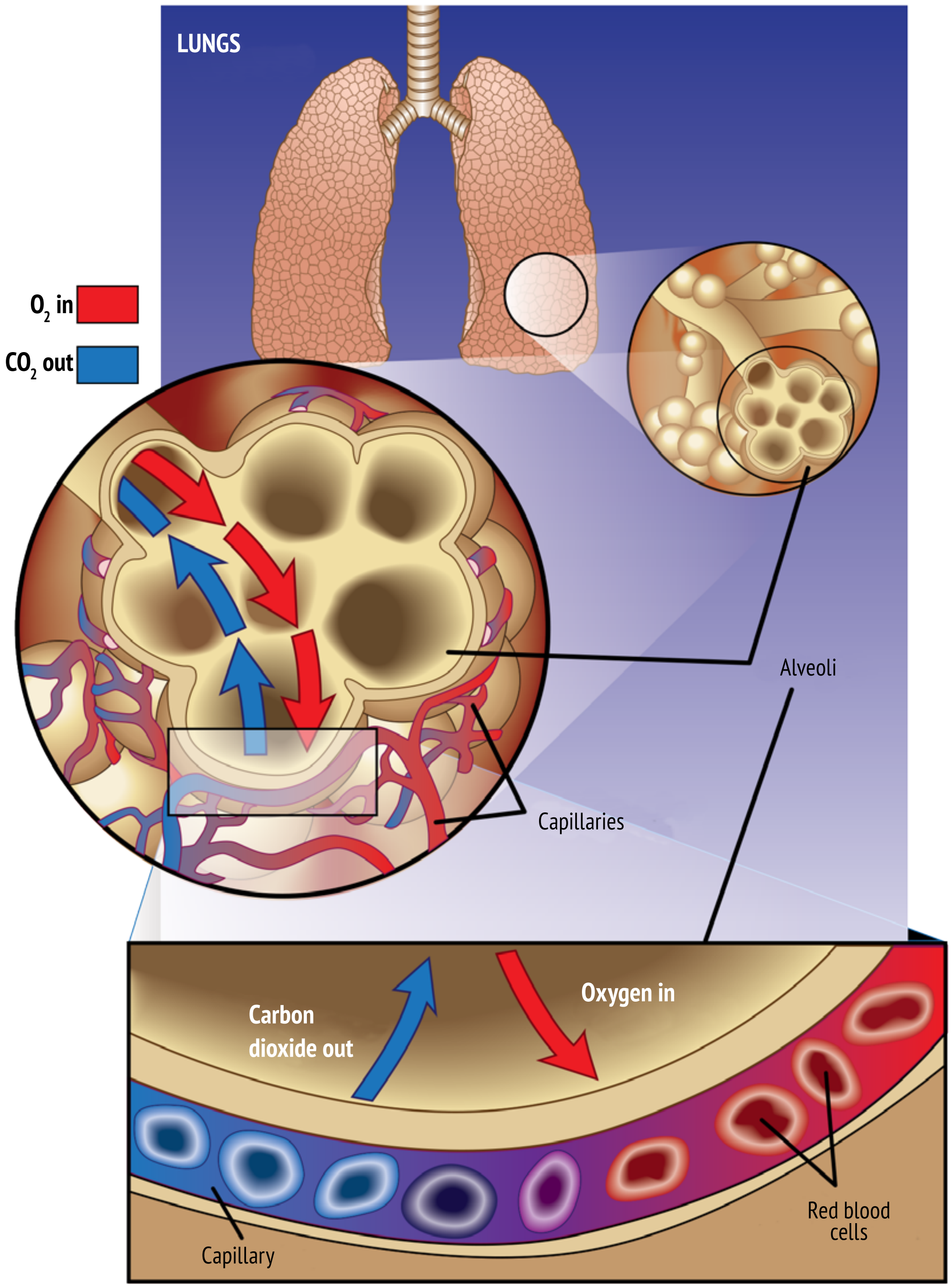
ADVANCED CONCEPTS

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 is no 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 m^2, or roughly the size of a tennis court.



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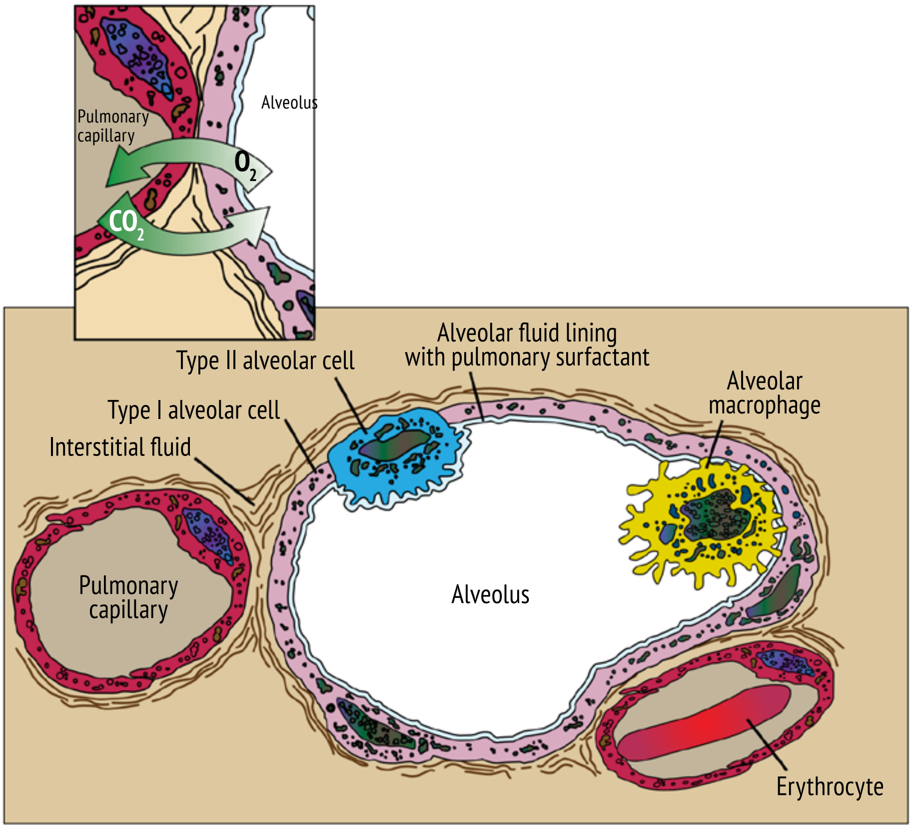
A detergent-like substance known as lung or pulmonary surfactant coats the inner surface of the alveoli. Pulmonary surfactant decreases the surface tension of water within the alveoli and thus reduces its tendency to collapse at the end of expiration. If the surfactant is removed, as may occur in a submersion 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 non-fatal drowning. Appropriate intervention can reduce or prevent complications associated with drowning.

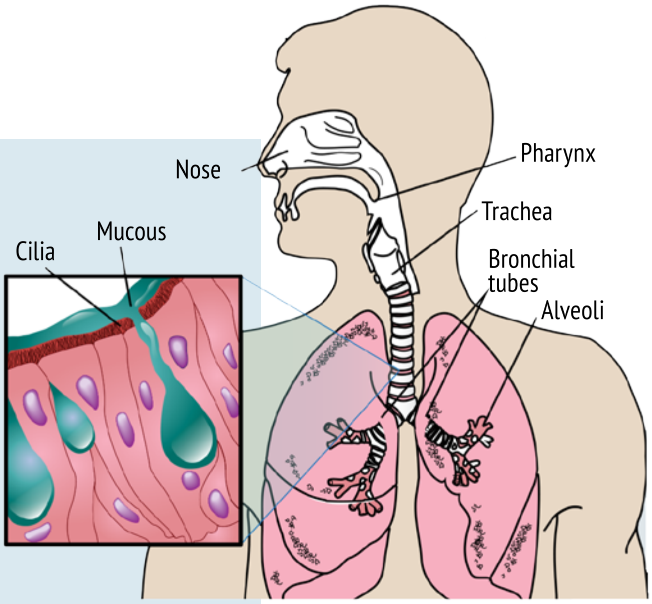


The average adult alveolus has an estimated diameter of 200-300 µm and is only a cell layer thick. Alveoli lie adjacent to capillaries that are also one cell layer thick and this proximity enables the rapid exchange of CO_2 and O_2. The thin alveolar-capillary membrane separates the content of the lung 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 hair-like structures called cilia and 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 mucous up into the pharynx, where it can be swallowed and digested, together with any other trapped foreign particles. In the case of smokers, the mucus is thicker and the cilia are damaged, which hinders the lungs' natural self-cleaning mechanism.



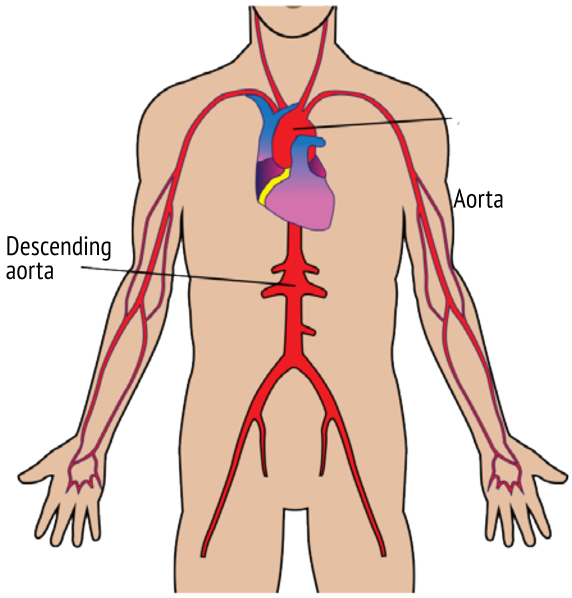
The Cardiovascular System

The cardiovascular system includes the heart and blood vessels. It is a closed-circuit system with a primary purpose of pumping blood, transporting oxygen and nutrients to tissues via the arteries, and removing waste products such as CO_2 via the veins.

The Heart

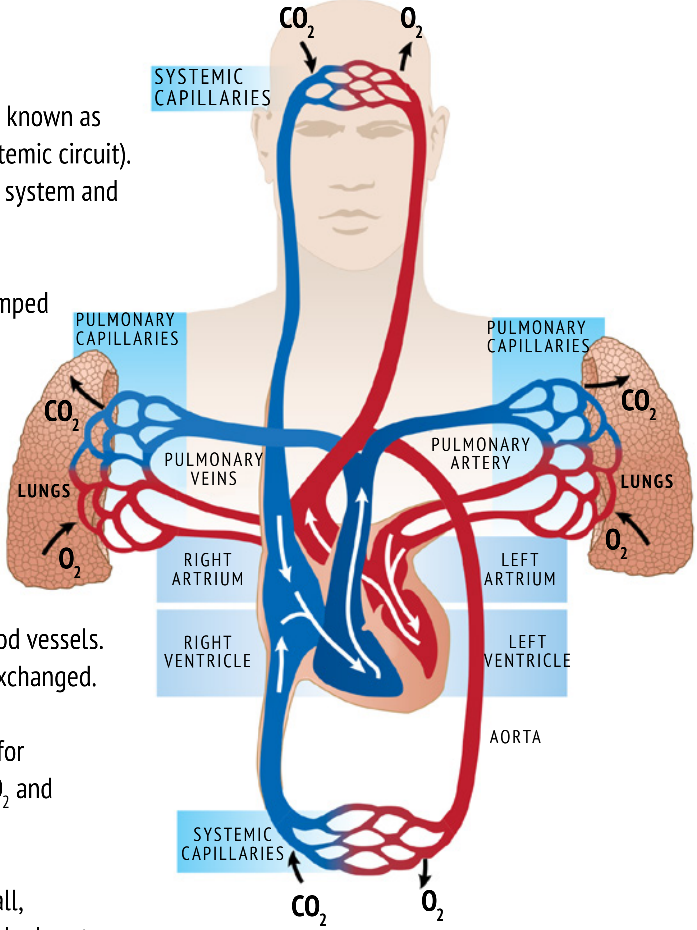
The heart is a hollow, muscular organ situated in the thoracic cavity, between the lungs, in a space called the mediastinum. A thin, connective tissue sac called the pericardium surrounds it. The pericardium (like the pleural linings of the lungs) reduces friction between the heart and surrounding structures.

The heart is a strong, muscular pump that, in the average adult, has the capacity to beat 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.[2] Approximately 6 litres of blood is pumped throughout the body every minute. When exercising, this output may double or triple, depending upon the amount of exertion.



The heart is divided into a right- and a 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 gasses.

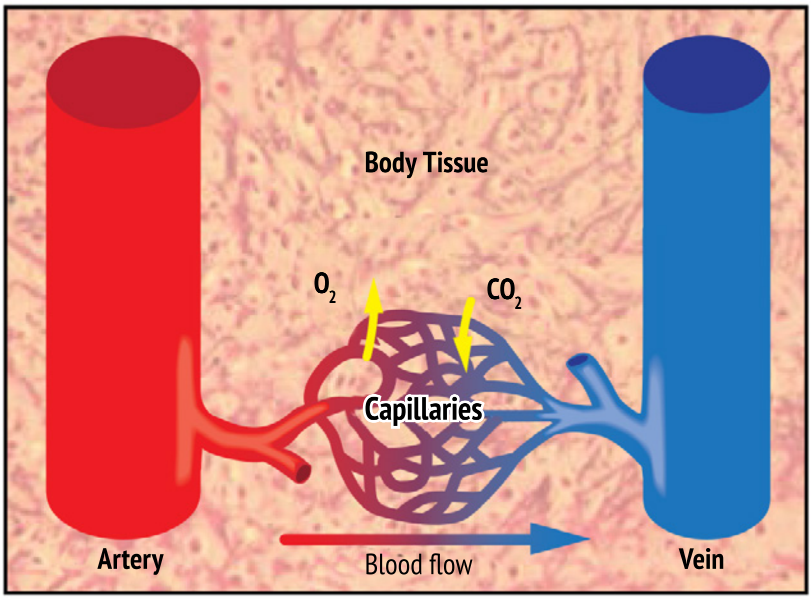
Oxygenated blood is returned to the left heart, where it is pumped to the systemic circuit. Transportation of blood through both circuits completes a circulatory cycle.



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, gasses 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 CO_2 and other metabolic waste products.

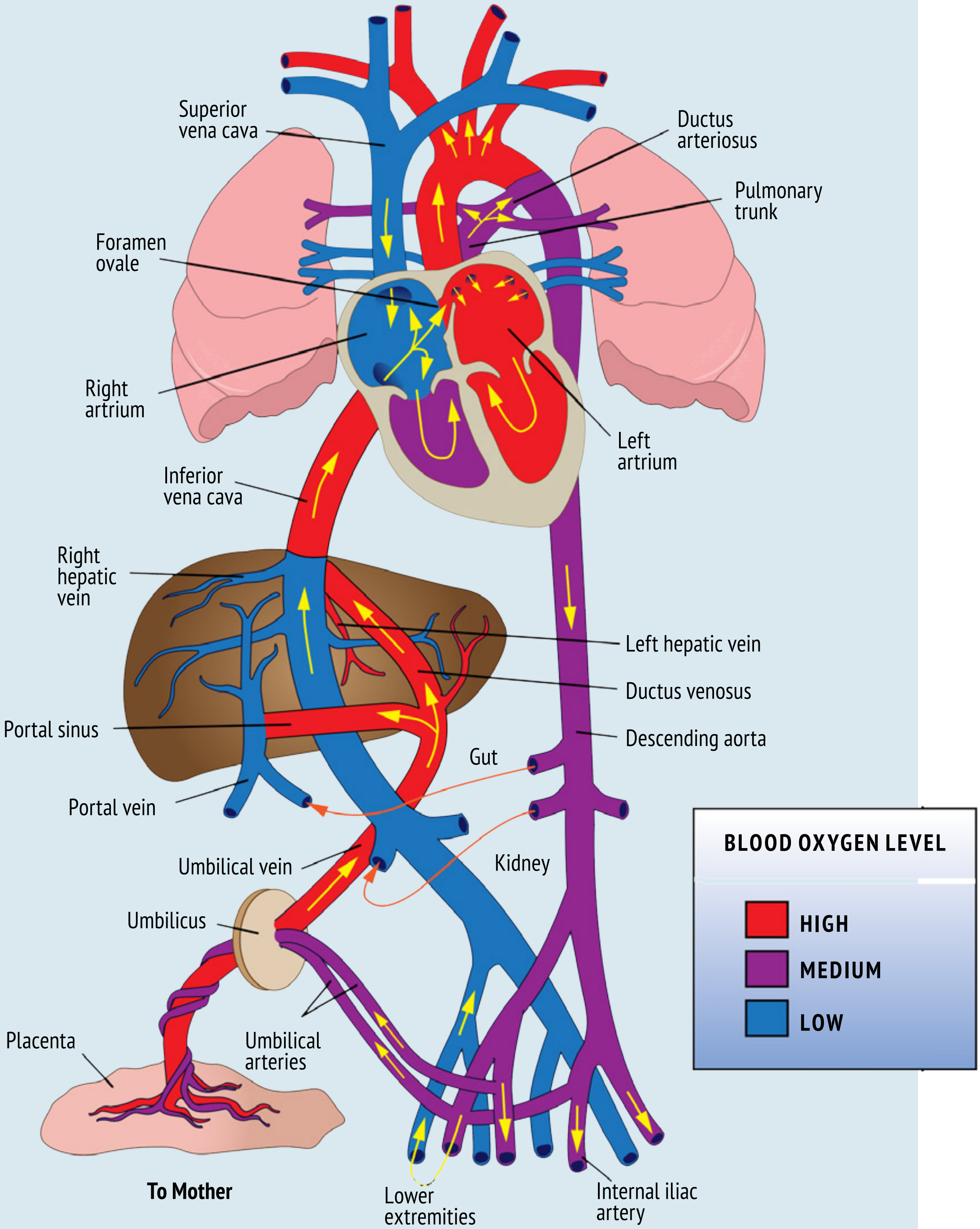
From the peripheral capillaries, the blood is gathered into small, thin-walled veins and returned via larger veins to the atria of the heart. Most veins direct blood flow by means of one-way valves that prevent blood from travelling in the wrong direction or pooling due to gravity.



ADVANCED CONCEPTS

Foetal Circulation

Within the uterus, the foetus 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 foetus, gas exchange takes place in the placenta, drawing available oxygen from the mother's blood. ***(Continued on the next page.)***



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Foetal Circulation (continued)

Two unique passages in the foetal circulation allow blood to bypass the lungs. These two portals, known as the ductus arteriosus and foramen ovale, usually close soon after birth and 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 non-functional 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% 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 specialised fluid (actually a distinct organ system) that links the respiratory system to the rest of the body. Approximately 55% of our circulating blood volume is comprised of plasmas, which is the visible, fluid fraction of blood. While mostly water, plasma also contains proteins, glucose, minerals, nutrients, waste products and dissolved gasses. 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.

CHAPTER 3:1 REVIEW QUESTIONS

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. spinal column interfaces
   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 242.

3

3 Basic Sciences Anatomy and Physiology Part 2: Nervous System

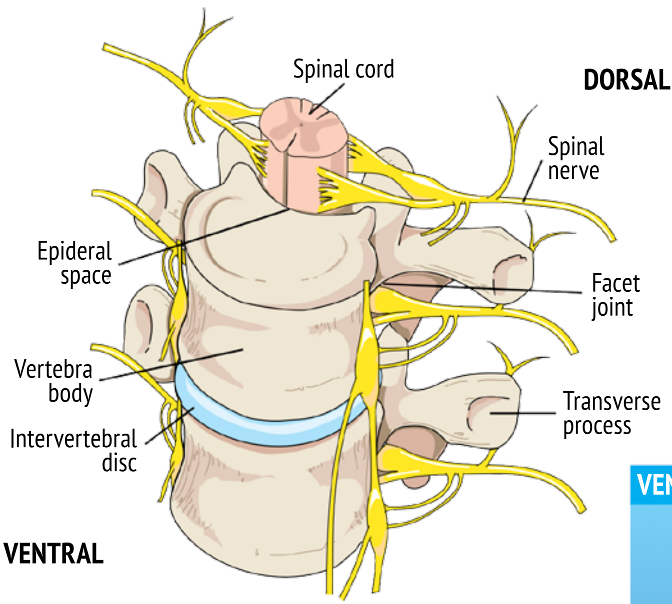
CHAPTER 3 OBJECTIVES

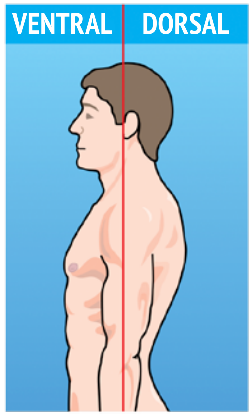
1. What are the primary components of the nervous system?
2. What is the functional unit of the nervous system?
3. What are possible causes of interruptions along neural pathways?

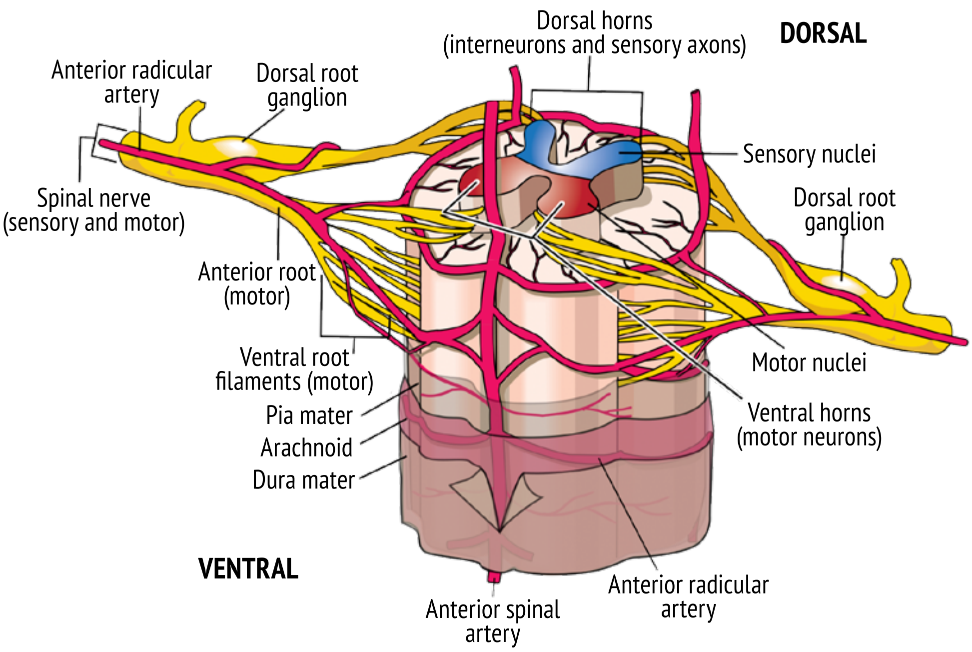
The primary components of the nervous system are the brain, spinal cord and nerves. The brain and spinal cord form the central nervous system, and the nerves that extend from the spinal cord or brain out to the body make up the peripheral nervous system. The functional unit of this system is the nerve 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 recognise prominent signs of possible neurological compromise.


Spinal cord
DORSAL
Spinal
nerve
Epideral
space
Facet
joint
Vertebra
body
Transverse
process
Intervertebral
disc
VENTRAL


VENTRAL
DORSAL


Dorsal horns
(interneurons and sensory axons)
DORSAL
Anterior radicular
artery
Dorsal root
ganglion
Sensory nuclei
Dorsal root
ganglion
Spinal nerve
(sensory and motor)
Anterior root
(motor)
Ventral root
filaments (motor)
Motor nuclei
Pia mater
Arachnoid
Dura mater
Ventral horns
(motor neurons)
VENTRAL
Anterior spinal
artery
Anterior radicular
artery

3

CHAPTER 3:2 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 242.

4 Basic Sciences
Atmospheric Gasses

CHAPTER 4 OBJECTIVES

1. What is oxygen?
2. How much oxygen is in both inhaled and exhaled air?
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 gasses. 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 gasses and the role they may play under pressure.

Oxygen (O_2)

O_2 is a colourless, odourless, tasteless gas that accounts for approximately 21% 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 erythrocytes. Haemoglobin is the oxygen-carrying molecule within erythrocytes responsible for binding both oxygen and carbon dioxide. At rest, humans consume approximately 5% of the available 21% of oxygen in the air. Exhaled air therefore contains about 16% oxygen. These percentages will vary somewhat by individual and level of activity, but they provide a tangible example of oxygen use.

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 haemoglobin saturation (the percent of haemoglobin binding sites occupied by oxygen) through a colour shift between oxygenated and deoxygenated blood states. Normal values while breathing air are 95-100% 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 (HCO_3-) and serves a critical role in acid-base buffering. The remaining carbon dioxide is found either dissolved in plasma or bound to haemoglobin.

Carbon Dioxide (CO_2)

Normal air contains only about 0.033% CO_2, which is a waste product of cellular metabolism. Exhaled gas from respiration contains approximately 4-5% CO_2. Elevated levels of CO_2 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 CO_2 than air, rescue breaths (if performed correctly) should not result in significant elevations in the victim's CO_2 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 CO_2 levels, relative to inhaled air, is an indication of metabolic activity. In some medical settings, CO_2 levels in exhaled air are monitored (capnography) so as to ascertain cellular respiration and adequacy of airway management.

Nitrogen (N_2)

N_2 exists in different chemical forms. As a gas, N_2 composes about 78% of the Earth's atmosphere and is physiologically inert in this form, meaning it is not involved in cellular metabolism. In non-divers who remain at a constant ambient pressure, the concentration of N_2 in the exhaled air is also about 78%. 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 off-gassing. However, because N_2 is an inert gas, 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. These are 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 (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 N_2.

4

Carbon Monoxide (CO)

Certain gasses, such as CO, interfere with tissue oxygen delivery. CO binds more fiercely to haemoglobin 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 tank can become toxic when breathed under pressure. For this reason, it is critical that the air quality and purity of compressor air is regularly tested. 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.

CHAPTER 4 REVIEW QUESTIONS

1. **Oxygen is a colourless, odourless gas essential to life**
   a. True
   b. False

2. **The atmospheric air we inhale contains ______% 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 makes up ______% 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 242.

5 Basic Sciences Decompression Illness

CHAPTER 5 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)

While the underlying cause of these two conditions may be different, the initial medical management (first aid) is the same.

NOTE
The most important initial actions performed in diving accidents are early recognition and the use of supplemental oxygen.

Decompression Sickness

DCS results from bubbles that are formed within tissues or blood by dissolved inert gas (N_2 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 impact us on a systemic level, specific signs and symptoms are thought to be a result of either bubble accumulation or its impact on specific areas. Examples include joint pain, motor or sensory dysfunctions and skin rash.

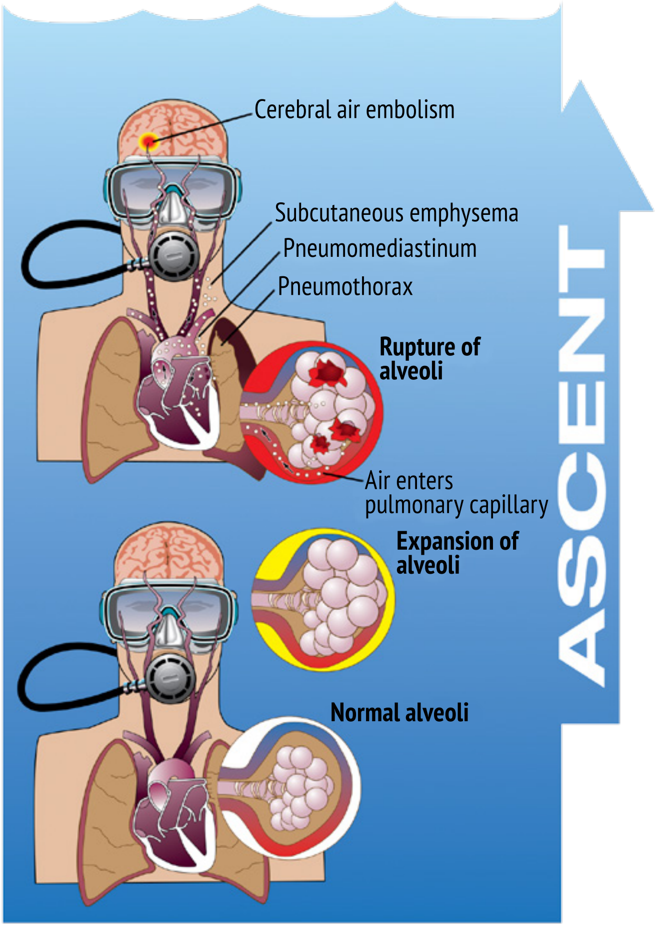
DCS is generally only life-threatening with extreme exposures. Early treatment with high concentrations of O_2 (as close to 100% as possible) has been shown to increase the speed of symptom resolution and optimise the impact of recompression therapy.[3] Though symptom resolution is a desired effect of oxygen first aid, it is important to emphasise 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 well into ascent during extreme exposures
- 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 m of seawater. Lung-tissue trauma can allow the entrance of breathing gas into the blood vessels leading 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.

5

The primary risk factor for AGE is breath-holding during ascent. Other potential risk factors include underlying conditions such as lung infections and pre-existing 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 colouration of the lips).

ADVANCED CONCEPTS

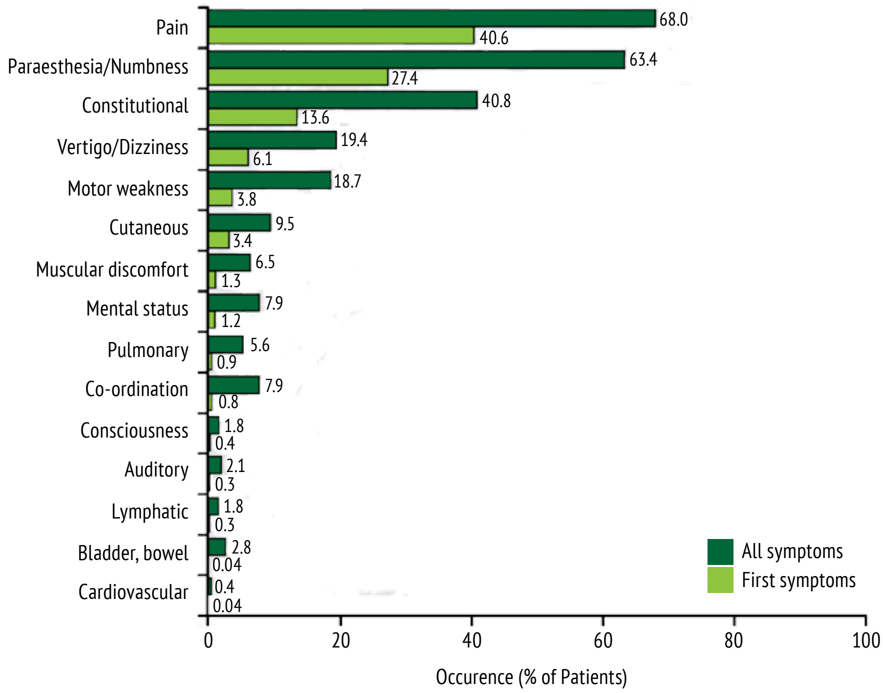
A separate but related concern is AGE that occurs secondary to venous bubbles bypassing the pulmonary filter and entering the arterial system directly. The process through which blood passes from the right side of the circulatory system to the left and bypasses the pulmonary filter is called shunting – 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 arterialised 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 visualised 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. The list is ranked in order of presentation frequency based on Project Dive Exploration (PDE) data from 2 346 recreational dive accidents reported to DAN between 1998 and 2004.

- **Pain** (initial symptom in 41% of cases)
  Commonly associated with neurological symptoms, the pain has been characterised 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 affected 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 non-specific discomforts
- **Paraesthesia/Numbness** (initial symptoms in 27% of cases)*
  Paraesthesia/anaesthesia/dysaesthesia are terms that refer to altered sensations and may present as abnormal feelings (paraesthesia), decreased or lost sensation (anaesthesia) or hypersensitivity (dysaesthesia). Paraesthesia is commonly characterised 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 occur most often in the limbs and may be associated with complaints such as a cold, heavy or swollen sensation
- **Constitutional symptoms** (initial symptoms in 14% of cases)
  These are generalised 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% 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 indicative of inner-ear/vestibular involvement
    - o There are several causes for such symptoms that are not related to DCI. These include round- or oval-window rupture (associated with difficulty equalising), 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 characterised as lightheadedness, and is commonly associated with nausea
- **Motor weakness** (initial symptom in 4% 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 between 1998 and 2004

- **Cutaneous (skin) symptoms** (initial symptom in 3% of cases)
  Skin symptoms are often located on the chest, abdomen, back, buttocks or thighs. Rashes commonly migrate (move to different parts of the body). Affected areas may be tender or itch and are thus often confused with allergies or contact dermatitis
- **Altered mental status** (initial symptom in 1.2% of cases)
  Symptoms may include confusion, personality changes or speech disturbances (slurring of words or non-sensical speech)
- **Pulmonary issues** (initial symptom in 0.9% 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
- **Co-ordination/cerebellar function** (initial symptom in 0.8% of cases)
  Cerebellar function controls the co-ordination of the body's voluntary movements. Although lack of co-ordination 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 manifest as the inability to walk in 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% of cases
- *Audiovestibular or inner-ear DCS:* This is an alteration of balance or hearing that can be associated with vertigo
- *Lymphatic DCS:* Identified as an initial symptom in only 0.3% of cases, it deserves mention because this symptom does not immediately resolve with successful recompression treatment. It is often characterised as localised swelling affecting the trunk and shoulders
- *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 catheterisation 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% were classified as possible AGE.[4]

The occurrence of DCS varies by population. Based on DAN data, the per-dive rate among recreational divers is 0.01-0.019%, among scientific divers it is 0.015%, for U.S. Navy divers it is 0.030% and for commercial divers it is 0.095%.[4, 5]

Previously published per-dive DCS rates based on 135 000 dives by 9 000 recreational divers were 0.03%. 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 it was 28/10 000 (0.0028)[6] for cold-water wreck divers in the North Sea.

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 from 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 the patient's 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. 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 co-ordination 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.

CHAPTER 5 REVIEW QUESTIONS

1. **Decompression illness includes**
    a. decompression sickness
    b. air gas embolism
    c. both of the above

2. **The most important initial actions in responding to diving accidents are recognising there is a problem and administering 100% oxygen**
    a. True
    b. False

3. **DCS is caused by**
    a. breath-hold during descent
    b. breath-hold during ascent
    c. inert gas bubbles in the body

4. **The primary risk factor for AGE is**
    a. breath-hold during descent
    b. breath-hold during ascent
    c. inert gas bubbles in the body

5. **It is important to seek medical evaluation when DCI is suspected because**
    a. symptom resolution does not mean DCI is no longer present
    b. symptoms may recur
    c. risk of recurrence may be reduced by hyperbaric treatment
    d. all of the above

6. **The single most common symptom of DCI is**
    a. numbness
    b. constitutional symptoms (fatigue, nausea)
    c. muscle weakness
    d. pain
    e. balance/equilibrium issues

7. **Initial DCS symptoms**
    a. occur within 15 minutes of the time of injury
    b. typically occur within six hours of surfacing
    c. may be delayed up to 24 hours
    d. both b and c

8. **AGE symptoms**
    a. occur within 15 minutes of the time of injury
    b. typically occur within six hours of surfacing
    c. may be delayed up to 24 hours
    d. both b and c

9. **The decision to return to diving following DCI should be made in conjunction with a physician knowledgeable in dive medicine**
    a. True
    b. False

Review answers are on Page 242.

6 Dive Emergency Preparation Blood-borne Pathogens

CHAPTER 6 OBJECTIVES

1. What is the purpose of the OSHA Blood-borne 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 blood-borne pathogen?
5. What is zoonosis?
6. What is required when diving in contaminated water?

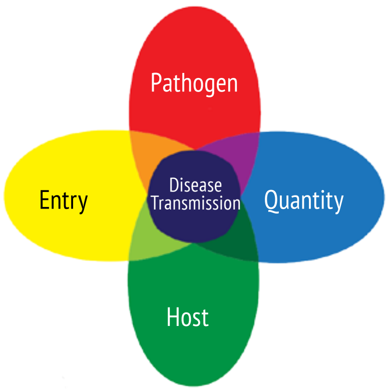
The U.S. Occupational Safety and Health Administration (OSHA) was created in 1970 "to ensure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance."[7] The Blood-borne Pathogens (BBP) Standard in 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 blood-borne pathogens, the options to 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 authorised individuals within your company to provide the details needed with your specific operation.

Disease Transmission

For diseases to be transmitted, four things must converge:

- an infectious pathogen
- sufficient quantity of the pathogen
- exposure to a susceptible host
- 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 or kissing, through an open wound or sexual contact
- ***Indirect:*** Transfer of a disease agent through an inanimate object such as clothing, utensils, furniture or door knobs
- ***Airborne:*** Transfer of a disease agent by droplets that contain pathogens being subsequently inhaled by another person (sneezing or coughing by an infected person produces air-borne 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. Blood-borne 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 faeces. 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 minimising 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, as well as eating or drinking in areas with a high risk of exposure. 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.

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 minimise 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)
- eating, drinking or storage of food or use of cosmetics areas

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 officer will provide details for your centre.

The ECP addresses the use of PPE, how contaminated materials are to be handled and their proper disposal. 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 well as 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 blood-borne 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. The virus is transmitted through contact with infected blood and other body fluids but not through casual contact. HBV is 50-100 times more infectious than HIV. Those infected with the HBV are themselves potentially infectious, although only about a quarter of them actually show symptoms.[8] Approximately 5-10% of people infected with HBV as adults go on to have chronic disease. Between 15 and 25% of people with a chronic infection will die of either liver failure or liver cancer.

Transmission: HBV is transmitted via blood and other bodily tissues and can be transmitted through blood transfusions, needle sticks, intravenous (IV) drug use and sexual intercourse (vaginal fluids and semen). HBV is very contagious; one in three people exposed to the virus via 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 97% effective and is required of most health-care workers.

Symptoms: HBV can cause an acute illness that lasts several weeks. Symptoms may include:

- yellowing of the skin and eyes (jaundice)
- extreme fatigue
- vomiting
- dark urine
- nausea
- abdominal pain

- For some people, symptoms may persist for several months or up to a year

Hepatitis C

Hepatitis C virus (HCV) is another blood-borne pathogen that can cause severe liver damage. Of those infected with HCV, about 40% recover fully. Those who do not clear the virus become chronic carriers. Of these, 20% develop cirrhosis and up to 20% of those who develop cirrhosis develop liver cancer.[9]

HCV may cause a relatively mild acute illness or jaundice (about 10% of those infected) and many people do not know they are infected until many years later. Most people are completely asymptomatic and go on to have chronic disease that leads to cirrhosis and liver cancer (hepatocellular carcinoma). It may take 20 years or more to develop symptoms.

Transmission: Routes of transmission/infection are the same as for HBV. The most common source for infection is seen in IV drug users who share needles. HCV has also been contracted from blood transfusions (prior to July 1992), needle sticks in health-care settings and through sexual intercourse.[10]

The likelihood of a HCV infection is less than with HBV, with a one in 20 risk. HCV can remain viable outside the body, but it is not as sturdy as HBV. Currently, there is no immunisation.

Symptoms: People infected with HCV are potentially infectious even if asymptomatic.
Symptoms for HCV include:

- nausea
- loss of appetite
- itchy skin
- abdominal pain
- fatigue
- jaundice

HIV/AIDS
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. The chance of infection from HIV is much less than from other blood-borne pathogens. A puncture-wound exposure from an infected source has an infection risk of one in 300. There currently is no immunisation or known cure for HIV.

Symptoms: People infected with HIV may remain asymptomatic for up to 10 years but can still pass the infection to others. Once infected, it usually takes about three months for the HIV enzyme-linked immunosorbent assay (ELISA) blood test to turn positive. Some of the potential signs and symptoms of infection include:

- loss of appetite
- night sweats
- fatigue
- weight loss
- skin rashes
- reduced infection resistance
- fever
- diarrhoea
- swollen lymph nodes

If you believe you have been potentially exposed to a blood-borne pathogen, follow these steps:

- If there is an open wound, milk it and encourage it to bleed
- Wash the wound with soap and water
- 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
- 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
- Report the injury as per the protocols outlined in your company's emergency action plan
- Seek medical evaluation and counselling 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 blood-borne pathogens but 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 nymph nodes, nausea, diarrhoea 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 or 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 professional divers and requires specialised training 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.

CHAPTER 6 REVIEW QUESTIONS

1. The OSHA Blood-borne 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 blood-borne pathogen, you should
   a. cover it tightly to protect it
   b. milk it to make it bleed
   c. report it according to your organisation'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. Specialised training is required when diving in contaminated water
   a. True
   b. False

Review answers are on Page 242.

7 Dive Emergency Preparation
Emergency Action Plans

CHAPTER 7 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 scuba diving professional, you are expected to be prepared, and to recognise 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 and equipment preparation.

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 organisations, 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 for 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 Emergency Hotline number (0800 020 111) for medical consultation and emergency assistance
- method for documenting injury/illness presentation 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
- dive profile information
  - how many days of diving
  - number of dives
  - maximum depth
  - surface interval times
  - gas used for diving (air, nitrox and its percentage, trimix and its percentage, 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. The first aid slates available as part of the DFA Pro course 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 0800 020 111 (local) or +27 828 10 60 10 (int).

Emergency Equipment

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

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.

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)
- non-latex 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, items:
- wound-closure strips (Steri-Strips)
- isothermal blanket
- irrigation syringe
- infectious waste bag
- penlight
- splint to immobilise 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 authorised to dispense medications or share their own prescriptions.

Recommended medications include:
- antiseptic solution
- eyewash
- hydrocortisone ointment
- antihistamine tablets
- antibiotic ointment
- pain reliever

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.

CHAPTER 7 REVIEW QUESTIONS

1. **Essential equipment to have available at every dive site includes**
   a. oxygen unit
   b. first aid kit
   c. emergency action plan
   d. all of the above

2. **Emergency action plans should include**
   a. local resources and emergency phone numbers
   b. communication equipment
   c. method of documenting information about injured divers and first aid provided
   d. location of the nearest hyperbaric chamber
   e. a, b and c only

3. **Hyperbaric chambers will always be available to treat injured divers**
   a. True
   b. False

Review answers are on Page 242.

7

8 Dive Emergency Preparation
Lifting and Moving

CHAPTER 8 OBJECTIVES

1. What are the general considerations for a rescuer when attempting to move a patient?
2. When should a patient 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 patient in the attempt. You should leave the person in the position found.

There are two exceptions:
- The person needs to be moved onto his back for CPR
- The person is in imminent danger (e.g., due to fire, explosives or uncontrolled traffic)

Use discretion when moving a patient and avoid it if at all possible. However, if a situation presents in which a move is absolutely necessary, 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 patient. 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.

Armpit-Forearm Drag (Rautek Technique)

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

Shirt Drag

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

Coat or Blanket Drag

Another effective technique is to use a coat or a blanket to drag the patient to safety. To get the patient onto the blanket, you will need to roll him onto his side and then tuck the blanket underneath him. Lay the patient back down and pull the other edge of the blanket out from beneath him. Gather the blanket into place under the patient'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 patient; none of these techniques allows you to adequately protect the patient's spine in case of an injury to the head, neck or spine. With heavier patients, a long backboard is more effective and minimises potential injury to the patient and rescuer.

A direct ground lift requires two or more rescuers. They should be on the same side of the patient. One rescuer supports the patient's head, neck and lower back. The other rescuer supports the hips and legs.

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

CHAPTER 8 REVIEW QUESTIONS

1. **Moving someone should be limited to times of emergency or when the current location places the victim 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 242.

9 Response And Assessment Scene Safety Assessment and Standard Precautions

CHAPTER 9 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 he is injured when approaching the victim or rendering care. Taking the time to assess the scene and circumstances surrounding the victim may prevent compromising the rescuer and causing further injury to the victim. Before providing basic life support (BLS), assess the scene and take steps to avoid or remove any sources of potential injury.

Scene Safety Assessment

Before providing aid, take a moment to remember the mnemonic S-A-F-E.

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

- **Stop:** Take a moment to think and then act
- **Assess** the scene: Before assisting another person, determine if the scene is safe
  Dangers may include:
  - fire
  - chemicals
  - electricity or gas
  - traffic
  - animals (tentacles from a jellyfish or a pet that feels threatened)
- **Find** your first aid kit, oxygen unit and automated external defibrillator (AED)
- **Exposure** protection: Avoid contact with blood and other body fluids
  - Locate and don barriers such as gloves, eye shields and resuscitation masks

Remeber S-A-F-E

S Stop
- Stop
- Think
- Act

A Access the scene
- Scene Safe?
- Safe to approach?
- Any hazards?
- Additional risks

F Find and secure the first aid kit (and oxygen and AED unit)
- First aid kits contain critical supplies such as barriers

E Exposure protection
- Use barriers such as gloves and mouth-to-mask barrier device
- Don gloves and inspect them for damage

Risk of Infection

As noted in the previous chapter, anyone in a position to provide first aid care may come into 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 blood-borne pathogens. Saliva, sweat, urine and faeces 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 sharps 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 minimise 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.

9

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

CHAPTER 9 REVIEW QUESTIONS

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. non-latex 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 242.

SKILL: Scene Safety Assessment

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.

S-A-F-E

S – Stop

- Stop
- Think
- Act

A – Assess scene

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

F – Find oxygen unit, first aid kit and AED, and take them to the injured person

- First aid kits contain critical supplies such as barriers

E – Ensure exposure protection

- Use barriers such as gloves and mouth-to-mask barrier devices

Remeber S-A-F-E

S Stop
- Stop
- Think
- Act

A Access the scene
- Scene Safe?
- Safe to approach?
- Any hazards?
- Additional risks

F Find and secure the first aid kit (and oxygen and AED unit)
- First aid kits contain critical supplies such as barriers

E Exposure protection
- Use barriers such as gloves and mouth-to-mask barrier device
- Don gloves and inspect them for damage

SKILL: Donning and Doffing Gloves After Use

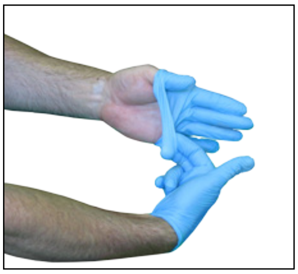
Objectives

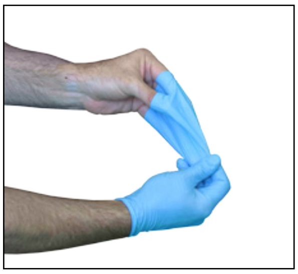
- *Demonstrate donning of gloves without tearing or compromising glove integrity*
- *Demonstrate removal of gloves without contaminating exposed skin*

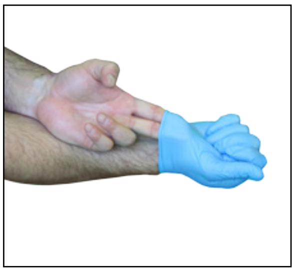
Before donning gloves, remove rings or jewellery that may tear the gloves during use.

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 bag to avoid others having contact with the gloves
    - This bag can also be used for the disposal of all other infected materials after use







10 Response And Assessment Initial Assessment and Positioning for Care

CHAPTER 10 OBJECTIVES

1. What are the three steps to the assessment sequence?
2. What technique assists the rescuer in placing an unresponsive person on his back?
3. What is agonal breathing?
4. When should the recovery position be used?
5. When should the recovery position not be used?

The assessment sequence consists of these primary steps:

- Assess for responsiveness, including rapid assessment of normal breathing and the presence of a pulse
- Activate EMS
- Adjust the patient's position for ongoing care as appropriate

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

Assessing Responsiveness and Pulse Check

Once a rescuer ensures the scene is safe, assess the victim'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 patient care while awaiting EMS. It will identify changes in responsiveness, alerting you to changes in the injured diver's condition.

If the injured diver is responsive, remember to introduce yourself, state you are trained in first aid and ask permission to help. He should initially be left in the position in which he was 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 victim may be placed in the recovery position or a position of comfort. Reassure the patient by showing a caring attitude and talk to him about what is happening. The rescuer should also try to keep bystanders at a distance to avoid added stress.

If the patient is unresponsive, tap the victim's collarbone and shout, "Are you OK?" At the same time, look quickly for normal breathing, particularly chest movement and a pink colour to the skin and nail beds.

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 victim'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 with 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. 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 may be required to find a pulse if present. 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 programme). For infants, conduct CPR for two minutes then activate EMS if not already done.

If the patient does not respond, call EMS, turn him on his back and begin CPR (CPR techniques are covered later in this book). To turn an adult patient from a face-down position onto his back, use the log-roll technique.

NOTE
Abnormal respirations are commonly associated with cardiac arrest. Breathing efforts may be infrequent, irregular, diminished or characterised as 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.

Positioning a Patient 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 minimises the risk of airway obstruction by the tongue or body fluids for individuals with a reduced level of consciousness

Recovery Position

If normal breathing is present or resumes, place the unresponsive, injured person in the recovery position to ensure an open airway. This helps to prevent blood and vomit from obstructing the airway or flowing into the lungs. Should vomiting occur or when blood or other fluids are present in the mouth, gravity will aid in removal and minimise the chance of aspiration.

Remember to call local EMS. Until help arrives, continually check that the victim is still breathing.

The recovery position is accomplished from a supine position.

- Kneel beside the patient and make sure that both of his legs are straight
- Place the patient's arm nearest to you at right angles to his body, with the elbow bent and palm facing upward
- Bring the far arm across the patient's chest and hold the back of his 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 the patient's clothing and pull the knee up, keeping the foot on the ground
- Keeping the patient's hand pressed against his cheek, pull the far leg 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 back the patient's head to ensure the airway remains open
- Adjust his hand under his cheek, if necessary, to keep the head tilted
- Check breathing regularly

10

NOTE

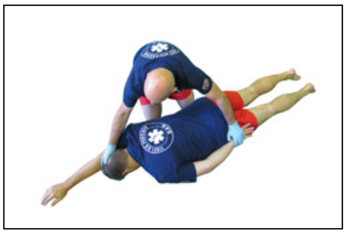
Do not place people with suspected spinal injury in the recovery position because it places them at increased risk of further injury.

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

Log Roll

If the patient is not on his back, you need to roll him into that position. To minimise the risk of neck and back injury or in the case of suspected spinal trauma, use the log-roll technique.

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



NOTE

When two rescuers are present, one should immobilise the patient's head while the second person rolls him on his back. The rescuer at the head controls the action by directing when to roll the patient.

CHAPTER 10 REVIEW QUESTIONS

1. **Initial assessment includes:**
   a. assessing for responsiveness and activating EMS
   b. adjusting the patient's position for care
   c. initiating CPR
   d. all of the above
   e. a and c 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 victim in the recovery position is important to maintain an open airway and to minimise the potential of blood and vomit causing an obstruction**
   a. True
   b. False

6. **Persons with neck, spine or pelvic 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 242.

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 shoulder 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 him remain where he is 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 patient does not respond:

- Shout for help or call EMS
- Move the patient on to his back
- Check for a pulse and normal breathing
    - To take a carotid pulse, place the tips of your index and middle fingers on the patient'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 patient does not have a pulse or is not breathing normally, send someone for help or if you are on your own, leave him and alert EMS. After this, return and start CPR, beginning with chest compressions

If the infant patient 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 patient from his back into the recovery position, keeping the spine aligned*

- Kneel beside the patient and make sure that both of his legs are straight
- Place the patient's arm nearest to you at right angles to the body, with the elbow bent and palm facing upward
- Bring the far arm across the chest and hold the back of the patient's 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 patient's clothing and pull the knee up, keeping the foot on the ground
- Keeping the patient's hand pressed against his cheek, pull the far leg at the knee to roll the patient toward you and onto his side
- Adjust the top leg to form 90-degree angles at both the hip and knee
- Tilt the patient's head back to ensure the airway remains open
- Adjust the patient's hand under his cheek if necessary to keep the head tilted
- Check breathing regularly

11 Response And Assessment
Neurological Assessment

CHAPTER 11 OBJECTIVES

1. How can you minimise permanent disability due to a blood-flow interruption to the brain?
2. What is F-A-S-T?

F Facial droop

A Arm weakness

S Speech difficulty, sudden severe headache

T Time (note the time and call EMS immediately)

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 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.

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 his arms and bend (extend) his wrists. Ask the person to hold that position for about 10 seconds. Watch for lowering of an arm or straightening of a wrist.

Speech

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

Time

Note the time, and quickly call 10177 (or your local emergency services number) 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 to which future changes can be compared.

CHAPTER 11 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 242.

SKILL: F-A-S-T

Objective

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

Have the injured person remain seated during the assessment.

- Have the injured person smile. Observe his 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 he 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 10177 or your local EMS number immediately

F Facial droop

A Arm weakness

S Speech difficulty, sudden severe headache

T Time (note the time and call EMS immediately)

12 Response And Assessment Conducting a Neurological Assessment

SKILL OBJECTIVES

1. How can you minimise permanent disability due to a blood-flow interruption to the brain?
2. What is F-A-S-T?

Use a neurological assessment as a follow-up to the F-A-S-T exam or when symptoms are obscure and 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 obvious, place the injured diver on oxygen (covered in the next section), then conduct the neurological assessment which will provide a clinical baseline.

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 diving 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 completed 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 patient's history. Understanding what happened (the events leading up to the injury) as well as any underlying medical issues can often enable a more accurate context for the assessment.

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

- **S**igns/symptoms
- **A**llergies
- **M**edications
- **P**ertinent medical history
- **L**ast oral intake
- **E**vents leading to the current situation

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 indicate abnormality. Factors like fitness level, recent exertion and emotional stress can result in heart and respiratory rates outside normal ranges but do not equate to a medical emergency. In all medical evaluations, consider the patient'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 gasses 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.

CHAPTER 12 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. **F-A-S-T stands for**
   a. obtaining information about an injured diver
   b. remembering to get a dive profile sample
   c. calculation assessment in mental function
   d. obtaining insurance and compensation

Review answers are on Page 242.

SKILL: Taking a History

Objective

- *Interview a patient in a simulated scenario using the S-A-M-P-L-E mnemonic to identify previous medical history and determine where he 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.**

- **S** – signs/symptoms
- **A** – allergies
- **M** – medications
- **P** – pertinent medical history
- **L** – last oral intake
- **E** – events leading to the current situation

The neurological assessment slate includes an area to record your findings.

SKILL: Taking Vital Signs

Objective

- *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 his 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 he is unable to finish sentences or is visibly short of breath, more immediate respiratory aid may be necessary. To minimise self-consciousness and the potential influence your observations may have on respiratory rate, try to count without letting the individual know that you are monitoring his breathing. It may be helpful to have a bystander count respirations, or you can continue to hold the individual's wrist after taking his pulse for a full minute while you count respirations for the second 30-second interval. Normal adult resting respiratory rates are between 12 and 20 breaths per minute.

13 Response And Assessment The Four Functional Areas of a Neurological Assessment

CHAPTER 13 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 co-ordination evaluated?

Dividing the neurological assessment into four functional compartments focuses the first aid provider’s attention on specific areas.

This convenient division allows the examiner to evaluate specific nervous-system functions and simplifies documentation of abnormal findings.

- Mental function
- Cranial nerves
- Motor function (strength)
- Co-ordination and balance

If you find a deficit as you are conducting the neurological exam, verify that EMS have been called. If the patient 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 mental-function 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.

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

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

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

Cranial Nerves

Emanating from 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.

Co-ordination and Balance

If the injured person's responses at this point are normal, then assess co-ordination and balance. DCI and CVA may cause nerve-cell injury or impairment of the cerebellum or spinal proprioception tracts, affecting co-ordination and balance (for more information, see Advanced Concepts below). Co-ordination is evaluated using a finger-nose-finger test (see Page 78). To assess balance, have the injured person walk a straight line and then perform a Romberg (or Sharpened Romberg) test (see Page 79).

NOTE

Speech, balance and co-ordination may also suffer temporary impairment from 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 patient every 60 minutes. Make note of the time of reassessment and any changes in the patient's condition.

ADVANCED CONCEPTS

Proprioceptors are specialised 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 fibres within the spinal cord that convey messages either to or from the brain. Sensory nerve tracts, located primarily in the dorsal horns of the spinal cord, convey information up the cord to the brain. Motor tracts, primarily located in the ventral horn, convey movement directives from the brain.

CHAPTER 13 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. Co-ordination 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. **Which of the following is not part of the cranial nerves evaluation?**
    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. **The Romberg test assesses**
    a. motor function
    b. cranial nerves
    c. mental status
    d. balance

Review answers are on Page 242.

SKILL: Mental Function

Objectives

- *Determine an individual's level of consciousness in a scenario with a simulated injury*
- *Using 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 using a standardised protocol*

Begin your mental-function assessment by simply talking to the person. You have 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:

- Alert
- Verbal stimulus
- Painful stimulus
- Unresponsive

If he is responding to you timely and appropriately, note on your slate he is "alert."

If not, record his 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, immediately begin basic life support

13

Orientation to Person, Place, Time and Event

- **Person:** Ask the injured person his name and if he knows who you are
- **Place:** Ask the injured person if he knows where he is
- **Time:** Ask the injured person the time, date and year
  - Time perception can vary, especially in an accident. As an alternative, consider asking about what period of the day it is (e.g., morning, afternoon or evening)
- **Event:** Ask the injured person if he knows why he is there or why you are having this conversation
  - Ask him to describe the events leading to the incident and about the event itself. Ask him to explain what he was doing prior to the event. Alternately, he 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 him close his eyes and stick out his tongue
- Test ability to communicate by asking him to say a simple phrase such as "red, white and blue" or "no ifs, ands or buts." Any simple phrase will do
- Next, point out three easily identifiable objects and have the individual tell you what they are. Examples may include a mask, pen, watch, light, scuba tank, snorkel and fins. Any easily recognisable combination of three 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 him to repeat his 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 do not force people to count down to single digits

Short-term Memory

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

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	**09**	08	07	06	05	04	03	**02**	01

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 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 his eyes in all directions. Hold your finger about 1 meter away from his face and while his head is kept still, move your finger to the right, left, up, down and diagonally. Record any direction the injured person cannot follow with his eyes.

Facial Control

To evaluate the facial muscles, ask the injured person to tightly close his 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 from the injured person's ear and by rubbing your thumb, index and middle fingers together. 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)

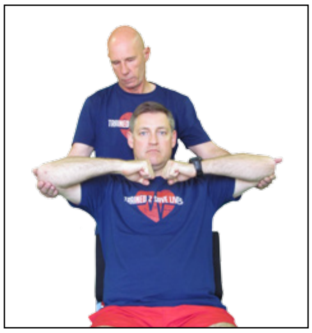
Objective

- *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 he can.

To test hip flexors, have the person raise his knee, lifting his 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 him pull up his foot against your hand as well as press down against your hand.

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

13

SKILL: Co-ordination and Balance

Objectives

- *Assess an individual's co-ordination 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 co-ordination and balance.

Finger-Nose-Finger

To test co-ordination, stand or sit in front of the person. Hold your finger approximately 9 cm from the person's face.

Have him touch your finger with his index finger, then touch his nose and then touch your finger again.

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

Minor differences may occur 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 m 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 his feet in a heel-to-toe stance and his arms crossed. Once stable, have him close his 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.

NOTES:

14 Oxygen First Aid in Scuba Diving Injuries Oxygen and Diving Injuries

CHAPTER 14 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 non-fatal drowning?
9. What is the first responder's role in a non-fatal 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 secondary to 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 following decompression. Bubbles may cause tissue disruption, compromise blood flow and/or trigger inflammatory responses, which may result in symptoms.

Though most cases of DCS are mild and do not pose an immediate risk to life, impaired circulation or function of 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.

In contrast to DCS, AGE is commonly associated with lung-overexpansion injury and can result in acute neurological symptoms including unconsciousness. Bubbles entering the arterial system through damaged lung tissue can quickly travel to the brain and interrupt circulation. The goal of first responders is to enhance blood oxygen levels and speed bubble-size reduction by establishing a gas gradient.

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 on a relative basis 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 can also reduce pain and swelling (oedema) and limit or reverse hypoxic injury.

The Diving First Aid for Professional Divers course emphasises the use of oxygen for diving injuries and non-fatal drowning, but does not address other indications for oxygen treatment.

Non-fatal Drowning

Non-fatal 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 non-fatal-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.[11]

Symptoms of non-fatal drowning may include difficulty breathing, bluish discolouration of the lips, abdominal distention, chest pain, confusion, coughing up pink frothy sputum, irritability and unconsciousness. Victims may also be anxious or cold and would benefit from removal of wet clothes and possible treatment for hypothermia.[11]

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.

Delivery of Oxygen

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 litres 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 (FiO_2). Enhanced flow rates are an inefficient way to compensate for a poor-fitting mask.

When accidents occur in remote locations or far away from medical services and oxygen supplies are limited, rescuers face the dilemma between maximising 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.

Delivery Device	Flow Rate	Inspired Fraction*
Oronasal mask (no reservoir bag)	10 lpm	≤ 0.5–0.6 (50%–60%)*
Non-rebreather mask	10-15 lpm	≤ 0.8 (80%)**
Bag valve mask	15 lpm	≤ 0.9–0.95 (90%–95%)
Demand valve	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 summarises various oxygen-delivery systems and potential values of inspired oxygen with their use.

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 pressures 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 on inspiration and coughing.

The most severe symptoms may occur after about 12-16 hours of exposure at 1 ATA.[12] The time to initial symptom onset is expected to reduce at higher partial pressures (greater than 1 ATA). Symptoms may be seen from 8-14 hours at 1.5 ATA[13] and from 3-6 hours at 2 ATA.[12, 13] 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 and 3 ATA is CNS toxicity.[12, 13, 14]

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 at ground or 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 and less than 2 lpm with total flow durations of little more than 15 minutes for one reactant set.

CHAPTER 14 REVIEW QUESTIONS

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 the following 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 non-fatal drowning may include**
   a. difficulty breathing
   b. abdominal distension
   c. chest pain
   d. hyperthermia
   e. all but d

4. **As a first responder to a non-fatal drowning, your role is to**
   a. monitor vital signs
   b. provide supplemental oxygen
   c. arrange transport to the nearest medical facility
   d. all of the above

5. **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

6. **In remote areas, the priority in oxygen delivery is**
   a. to conserve oxygen supplies
   b. to maximise the highest inspired fraction of oxygen
   c. limit the flow of oxygen

7. **Oxygen toxicity, whether CNS or pulmonary, is not a concern for oxygen first aid to an injured diver**
   a. True
   b. False

Review answers are on Page 243.

15 Oxygen First Aid in Scuba Diving Injuries Handling Oxygen Safely

CHAPTER 15 OBJECTIVES

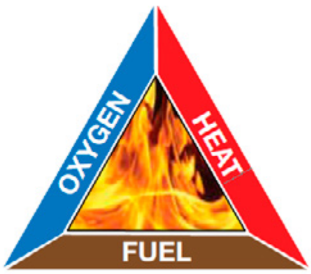
1. What is the fire triangle and how is oxygen involved?
2. What two steps should be implemented to reduce the risks of handling oxygen?
3. What safety precautions should be implemented when using oxygen equipment?
4. What grade of oxygen should be used for diving first aid?
5. What documentation is required to receive an oxygen fill?
6. How should an oxygen unit be stored?
7. When should an oxygen unit's components and cylinder pressure be checked?
8. 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. Problems associated with the use of properly maintained emergency-oxygen devices are rare. Three elements are required for a fire to exist: Heat, fuel and oxygen. 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 (oil deposits and hydrocarbons are commonly used as lubricants for diving and are found on dive boats), heat from the sun and rapid opening of the oxygen cylinder valve are minimised.

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% 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 odour test is conducted and the cylinder contents be evacuated before the fill. When odours are detected or damage to the valve or cylinder is observed, medical-grade oxygen cylinders are cleaned before returning them 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 gasses 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 into contact with oxygen. The result may be a fire
- Oxygen cylinders should not be exposed to temperatures higher than 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 pressurise. This will reduce the possibility of an oxygen fire if combustible contaminants have been introduced into the system. Once the system is pressurised, 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
- Only use equipment (cylinders, regulators, valves and gauges) that is 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 medication, which can make it difficult to refill your emergency oxygen cylinder. The most common method of documenting the need for oxygen is a prescription but 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 programme. Ask your instructor about retraining opportunities.

Another method that is not commonly used is the 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 can provide this prescription.

Some countries 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/or the regulator depressurised. 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
- Thoroughly clean 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

CHAPTER 15 REVIEW QUESTIONS

1. **Oxygen is one element of the fire triangle**
   a. True
   b. False

2. **The risks of handling oxygen can be reduced by**
   a. keeping the oxygen units free of hydrocarbons found in oils and lubricants that are often found on dive boats
   b. opening the oxygen cylinder slowly
   c. keeping the unit away from the heat of the sun
   d. all of the above

3. **Safety precautions to implement when using oxygen cylinders include**
   a. not allowing any oil or grease to come into 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

4. **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

5. **Methods for obtaining oxygen fills may include**
   a. prescription
   b. documentation of training in oxygen delivery
   c. prospective prescription
   d. any of the above

6. **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

7. **An oxygen unit should be stored**
   a. with the valve closed
   b. in its protective case
   c. assembled
   d. all of the above

8. **It is not necessary to clean oxygen parts and masks**
   a. True
   b. False

Review answers are on Page 243.

16 Oxygen First Aid in Scuba Diving Injuries

Oxygen Delivery Systems and Components

CHAPTER 16 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 two to 10 years; the hydrostatic testing requirement in South Africa is every four years.

If the fill station has concerns about the condition of the cylinder between hydrostatic testing dates, they may require additional testing or inspections before filling the cylinder.

Oxygen cylinders should be clearly labelled. For easy identification and to minimise the risk of using a cylinder and/or its contents for an unintended purpose, oxygen cylinders are colour coded.

Common oxygen cylinder colour combinations include the following:

- green (United States)
- black with a white shoulder (Australia, New Zealand, United Kingdom, Africa and others)
- white (Canada and Europe)

Ask your DFA Pro Instructor for the colour-coding requirements of your region.

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 15-60 minutes. Non-portable oxygen cylinders can last up to eight hours or more. DAN Oxygen Units come with a 2,5 liter 200 BAR steel oxygen cylinder (500 liters).

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 off a boat close to shore. When diving far offshore and assistance is hours away, consider carrying a non-portable 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 constant-flow regulator (discussed later), the approximate duration of an oxygen cylinder can be determined using this formula:

Capacity in litres ÷ flow in litres per minute = approximate delivery time

For example, if a cylinder holds 640 litres and the oxygen flow rate is 15 lpm, the cylinder will last approximately 43 minutes. At 10 lpm, 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 8-10 lpm. Demand-style delivery is preferred because no oxygen is wasted and the oxygen supply usually lasts longer.

A partially filled oxygen cylinder should be changed to a full one when the pressure drops below 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 gasses 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.

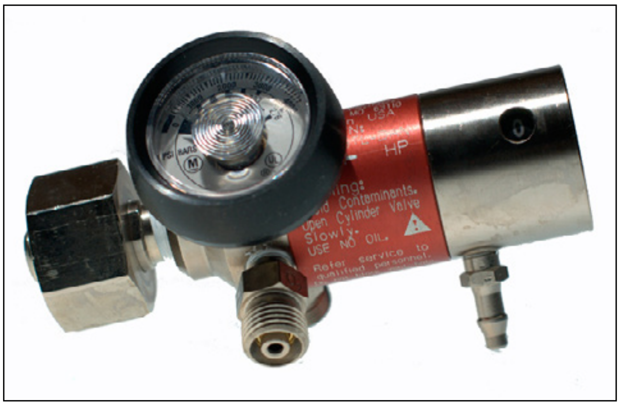
Oxygen delivery occurs via three common types of regulators regardless of how the regulator is attached to the cylinder valve.

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 constant-flow regulators.

A multifunction regulator is preferred over the other styles because it will allow a rescuer to provide as close to 100% 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-authorised service representative.



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 14 bar, 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.

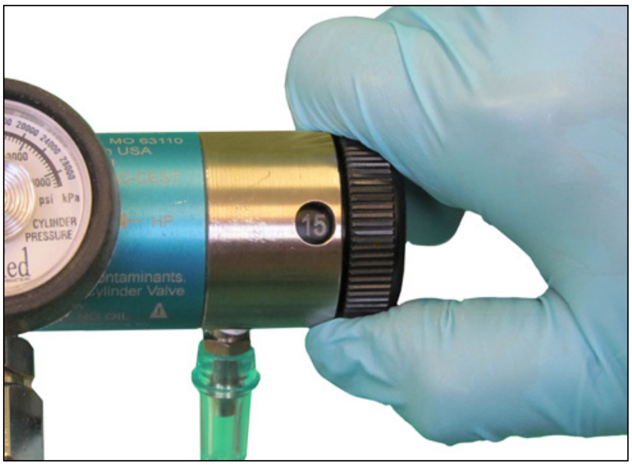
Flow meter. The flow meter, an integral part of the pressure regulator, indicates the oxygen flow rate delivered through the barbed outlet to the constant-flow device (non-rebreather mask or oronasal resuscitation mask with supplemental oxygen inlet). Oxygen flow is measured in lpm. The control valve 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 of 10 lpm when used with either a non-rebreather 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 non-portable ones.

Oxygen system adapters are available commercially. To minimise 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 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 is typically green, indicating it is intended for oxygen delivery.

Certain types of constant-flow masks provide oxygen-safe, clear, plastic tubing to connect the mask to the regulator's constant-flow barb. The flow meter adjusts the flow volume through this hose to the mask.

Oxygen Masks and Delivery Devices

An oxygen mask held 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% inspired oxygen as possible. In contrast, common constant-flow masks provide from 35-75% 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.

Non-rebreather mask

The non-rebreather 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 non-rebreather mask consists of a mask with three non-return valves: One on either side of the mask and one separating the mask from the reservoir bag. 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, from which the injured diver breathes in the oxygen. The non-return 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 non-rebreather 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 non-rebreather 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 non-rebreather mask. Adjust the flow rate to the non-rebreather 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 non-rebreather mask may deliver inspired oxygen concentrations up to 80%.

NOTE

Caution: If the oxygen supply to the non-rebreather 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 non-rebreather 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.

CHAPTER 16 REVIEW QUESTIONS

1. **Oxygen delivery systems consist of which of the following?**
   a. First aid kits and barriers
   b. Oxygen cylinders and pressure-reducing regulator
   c. Oxygen hose and face mask
   d. b and c

2. **Two considerations when choosing an oxygen cylinder are distance to emergency care and size (volume) of the cylinder**
   a. True
   b. False

3. **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**
   a. True
   b. False

4. **During administration, an oxygen cylinder should be switched when the pressure drops below 14 bar if there is another cylinder available. If not, use the cylinder until it is empty**
   a. True
   b. False

5. **Oxygen cylinders are subject to periodic visual and hydrostatic testing**
   a. True
   b. False

6. **Oxygen-cylinder marking colours are standardised throughout the world to avoid confusion**
   a. True
   b. False

7. **Oxygen regulators are fitted with a pin-indexing system to prevent use with other cylinder valves that may not contain oxygen**
   a. True
   b. False

8. **A demand valve flows only when the injured diver inhales, allowing the oxygen to last longer**
   a. True
   b. False

9. **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

10. **The constant-flow mask that is recommended when a breathing, injured diver cannot activate the demand inhalator valve or when there is more than one injured diver is called a**
    a. non-rebreather mask
    b. oronasal resuscitation mask
    c. bag valve mask

Review answers are on Page 243.

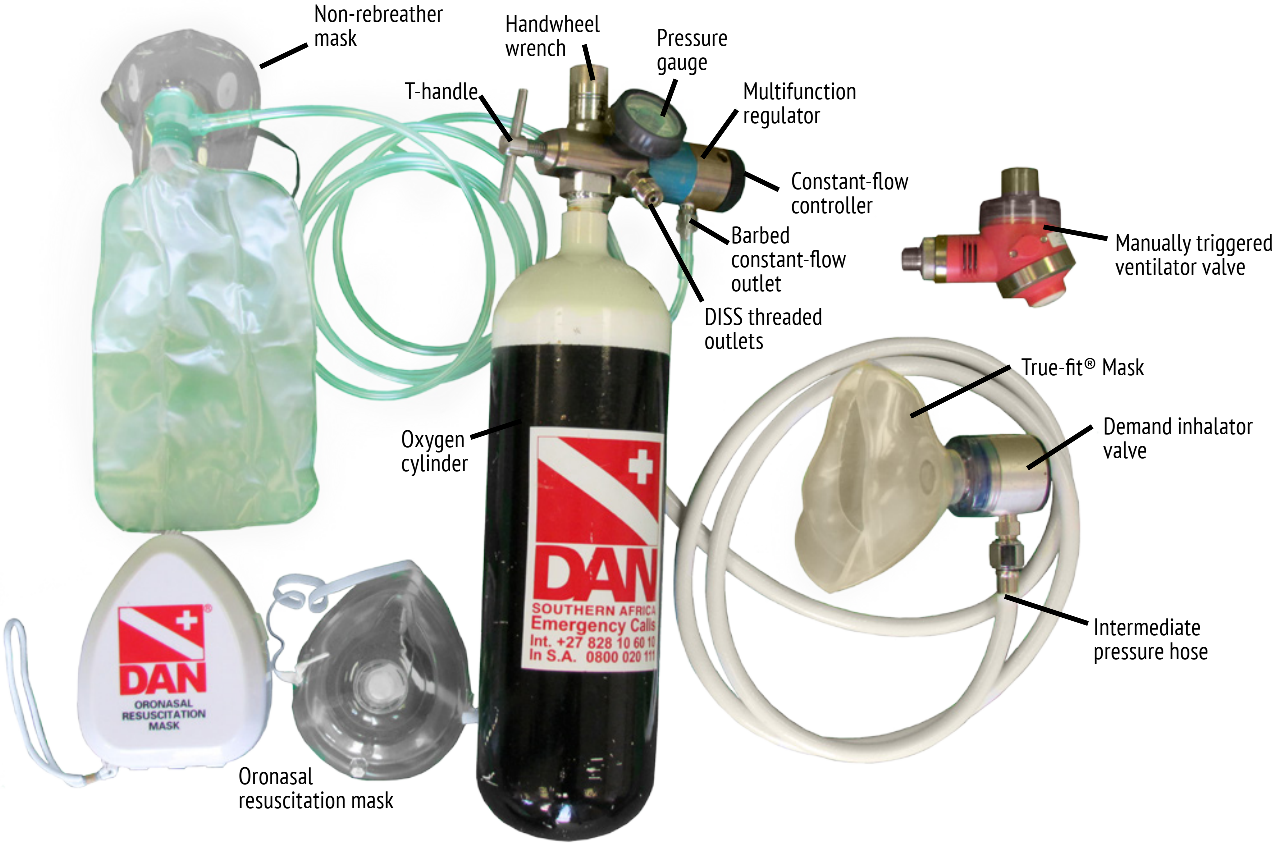
SKILL: Oxygen Equipment Identification, Disassembly and Assembly

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 depressurised
- 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
  - Check valves to ensure oxygen does not flow from threaded ports
- 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



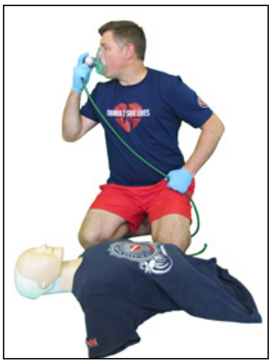
16

SKILL: Demand Inhalator Valve

Objective

- *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.

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

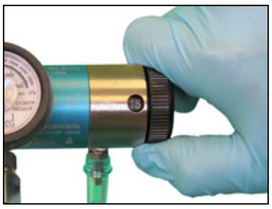
- Call EMS or appropriate medical facility
- Contact DAN for consultation and co-ordination of hyperbaric treatment

SKILL: Non-rebreather Mask

Objectives

- *Provide emergency oxygen to an unresponsive breathing, injured diver using the non-rebreather 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 non-rebreather mask. The non-rebreather 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 non-rebreather 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 lpm

Prime mask reservoir bag

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

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

- Check the mask for any leaks around the injured diver's face
- Adjust the elastic band around the head to hold the mask in place
- 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 non-return 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

NOTES:

17 Cardiopulmonary Resuscitation

CHAPTER 17 OBJECTIVES

1. What is the goal of CPR?
2. What are the five 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 quickly become worse. Constantly monitoring an injured diver and being prepared to take the next step is critical in incident management. Should the injured person stop breathing or if his heart should stop, intervention with cardiopulmonary resuscitation (CPR) is essential to maintain oxygen supply to tissues.

Maintenance of oxygen supply to tissues 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 four to six 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 normal breathing and check for a pulse if trained to do so (approximately 10 seconds).
3. If the patient is not breathing normally, provide chest compressions to temporarily take over the function of the heart and circulate blood.
4. Open the airway and provide rescue breaths to deliver air to the lungs.

Circulation
Airway
Breathing

NOTE
The exhaled air used during rescue breathing contains about 16% oxygen compared to 21% in the normal air we breathe. 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

A heart attack, also known as an acute myocardial infarction (AMI) or acute coronary syndrome (ACS), is the term used to describe the symptoms associated with the blockage of the arteries that supply the heart. 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, which is available as either pills or a sublingual spray. You may need to assist the person with taking his own medicine, but do not attempt to give nitroglycerine to anyone who does not 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, 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 centre of the chest or 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 pre-existing medical conditions.

NOTE

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

Special Circumstances with Resuscitation[1]

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 responder. 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 patient 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 the patient for purposeful movement or regular breathing to indicate responsiveness.

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 patient does not respond, continue CPR and verify that EMS is on the way.

Drowning

Drowning is defined as submersion/immersion in a liquid that impairs respiration and can be fatal or non-fatal. In the event the heart stops or experiences an arrhythmia due to submersion with a resulting loss of circulating oxygenated blood, immediate intervention with CPR can provide the victim with the support necessary for survival. However, multifaceted medical intervention is required 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 rescue breaths (not compressions). 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.

Airway

Breathing

Circulation

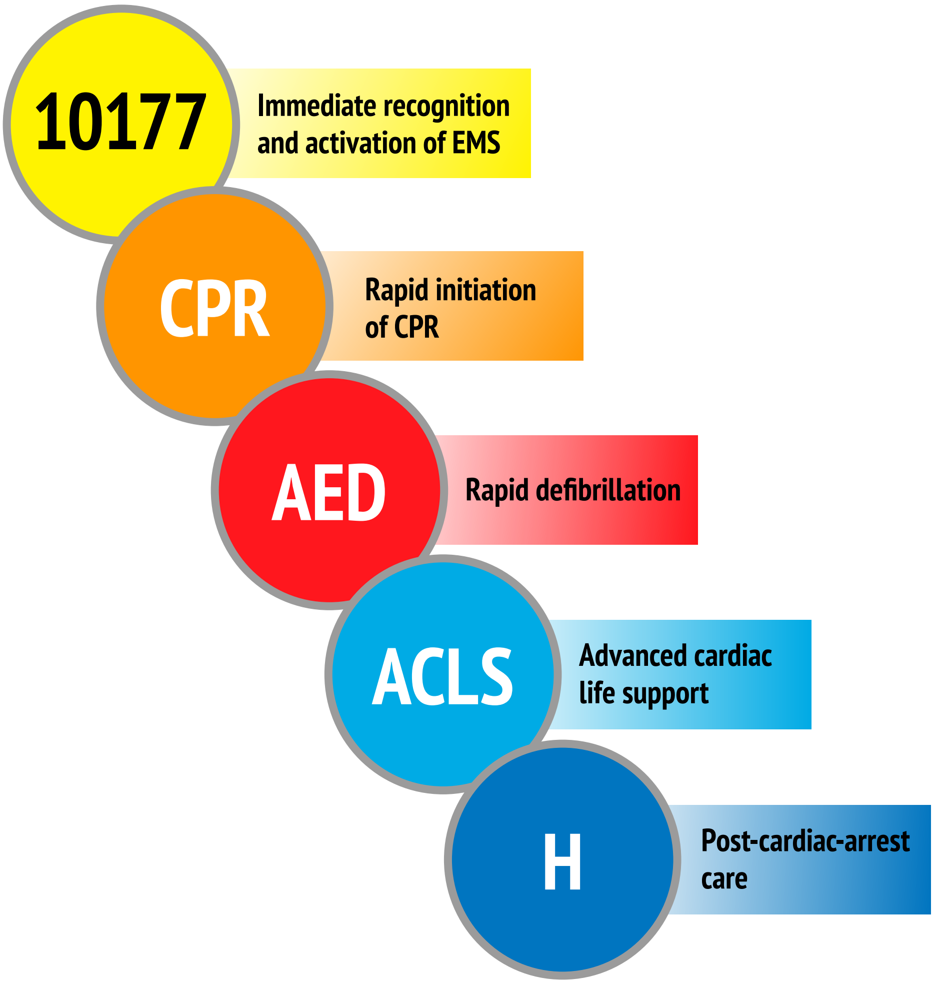
Non-fatal drowning refers to a situation in which someone almost died from being submerged and unable to breathe. While non-fatal drowning victims may revive quickly, lung complications are common and require medical attention.

Symptoms of non-fatal drowning may include difficulty breathing, bluish discolouration of lips, abdominal distention, chest pain, confusion, coughing up pink, frothy sputum, irritability and unconsciousness. Victims 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 victim to the nearest medical facility as soon as possible.

Chain of Survival

There are five key steps in the chain of survival.



Immediate Recognition and Activation of EMS

In the event of an emergency, the critical first step is recognising 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 using those resources. After establishing unresponsiveness, call EMS. By activating local EMS, the victim's 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 cell phone on the speaker setting. This practice minimises 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:

- child victim
- 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 do not have AEDs readily available, so calling EMS to get an AED on scene as soon as possible provides the best chance of re-establishing a life-sustaining heart rhythm.

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

- his/her name
- exact location
- condition of the patient(s)
- care provided
- number of patients
- call-back phone number
- what happened

Do not hang up until the operator releases you to return to the patient. 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 recognising cardiac arrest.

Rapid 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.

Rapid 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. Delays of as little as 7-10 minutes greatly reduce the person's chance of survival.

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 stabilise the patient and make him 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 patient 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.

CHAPTER 17 REVIEW QUESTIONS

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, a patient's heart restarts after someone performs CPR on them**
   a. True
   b. False

6. **The five links in the chain of survival in correct order are**
   a. 10177, CPR, AED, advanced cardiac life support, post-cardiac-arrest care
   b. CPR, 10177, AED, advanced cardiac life support, post-cardiac-arrest care
   c. AED, advanced cardiac life support, post-cardiac-arrest care, 10177, CPR
   d. post-cardiac-arrest care, advanced cardiac life support, 10177, 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 persons are involved
   d. your name and the first aid provided
   e. all of the above

Review answers are on Page 243.

18 Cardiopulmonary Resuscitation
Starting CPR: Supporting Circulation

CHAPTER 18 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?
3. What is the recommended depth and rate for CPR compressions on an infant?
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 are not present, a single rescuer initiates CPR, while another individual (if available) activates EMS. The individual activating emergency services should inform them that the patient is not breathing normally and has no pulse.

The single rescuer should ensure the patient 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 centre of the victim'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 centre 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 120 beats per minute. Pivoting from the hips for compressions allows the rescuer to use his body weight to assist with compressions and facilitates a smooth, rhythmic motion.

Compression depth should be 5-6 cm. Compressions should be done 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 (Health-care Provider (HCP) Version)

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 minimise 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 minimise rescuer fatigue.

Chest Compressions on Children (HCP Version)

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 a 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 one-year old and puberty, but the physical size of the child, not his 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 or approximately one-third of the thickness of the child’s chest. The compression rate remains 120 beats per minute. A single rescuer should use a 30:2 CPR compression and ventilation ratio for children.

Two-Person Child CPR (HCP Version)

When a second rescuer is available for CPR on a child, the compression-to-ventilation ratio changes to 15:2, maintaining a rate of 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 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 (HCP Version)

Infants are generally considered to be younger than one-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 centre 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 120 per minute followed by two small breaths (puffs of air from the rescuer's cheeks), then repeat.

Two-Person Infant CPR (HCP Version)

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 from 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.

ADVANCED CONCEPTS

Cardiac arrest in children and infants is usually due to respiratory arrest. If they stop breathing, their hearts stop once the oxygen circulating in the bloodstream has been depleted. 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, especially an infant or child, who has received CPR should be evaluated by health professionals.

CHAPTER 18 REVIEW QUESTIONS

1. **The recommended rate of compression for CPR on all ages is**
   a. 60-80 compressions per minute
   b. 120 compressions per minute
   c. at least 140 compressions 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. 4-5 cm
   b. 5-6 cm
   c. 7-8 cm
   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
   c. 2.5 cm

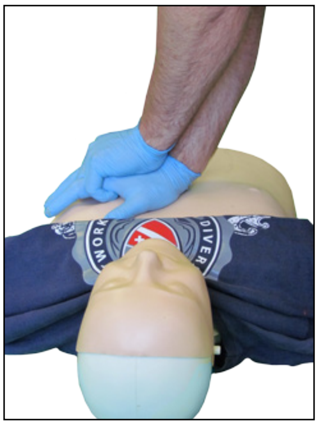
4. **The compression-to-ventilation ratio for two-person CPR on children and infants is**
   a. 30:2
   b. 30:3
   c. 15:2
   d. 15:1

Review answers are on Page 243.

SKILL: Chest Compressions for CPR

Objectives

- *Demonstrate proper hand positioning for chest compressions on a manikin for both an adult and a child*
- *Use proper body mechanics to accomplish chest compressions consistently to a depth of 5-6 cm on an adult CPR manikin, at a rate of 120 compressions per minute*
- *Use 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 120 compressions per minute (HCP version)*
- *Demonstrate proper finger/thumb placement for infant chest compressions (HCP version)*
- *Use proper body mechanics to accomplish chest compressions consistently to one-third the chest depth on an infant CPR manikin at a rate of 120 compressions per minute (HCP version)*



Chest Compressions: Adult and Child

- Kneel by the patient's side
- Place the heel of one hand in the centre of the chest, between the nipples
- For adult patients, 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 for an adult, 5 cm 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 120 compressions per minute
- Compression and release should take the same amount of time
- For children, use only one hand if the size of the child permits it

Chest Compressions: Infants – Single Rescuer (HCP Version)

- Position yourself at the infant's side
- Place two or three fingers side by side in the centre 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 120 compressions per minute
- Compression and release should ake the same amount of time

Chest Compressions: Infants – Two Rescuers (HCP Version)

- Position yourself at the infant's feet
- Circle the infant's chest with both hands, placing your thumbs in the centre 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 120 compressions per minute
- Compression and release should take the same amount of time

19 Cardiopulmonary Resuscitation
Continuing CPR: Supporting Respiration

CHAPTER 19 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 victim'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 victim's mouth. Barriers are recommended to minimise exposure risk. Disposable face shields are available in packets that can be carried in a wallet. Larger barriers such as oronasal resuscitation masks and 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 victim'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 with 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 certification.

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 possible obstruction of the airway. Allow the chest to fall (exhalation) about one second and then deliver a second breath. If rescue breaths do not cause the chest to rise, reposition the victim'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 victim's dentures only if they cannot be kept in place. In all other situations, keep them in the victim's mouth because they will make it easier to create a seal.

Rescue Breathing for Children (HCP Version)

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 (HCP Version)

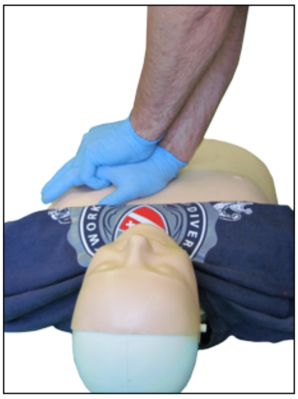
The technique for providing rescue breaths for an infant requires less extension of the infant's neck and a smaller volume of air. Gently tip the infant's head to straighten the neck and airway to a neutral position. Overextending the neck as you would with adults and children will collapse an infant's 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.

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

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

Rescue Breaths Without Compressions



If a pulse is present but the victim is either not breathing or not breathing normally, the rescuer at the level of HCP should provide rescue breaths. Begin rescue breaths with a single ventilation for all age groups. Continue with one breath every five to six seconds for adults and children and every three to five seconds for infants. Use the same techniques as when providing rescue breaths during full CPR.

Maintain the airway and monitor the patient 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 infants, children, and 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%. Therefore, oxygen should be present at every swimming pool and dive site.

By providing oxygen during CPR for victims of scuba diving accidents or drowning, the fraction of oxygen delivered to a non-breathing 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% 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 in which physical contact is not desired. It is a good choice when two rescuers are available because using it is less fatiguing than providing rescue breaths.

The BVM is connected to a mask by means of a mechanism with several one-way valves. When the bag is compressed, air or oxygen 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%, compared with the 16-17% 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 bag and the mask are available in sizes suitable for adults, children and infants. Most adult self-inflating bags have a volume of 1 600 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 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 minimised 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, such as may be encountered if the lungs are overfilled, 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 then prohibits further air volume 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 non-return 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 re-entering 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.

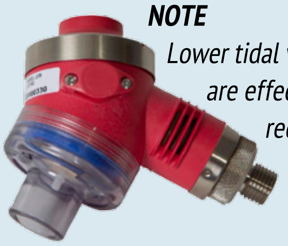
Oxygen reserve bag. The majority of BVM devices have a reserve bag of some type. The reserve bag is designed to collect the oxygen during the expiration cycle so that it is available for the inspiration cycle.

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 re-enter when the reserve bag is used in cases where 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, oxygen-powered resuscitator, is a dual-function regulator. It allows rescuers to provide emergency oxygen with optimal oxygen levels to a non-breathing 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 minimise 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 non-breathing 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_2O. In addition, the unit includes a redundant valve should the first one fail.

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 oesphagus pressure is greater than 15-20 cm H_2O).

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 acoustic alarm that alerts the operator of excessive levels of pressure in the airways. If the device does not signal an acoustic alarm, 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.

CHAPTER 19 REVIEW QUESTIONS

1. **Each rescue breath should last about**
   a. two seconds
   b. one second
   c. five seconds

2. **To avoid overexpansion of their lungs, the volume of ventilations for children should be adjusted to accommodate their size**
   a. True
   b. False

3. **When delivering rescue breaths to an infant, the head should**
   a. be extended as it would for an adult or child
   b. not be extended at all
   c. be extended gently but not as far as you would for an adult or child

4. **When delivering only rescue breaths (no compressions) on an adult, the rate of ventilations is one breath every**
   a. 10 seconds
   b. 5-6 seconds
   c. three seconds

5. **Rescue breaths only (no compressions) on an infant should be delivered every 3-5 seconds**
   a. True
   b. False

6. **Full CPR is always recommended for**
   a. drowning victims
   b. scuba diving injuries
   c. both a and b

7. **A bag valve mask**
   a. is a self-inflating bag with a mask that aids in rescue breathing
   b. has a manual trigger that initiates oxygen flow
   c. is best used by two rescuers working together
   d. a and c

8. **Manually triggered ventilators**
   a. allow rescuers to deliver high concentrations of oxygen to non-breathing or inadequately breathing divers
   b. can also function as a demand valve
   c. is best used by two rescuers
   d. all of the above

Review answers are on Page 243.

SKILL: Rescue Breathing

Objectives

- *Demonstrate the proper rescue-breathing technique for an adult and (HCP version) child on a CPR manikin*
- *Demonstrate the proper rescue-breathing technique on an infant manikin (HCP version)*

Rescue Breathing for Adults and Children

- Remain at the patient's side
- Place the face shield or resuscitation mask on the patient'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 patient'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 but 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 the head back 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 patient'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 (HCP Version)

- 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 exhalation before ventilating again

SKILL: Resuscitation with a BVM

Objective

- *Provide emergency oxygen as part of a team to a non-breathing or inadequately breathing, injured diver using a bag valve mask*

Follow these steps to use a BVM to resuscitate a non-breathing or inadequately breathing, injured diver. Ventilating a non-breathing or inadequately breathing, injured diver using the BVM 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 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 an 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 and DAN

SKILL: Using an MTV

Objective

- *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 non-breathing 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 centre 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 his 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 and DAN

SKILL: Full CPR

Objectives

- *Perform two minutes of full CPR as a single rescuer on adult and (HCP version) 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 (HCP version)*

Full CPR: Adult

- Using the compression and ventilation techniques from the previous skills, deliver chest compressions at a rate of 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 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 (HCP Version)

- Using the compression and ventilation techniques from the previous skills, deliver chest compressions at a rate of 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 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

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

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

20 Cardiopulmonary Resuscitation
Use of AEDs During CPR

CHAPTER 20 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 out of 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 disorganised 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 re-establish a normal heart rhythm is with defibrillation. While CPR helps to oxygenate blood and circulate it throughout the body, CPR cannot re-establish 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. 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 recognisable 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 for survival increase. Survival rates drop about 7-10% for every minute a person is in VF without CPR.[15] 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 implementation of the AED. Place the cell phone on speaker function and keep it close, allowing for constant contact with EMS dispatch while initiating 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 patient's heart rhythm.

To use an AED, the patient'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 non-shockable 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 will deliver the shock. Once the AED delivers the shock, *immediately* resume chest compressions. The heart still needs the support of chest compressions, so resume them immediately 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 analysing the heart rhythm again.

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

NOTE

While AEDs can be used in an aquatic setting (near water or where water is on or around the victim), you must dry the chest before placing the pads on the patient. Place AED pads on the patient's chest according to the diagrams on the pads.

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 patient'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 as for an adult. Use paediatric 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 centre of the chest and in the centre of the back.

Cautions

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

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

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 moving boats.

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 charge.

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

Carefully handle pads using the provided tabs or the space 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.

CHAPTER 20 REVIEW QUESTIONS

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

2. **Every minute the heart is in fibrillation, 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 patient 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 centre of the chest and centre of the back
   c. under both arms, with the heart centred between them

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

Review answers are on Page 243.

SKILL: Using an AED

Objectives

- *Demonstrate proper AED pad placement for adults, and (for HCP version) on children and infants, using CPR manikins*
- *Follow the prompts of an AED training unit to simulate care for a non-breathing patient on an adult CPR manikin*
- *Use an AED training unit as part of CPR on an adult CPR manikin*

Remember S-A-F-E.

If the person is unresponsive:

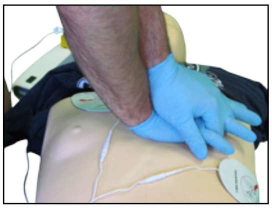
- Shout for help or call EMS

If the person is not breathing normally:

- Send someone for an AED or go for one yourself
- Perform CPR 30:2 until the AED is attached
- Turn on the AED and follow the prompts
- Attach the defibrillator pads to the victim and plug the cord into the AED, following the prompts of the specific unit in use
  - For adults and children, place the pads on the upper-right chest wall below the shoulder and on the lower-left chest extending onto the lateral surface
  - For infants, place the pads on the centre of the chest and on the centre of the back

NOTE: If paediatric AED pads are not available, it is OK to use adult pads.

- Allow the AED to analyse the heart rhythm
- Do not touch the victim during this analysis



If shock is required, follow the AED unit's prompts.

- Visually and physically clear the victim
- State: "I'm clear, you're clear, all clear"
- Administer shock
- Immediately resume CPR 30:2 beginning with compressions. Continue CPR for two minutes

If no shock is required, resume CPR 30:2 until the victim starts to breathe normally or EMS arrives. Do not turn off the AED or remove the pads. The AED will re-analyse the patient's status every two minutes.

21 Cardiopulmonary Resuscitation Foreign-body Airway Obstruction

CHAPTER 21 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 his throat – this is the universal sign for choking. Ask the victim, "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 his head to your question. He 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 the 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 victim can speak, cough, make sounds), the rescuer should encourage the choking victim to cough but should do nothing else. If the victim shows signs of a severe airway obstruction and is conscious, perform abdominal thrusts (often called the Heimlich manoeuver) by doing the following:

- Stand behind the victim 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

If the victim at any time becomes unconscious:

- Carefully lower the victim 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 patient and call EMS. If spontaneous breathing does not start with the removal of foreign material, initiate CPR.

First Aid for Choking Infants (HCP Version)

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 his body. Deliver five back blows between the infant's shoulder blades. Immediately turn over the infant by sandwiching him between your forearms, continuing to support the infant's head and keeping 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 not visible, turn the infant face down, 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 recognise a problem. Even if the object is successfully removed without EMS assistance, medical evaluation is recommended.

Victims of Drowning: Aspiration of Water

The aspiration of water can be suspected in cases of drowning. However, it is usually only a small amount 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 victim on his 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 five seconds on an infant. This is 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 victim to his back and resume CPR or rescue breathing if indicated.

CHAPTER 21 REVIEW QUESTIONS

1. **The most common cause of airway obstruction and choking in adults is**
   a. their tongue
   b. food
   c. dentures

2. **With infants and children, airway obstruction and choking can also be caused by**
   a. food
   b. foreign bodies (toys, coins, nuts)
   c. fingers

3. **Grasping the neck is a common sign made by choking victims**
   a. True
   b. False

4. **If you suspect that someone is choking**
   a. look in the mouth
   b. check for responsiveness
   c. ask, "Are you choking?"
   d. ask a doctor

5. **With complete airway obstruction, the victim will be unable to __________ but might nod his head in response to your question. If the victim is unable or has a limited ability to move air, he may soon lose __________**
   a. yell for help, his breath
   b. talk, his breath
   c. breathe/cough/speak, consciousness

6. **In the case of a partial airway obstruction, the rescuer should encourage the choking victim to cough but should do nothing else**
   a. True
   b. False

7. **If the victim at any time becomes unconscious, the rescuer should**
   a. drop the victim in the hope that the fall will dislodge the foreign body
   b. ease the victim to the ground, remove the foreign body if visible and start CPR
   c. ease the victim to the ground and initiate supplemental oxygen therapy

8. **An obstructed airway in a responsive infant should be cleared with back blows, alternating with chest compressions**
   a. True
   b. False

9. **What must you do when a victim regurgitates?**
   a. Roll the patient on his side and wipe or suction out the mouth
   b. Blow vomit back into the stomach
   c. Remove gloves and wipe away vomit with bare hands

10. **Suctioning for adults, children and infants respectively should be limited to**
    a. 15 seconds, 10 seconds, five seconds
    b. two minutes, one minute, 30 seconds
    c. 20 seconds, 10 seconds, five seconds
    d. 30 seconds, 15 seconds, 10 seconds

Review answers are on Page 243.

SKILL: Foreign-body Airway Obstruction

Objectives

- *Demonstrate proper abdominal thrust technique for management of an obstructed airway in an adult*
- *Demonstrate proper technique for management of an obstructed airway in an infant (HCP version)*

In the case of a mild airway obstruction, encourage the choking victim to cough but do nothing else. If the victim shows signs of a severe airway obstruction and is conscious, perform abdominal thrusts.

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

If the patient at any time becomes unconscious, do the following:

- Carefully lower the patient to the ground
- Activate EMS
- Begin CPR (chest compressions followed by rescue breaths)
- Look in the mouth for obstruction prior to giving rescue breaths
- Finger sweep object only if visible

Obstructed Airway in Infants (HCP Version)

- 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 the infant so it is face up 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 the infant so it is face down and deliver five back blows

SKILL: SUCTIONING

Objective

- *Demonstrate the appropriate technique and duration for suctioning on an adult or child manikin (HCP version) 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 victim on his side
- Estimate the distance from the front of his mouth to his throat
    - Use your fingers to measure from the corner of his mouth to his ear lobe
    - Transfer the distance to the catheter. This is the maximum allowable distance for insertion
- Use a cross-finger technique to open the victim'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 scissor-like 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 victim

Suctioning an Infant (HCP Version)

- 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

22 Secondary Care General Assessments and Medical Emergencies

CHAPTER 22 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 heart attack?
5. What is hypoglycaemia versus hyperglycaemia?
6. What is the primary first aid for seizures?
7. What is the primary 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 Patient Assessment

- State of health: Obtain a general impression of the patient's health and well-being. Is he 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 a patient, 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:

- **S**igns/symptoms
- **A**llergies
- **M**edications
- **P**ertinent medical history
- **L**ast oral intake
- **E**vents leading to the current situation

While conducting the history interview, observe how the patient appears overall. For example, note if his breathing is difficult or if he is having trouble speaking. Does he appear flushed or is he 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 patient'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 non-contagious respiratory illness characterised by airway narrowing and enhanced bronchial thickening. People with asthma are more prone to abrupt airway narrowing if exposed to particular triggers. Most asthmatics 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.

However, when someone with asthma has a prolonged attack with severe symptoms, this can be a life-threatening situation and requires prompt medical attention. When this happens, activate EMS immediately. Try to calm the person to reduce his breathing workload and anxiety. Assist the patient with his prescribed inhaler if necessary (an inhaler should not be given to someone for whom it is not prescribed).

Heart Attack

A heart attack (AMI or 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 the 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 and activate EMS. If the patient has no history of allergy or recent bleeding, consider giving one or two adult aspirin (325 mg) or four baby aspirin (81 mg). Some people with a history of heart problems carry nitroglycerine, which is available as either pills or a sublingual spray. You may need to assist the patient with taking his own prescription but do not attempt to give nitroglycerine to a person who does not 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 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 pre-existing 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" refers 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 (blood-glucose) levels are markedly elevated (hyperglycaemia) or low (hypoglycaemia), 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 may result in hyperglycaemia.

For diabetics who require insulin injections, use of insulin without adequate dietary intake will cause a drop in blood-glucose levels and may cause hypoglycaemia.

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 which is standard equipment for all diabetics). Most diabetics will recognise 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.

Hypoglycaemia 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), dried fruit (two pieces) or orange juice (200 ml or 3/4 cup). It may take 10-15 minutes for the hypoglycaemic symptoms 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.

Once a diabetic has either taken his insulin or 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.

Hyperglycaemia may require medical intervention but rarely requires emergency treatment from the first aid provider. The diabetic experiencing hyperglycaemia will usually be capable of checking his own blood sugar and administering his own insulin if needed.

Signs of Hypoglycaemia	Signs of Hyperglycaemia
- hunger - tremors or seizures - anxiety - sweating - dizziness or lightheadedness - sleepiness - confusion and/or changes in level of consciousness - difficulty speaking - nervousness - weakness	- increased thirst - headaches - difficulty concentrating - blurred vision - frequent urination - fatigue (weak, tired feeling)

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 (haemorrhage).

Strokes can manifest with sudden loss of motor function (inability 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.

Remember: F-A-S-T first then call EMS.

- **Facial droop.** Facial droop occurs on one side of the face and in stroke may involve either the left or right side
- **Arm weakness.** Assess arm weakness by asking the injured person to raise both his arms and bend his wrists so his hands point upward. Ask the person to hold that position for about 10 seconds. Watch for lowering of an arm or straightening of a wrist
- **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

Call EMS at the first sign of stroke. Depending on the victim's condition, BLS may be necessary as airway management can become compromised.

F Facial droop

A Arm weakness

S Speech difficulty, sudden severe headache

T Time (note the time and call EMS immediately)

Seizures

Seizures (also known as fits and convulsions) result from a sudden massive electrical discharge within the brain. Seizures may present as brief, trance-like states or full body convulsions. Epilepsy is a disorder that results from surges in electrical signals inside the brain, causing recurrent seizures. Generalised 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 generalised seizure is the tonic-clonic or grand-mal seizure. Seizures may also be focal and involve only one limb.

Generalised 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 characterise a seizure. The period following a generalised 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 is not 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 patient 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)
- infections, including meningitis or encephalitis
- poisoning, including drugs or heavy metals
- hypoglycaemia
- head trauma
- shock
- hypoxia/hyperoxia
- drug or alcohol overdose or withdrawal
- intracerebral bleeding (i.e., stroke)
- 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.[16]

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
- diarrhoea

Any time you suspect poisoning, call 10177, other local emergency number or a poison control centre. The number for the Tygerberg Poison Information Centre is 0861 555 777. Stating the poison type (type of medication, drug, etc.), approximately how much was used and current symptoms will help guide management. A patient's medical status can worsen rapidly, so all suspected poisonings should be evaluated in a hospital.

Once EMS has been called, your primary role is to monitor breathing and be prepared to perform BLS in the event the person has a compromised airway, stops breathing or becomes unconscious.

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 patients 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. As long as the individual can swallow, oral rehydration in the absence of shock or confusion is a reasonable first aid approach.

Attempt rehydration with 5-8% 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 or 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 be evaluated by a health-care professional. Defer use of mechanical machinery, driving, cycling, participation in sport activities or use of any electronic equipment until after evaluation and clearance by a health-care provider.

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. If the first aid provider can reimplant the tooth without undue pain to the patient, it should be done.

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

CHAPTER 22 REVIEW QUESTIONS

1. A general patient assessment includes assessing
- a. overall impression of the patient's health and well-being
- b. respiratory effort
- c. presentation of skin colour
- d. all of the above

2. Asthma
- a. is a non-contagious 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. Hypoglycaemia 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 patient 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 centre 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 his regular activities regardless of how he may feel
- a. True
- b. False

10. An avulsed tooth can be stored in
- a. egg white
- b. full-cream milk
- c. the injured person's saliva
- d. all of the above

Review answers are on Page 244.

23 Secondary Care
Temperature-related Injuries

CHAPTER 23 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 conduction and how can they benefit the hyperthermic patient?
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 37°C.

Hypothermia[17]

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.

MILD hypothermia is classified as a body core temperature of 32-35°C. Expected symptoms include shivering, lethargy and apathy. Motor skills may also be compromised.

MODERATE hypothermia occurs with body core temperatures of 28-31°C. 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. 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.

Rewarming Strategies

When hypothermia is suspected, prevent further heat loss and initiate rewarming strategies.

Remove the victim from the cold and place him in a dry, warm environment away from wind. Remove wet clothing and replace with dry, warm coverings that also cover the head and activate EMS. Monitor breathing and heart rate, and be prepared to perform CPR should either become dangerously slow or stop and the patient becomes unconscious.

When providing care, avoid rough handling of hypothermic patients. Rough handling may cause an irritable heart to develop arrhythmias such as ventricular fibrillation.

In addition to the steps described above, rewarming can also include the use of hot-water bottles or heating pads applied to the chest, neck and groin to optimise core warming.

Symptom severity and the patient's mental status will largely determine the course of further treatment. Anyone presenting with a history of confusion, lethargy, unconsciousness or stupor 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 but is a condition that may stabilise with rewarming. This condition has led to an axiom within emergency medical circles that, "Patients are not dead until they are warm and dead." Therefore, resuscitation efforts are often performed for prolonged periods with hypothermic patients, especially 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 characterised by clinical deterioration.[17] The 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 minimise 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. Minimise or, better yet, eliminate any exertion by the patient during or after care, until they are 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 diarrhoea, that predispose one to dehydration
- divers wearing 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 patient's condition.

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 does not 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, airconditioning vent or exposure to wind. It works best if combined with a cool mist spray to use 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 patient for airway compromise, seizure, unconsciousness or cardiac arrest.

The next sections describe the progression of hyperthermia severity and the appropriate care for each level.

Heat Rash

Heat rash looks like small pimples and is caused by excessive sweating. It is commonly seen around the neck, groin, elbow creases and beneath breasts. 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:[18]

- heavy sweating
- nausea/vomiting
- headache
- muscle cramps
- fatigue
- weakness
- fainting

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 patient from the heat source
- Keep the patient at rest
- Place the patient 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 patient 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.

Signs and symptoms of heat stroke may include the following:

- rapid pulse
- red, hot and often dry skin
- strange behavior
- hallucinations
- confusion
- seizures
- coma and death

NOTE

Symptom onset may be rapid and requires aggressive cooling and immediate activation of EMS.

Immediate first aid measures include the following:

- Remove the patient from the heat source
- Activate EMS
- Keep the patient at rest
- Place the patient in a cool environment and on a cool surface
- Remove unnecessary clothing
- Replace fluids and electrolytes (intravenous fluids are usually advised because airway management may be compromised)
- Cooling methods: Evaporation, conduction, convection and radiation
    - Apply cold packs to the patient's head, neck, armpits and groin
    - Cover the patient with water-soaked towels or blankets (keep coverings wet with additional cool water)
    - Place the patient near an air-conditioning vent or fan

CHAPTER 23 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 244.

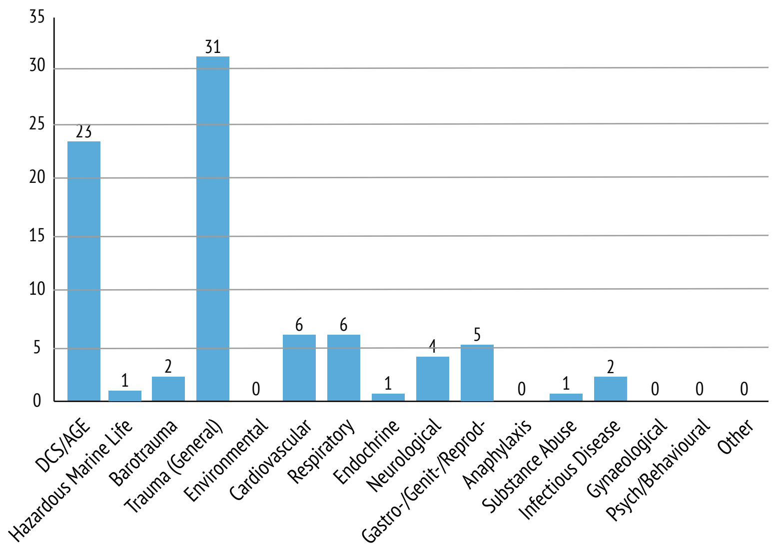
24 Secondary Care

Slips, Falls and Secondary Assessment: Fractures and Splintings

CHAPTER 24 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?

Diving is naturally associated with wet surfaces and, as a result, presents the potential for mishaps. Emergency calls to DAN Medical Services rank such categorical incidents – trauma (general) – even higher than decompression illness. This category includes fractures, lacerations and fingers caught in dive boat ladders.



Diagnostic categories of evacuations co-ordinated by DAN Medical Services in 2012

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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 minimised with proper drainage, rubber matting, non-skid 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. Health and safety standards as well as national and local regulations may apply.

Secondary Assessment

Should someone fall but not incur a life-threatening injury, it is best to leave the injured person in the position he was 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 he has 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 victim that the exam requires limited touching. Pay close attention to his response to your examination and note any areas where pain or discomfort occurs. Signs of injury should prompt EMS activation. If at any point the patient experiences pain, stop the assessment and notify EMS if you have not already called them.

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 patient's nose and ears for blood or fluid.

Palpate the patient’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 patient and shade his 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 patient’s collarbone to check for deformities or discolouration. 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 patient 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 centre point. Gently press on each quadrant in turn to check for any areas that are sensitive, stiffened, hard or painful. If the patient complains of pain in any particular area, press on that area last.

Next, place a hand on either side of the patient’s pelvis and gently push straight down and then in from both sides. Note any instability or painful responses.

Finally, palpate down the arms and legs 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 possible further injury is possible. Attempt to stabilise the injured limb to limit movement and pain.

Test for retained nerve and motor control by asking the patient to wiggle his fingers and toes.

Fractures

Fractures that cause a bone to stick through the skin are referred to as open. 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 immobilised. 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 victim has normal sensation distal to the injury. Repeat these checks every 15 minutes after you apply a bandage to ensure that circulation has not been impaired.

Apply a splint any time you think one might be helpful, but do not attempt to push bones back into place. Pad the injured area to provide both security and comfort, and prepare to evacuate the patient to the nearest appropriate medical facility.

Splinting

Splints reduce movement and physical stress to injured limbs. If EMS is readily available, protect and stablise 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 or cast will not only secure the injured area but will also immobilise the joints above and below the injury. For example, if splinting a forearm, immobilise both the wrist and elbow.

You can use just about anything to immobilise an injured limb. Commercial splints may be made for a specific purpose but splint materials can be improvised. Prior to splint application, remove all jewellery and ensure adequate visualisation of the injured area. This may involve cutting away clothing. Keep the injured area in the same position. Do not attempt to realign the bones (reduce) or straighten the limb. Immobilise joints on either side of the fracture to prevent further injury. Once the splint is in place, continue to monitor circulation and sensation.

CHAPTER 24 REVIEW QUESTIONS

1. **Slips and falls can be prevented by**
   a. keeping walkways as dry as possible
   b. providing drainage, rubber matting or rough surface concrete
   c. using wet-surface warning signs
   d. all of the above

2. **The purpose of a secondary assessment is to identify injuries that may not be readily apparent**
   a. True
   b. False

3. **General guidelines that should be used when conducting a secondary assessment include**
   a. S-A-F-E, standard precautions, asking permission to help
   b. keeping the injured diver in the position found, realigning any limb deformity as quickly as possible
   c. disregarding any complaints of pain due to the fall
   d. calling EMS immediately
   e. a and d only

4. **A splint is used to**
   a. immobilise the joints on either end of an injured limb
   b. ease pain
   c. protect the limb from further injury
   d. all of the above
   e. a and c

Review answers are on Page 244.

SKILL: Secondary Assessment

Objective

- *Demonstrate the technique for 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 patient
- Palpate the patient'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 patient experiences pain, stop the assessment and notify EMS if you have not already called
- Visually inspect the patient's nose and ears for blood or fluid
- Palpate the patient's neck
  - The mechanism of injury will give you a good idea about whether a head or neck injury is likely
- Shade the patient's eyes from the sun or lights, then remove your hands while observing his 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 patient's collarbone for injuries or discolouration
  - Gently slide the tips of your index and middle fingers along the collarbone, with one fingertip on each side of the bone, to check for movement or reaction to your examination. Repeat the action on the other collarbone
- Examine the chest
  - Place your hands on either side of the rib cage and ask the patient 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 patient, hard or painful
- Place a hand on either side of the patient's pelvis and very gently push in and down
  - Note any instability or painful response
- Palpate the patient's arms and legs, checking the bones beneath the skin and muscle

SKILL: Splinting

Objective

- *Apply a splint to a simulated injured limb, immobilising 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 jewellery 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 immobilised
- 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 colour under the nails to return quickly after pressure is released. If colour does not return in three seconds or less, loosen the bandage and rewrap
- Continually reassess the patient and monitor for signs of shock
- Activate EMS if not already done

25 First Aid for Hazardous Marine Life Injuries

CHAPTER 25 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 use?

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 defence 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, these occurrences 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 organise life and indicate natural relationships between different organisms. The table below provides examples of this system through the phylogenetic organisation of some common organisms. The first column identifies the primary taxonomy categories. The remaining columns provide examples of how this system is applied for 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.

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*	Prokaryote* (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*

**See glossary.*

Table 2 shows the primary members of vertebrate and invertebrate families associated with human injury.

Table 2. Taxonomy of specific organisms covered in this text

Vertebrates	Invertebrates
Scorpionfish and stonefish	**Cnidarians (jellyfish, corals and anemones)**
Phylum: Chordata	Phylum: Cnidaria
Class: Actinopterygii (ray-finned fish)	Class: Hydrozoa
Order: Scorpaeniformes	*Millepora* spp. (fire coral)
Suborder: Scorpaenidae	*Physalia* spp. (Portuguese man-of-war)
Pterois spp.	Class: Cubozoa (box jellyfish)
Scorpaena spp.	*Chironex fleckerii*
Suborder: Synanceiidae	*Chiropsalmus* spp.
Synaceja spp.	*Carukia* and *Malo* spp. (Irukandji)
	Class: Scyphozoa (true jellyfish)
Stingrays	Class: Anthozoa (anemones and corals)
Phylum: Chordata	
Class: Chondrichthyes	**Mollusks**
Order: Myliobatiformes	Phylum: Mollusca
Family: Urotygonidae	Class: Gastropoda
	Conus spp. (cone snails)
Sea snakes	*Glaucus* spp. (blue ocean slug)
Phylum: Chordata	Class: Cephalopoda (octopuses and squids)
Class: Reptilia	*Hapalochlaena* spp. (blue-ringed octopus)
Order: Squamata	
Suborder: Serpentes	**Echinoderms (urchins, starfish and sea cucumbers)**
Family: Elapidae	Phylum: Echinodermata
Subfamily: Hydrophiinae	Class: Echinoidea (sea urchins)
	Class: Asteroidea (starfish)
	Acanthaster planci (crown-of-thorns)
	Class: Holothuroidea (sea cucumbers)
	Sponges
	Phylum: Porifera
	Bristle worms
	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 non-latex, medical-style gloves. Use protective eyewear or masks if they are available.

CHAPTER 25 REVIEW QUESTIONS

1. **The three general categories of marine life injuries include**
   a. envenomations
   b. traumatic injuries
   c. seafood poisoning
   d. all of the above

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. non-latex, medical-style gloves
   b. surgical-style masks
   c. protective eyewear
   d. all of the above

Review answers are on Page 244.

26 First Aid For Hazardous Marine Life Injuries Envenomations and Toxins

CHAPTER 26 OBJECTIVES

1. By what mechanisms do envenomations occur?
2. Why do most envenomations occur?
3. What factors may affect the victims' response to envenomations?
4. What are the first aid steps for venomous fish injuries?
5. For which three injuries is the pressure immobilisation 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?

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 victim response.

Envenomations may also cause allergic reactions and, 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 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 minimise 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. Centres for Disease Control and Prevention (CDC) recommends tetanus boosters 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 characterised by the presence of backbones and spinal columns. Members include fish, amphibians, reptiles, birds and mammals. Envenomations from fish species include localised 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 needle-like spines located along the dorsal, pectoral, pelvic and anal fins.

Puncture wounds can be painful, with rapid oedema and subcutaneous bleeding. Pain can last for several hours, oedema typically resolves in two to three days and the tissue discolourations 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 does not readily stretch, tissue trauma or envenomation that causes bleeding or oedema 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 and lower leg.

NOTE
Aquariums and dive operations diving with or around venomous species should have an emergency action plan that includes co-ordination with the local hospitals regarding antivenom options.

Summary: Lionfish, stonefish, scorpionfish and other Scorpaena
- Envenomation results from direct contact/puncture
- Mimetic species tend to cause more serious reactions
- Oedema 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 approximately 1 500 accidents per year in the United States. 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 at the end of 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 and it is for this reason that 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

- puncture or laceration
- blisters around the puncture site
- patches of purple or black skin colouration
- intense pain
- swelling
  - can lead to compartment syndrome
- other
  - nausea
  - vomiting
  - shock (rare)
  - respiratory arrest (rare)
  - cardiac arrest (rare)

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 non-scalding fresh water (upper limit 45°C) for 30 to 90 minutes. Repeat as needed
- Apply topical antibiotic ointment or cream, if available
- Apply bandaging as necessary
- Administer pain-control medications, if necessary
- Seek professional medical evaluation. 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 minimise 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 temperatures 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, minimise 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 victim's assessment, as intense pain may impair his ability to discriminate between "hot but tolerable," "too hot" and "much too hot."

Sea snakes

Phylum: Chordata
Class: Reptilia
Order: Squamata
Suborder: Serpentes

Sea snakes are highly venomous, air-breathing 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 the adult sea snake can reach 90-110 cm in length. They are adept and graceful swimmers, and have been known to reach depths of up to 40 m 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. This is 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 localised 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 but 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 in their 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.

Treating Sea-Snake Envenomations

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

Initial treatment is symptomatic and the first aid responder must focus on three primary tasks:

- Pressure immobilisation technique is recommended for affected limbs. Limiting all movement as much as possible is also advised
- Keep victim hydrated
- Transport victim to a hospital capable of advanced life support and possibly antivenom administration

Summary: Sea snakes

- Prevent bites by avoidance and do not antagonise 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 immobilisation of wounded limbs, limiting movement of the injured diver and hydration
- Seek medical attention if bitten (antivenom may be available)

ADVANCED CONCEPTS

Antivenom* (or **antivenin** or **antivenene**) is a serum product cultivated from animal blood and given therapeutically to neutralise the effects of venomous bites and stings. Antivenom is generally specific to particular venom and works by introducing venom-specific antibodies that help to minimise 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

Pressure Immobilisation Technique

The pressure immobilisation 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 (vs. roller/crepe gauze) is recommended but should not be applied too tightly. Peripheral pulses and circulation should be checked to ensure adequacy. A suggested technique for wrapping pressure is similar to 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 immobilisation 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 minimise this effect, active hydration (ideally with IV fluids) and immobilisation (to minimise muscular activity) are the cornerstones of first aid and medical management.

CHAPTER 26:1 REVIEW QUESTIONS

1. **Envenomations may occur by**
   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 the victim's 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 immobilisation is recommended for which vertebrate injury?**
   a. Stingray punctures
   b. Lionfish stings
   c. Sea snake bites

Review answers are on Page 244.

BONUS CONTENT

Snake Morphology: What do their shape and physical features tell us?

Venomous vs. non-venomous: There are a few physical characteristics that enable differentiation between most venomous and non-venomous snakes, whether terrestrial or marine. It is important to emphasise 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, non-venomous snakes such as colubrids do not. The heads of many venomous snakes are triangular, while the heads of non-venomous snakes tend to be more spoon-shaped.

Elliptical pupils: Most venomous snakes have elliptical pupils, while non-venomous snakes have round pupils.

Loreal pit: Venomous snakes have loreal pits, while non-venomous 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, non-venomous 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, non-venomous snakes.

Head Shape and Fang Location

Whether terrestrial or marine, snakes are characterised 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 poison glands. Two-thirds of all snakes belong to this group. Most aglyphous snakes are non-venomous. Pythons are aglyphous.

Opisthoglyphous (prefix *opistho-* meaning “back”). Opisthoglyphous snakes are found in the family Colubridae. Their classification stems from the “back-of- the-mouth” location of their fangs. These specialised 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 and 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 venom-delivery mechanism. The upper jaw supports a hollow fang on each side, which can be up to half the length of the animal’s head. Fangs are retractile, meaning that fold backwards, and these animals can open their mouths to almost 180º, 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% of Earth's animal species. Injuries arising from contact include envenomation and localised 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.

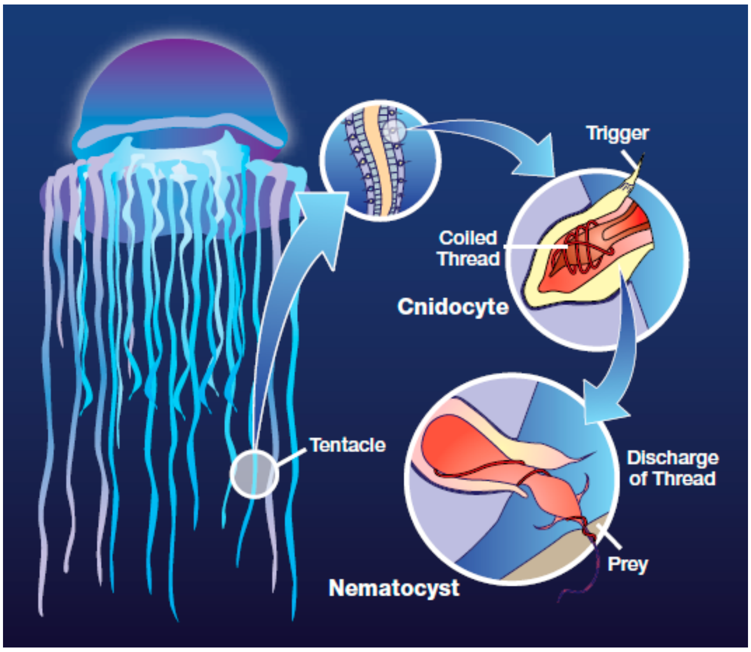
CNIDARIANS

Jellyfish, corals, anemones and hydroids

Phylum: Cnidaria

Cnidarians (nematocyst-carrying species) are responsible for more envenomations than any other marine phylum. These organisms contain tentacles with numerous stinging cells called nematocysts. These ingenious harpoon-like devices excel at venom delivery.

There are thousands of cnidarians, but only a fraction pose potential harm to humans. 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

Of all the cnidarians, jellyfish cause the most frequent and severe human injuries. Injuries result from direct contact and are usually localised 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 by 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 are responsible 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.

NOTE
There is a specific antivenom (bovine origin) for box jellyfish.

Signs and symptoms

- immediate, extreme pain
- significant localised welts and discolouration of skin
- rapid progression of symptoms
  - may lead to death within minutes

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. Nonetheless, stings are 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 on the lungs (pulmonary oedema), 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 bladders to catch wind currents that propel these animals along the surface of the open ocean. The gas bladder, known as a pnematophore, is filled with atmospheric gasses and it may contain up to 90% carbon dioxide (CO_2).

There are two species: The larger Atlantic or Portuguese man-of-war and its smaller Indo-Pacific relative known as the 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 are typically found in Australia, the Indian Ocean and New Zealand, they have also been reported in the Hawaiian Islands.

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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 paralyse 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

- localised pain
- localised redness
- pain with breathing
- back pain and abdominal cramps
- anxiety

NOTE

The American Heart Association (AHA) recommends vinegar as an effective measure to prevent unfired nematocysts from discharging on all cnidarians. In the case of Physalia *spp. (Pacific Portuguese man-of-war or bluebottle), however, the Australian Resuscitation Council (ARC) strongly discourages the use of vinegar for these species because some studies report that vinegar stimulates massive nematocyst discharge. These conflicting approaches may cause some people to delay treatment. The most recent AHA guidelines are based on the best available experimental evidence and recommend the use of vinegar in all cases of jellyfish stings. If these recommendations change or are refined, we will update this text.*

BONUS CONTENT

Despite its appearance, the Portuguese man-of-war technically is not a jellyfish; it is a siphonophore. These differ from jellyfish in that they are not actually single organisms but a colony of specialised polyps or zooids. One type of polyp fills itself with gas and forms the pneumatophore; three others take up the roles of defence (dactylozooid), reproduction (gonozooid) and feeding (gastrozooid). Their tentacles, covered with stinging dactylozooids, can reach up to 50 m in length.

BONUS CONTENT

There are two species of nudibranchs (gastropods or sea slugs) that are known to feed on Portuguese man-of-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 specialised sacs (cnidosacs) at the tip of their thin, feather-like 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 limestone-like 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 symptomatic 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 infection.

Soft corals, **sea feathers** and **gorgonians** are non-venomous and any contact that results in injury should require only thorough cleaning with soap and fresh water, and symptomatic treatment. If necessary, remove any foreign material.

NOTE

The routine use of home remedies, such as meat tenderiser 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
- localised 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 4-6% acetic acid solution). This does not reverse the effects of venom or control pain, but it helps prevent the discharge of unfired nematocysts
- **Removal**. Carefully remove visible tentacles or filaments with the aid of fine tweezers or protective barriers. Gloves, women's 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 octopus

Of the nearly 85 000 recognised species of mollusks, only two are potentially harmful to humans: Cone snails and blue-ringed octopus.

Cone snails

Phylum: Mollusca
Class: Gastropoda
(Unranked): different clades
Family: Conidae

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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 harpoon-like structure that delivers potent neurotoxic venom. Injury occurs when handling these animals and should therefore be avoided.

ADVANCED CONCEPTS

Slow-moving but voracious night predators, cone snails require fast-acting venom to paralyse 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 oedema 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%) and very venomous; shellfish eaters, more abundant (30%) but less venomous; and worm eaters, very abundant (60%) and the least venomous. The relative toxicity of venom makes sense as fish are harder to subdue than worms.

Blue-ringed octopus

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 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 tentacles. Their iridescent blue rings are expressed when the animal is disturbed or on the prowl. Its small size and distinct markings enable easy identification. Envenomation happens when the animal is handled.

BONUS CONTENT

Like all other cephalopods, the mouth of the blue-ringed octopus is armed with a strong beak in the centre of its body, right at the confluence of all its tentacles. 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 generalised weakness that can lead to paralysis and death. A single 25-gram specimen possesses enough venom to paralyse at least 10, regular-sized adults.

Signs and symptoms

- bite site might be painless and difficult to find
- confusion
- progressive weakness
- nausea and vomiting

Symptoms usually resolve within 24 hours and may be associated with generalised itching (pruritus), wheals/hives (urticaria) and joint swelling. Symptoms can progress quickly, so immediate medical evaluation and support is strongly advised. Victims who live through the first 24 hours generally go on to make a complete recovery.

Treating Mollusk Injuries

Signs and symptoms

- blurred or double vision
- difficulty speaking or swallowing (dysphagia)
- slurred speech, vocal hoarseness
- numbness and fullness around the mouth, neck and throat (especially with blue-ringed octopus)
- progressive weakness
- paralysis
- death (from respiratory depression due to paralysis)

First aid

- Clean wound thoroughly with soap and fresh water
- Remove any foreign material
- Pressure immobilisation technique is recommended for affected limbs. Limiting all movement as much as possible is also advised
- Immediately transport victim 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 patients 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 antivenin.

Immersion in hot water may provide some relief but may also enhance venom distribution due to vasodilatation.

Summary: Mollusks

(Cone snails and blue-ringed octopus)

- 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 reptiles 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. Victims often do not realise 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 colours, 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 uses water. This system consists of five radial canals, and 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 synchronised movements, they can transport the animal around the sea bed. Synchronic traction can also be strong enough for gripping and these pedicellariae have 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 its spines. These species have a wide habitat and are found from the Red Sea to the Great Barrier Reef in Australia and even further west to the western tropical Americas. They are known for achieving plague-like population proportions 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 will not 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 short spines are not the problem, but its pedicellaria are (see bonus content on page 186). 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 colour 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 to 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 paraesthesia (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 27)
- Tetanus coverage is recommended

The use of topical antibiotics or corticosteroids may help reduce discomfort and minimise 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

26

OTHER PHYLUMS
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 aabyssal plains, to the extreme heat of hydrothermal vents, to tropical tidal pools. Injuries typically result from accidental contact or deliberate handling. Such contact can result in the worm's bristles, located along the sides of the animal, embedding in the contact skin.

Symptoms usually last for several hours but may take several days to completely resolve.

Treating Sponge and Bristle Worm Envenomations

Signs and symptoms

- sharp, stinging pain
- localised redness, skin irritation
- bleeding associated with cuts/scrapes
- mild to severe itching
- oedema
- 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

CHAPTER 26:2 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 immobilisation 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 244.

SKILL: Injury Management

Objective

- *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 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 victim, it should be left in place (if possible) and secured from motion until the victim 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 neutralises 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 analgaesics (aspirin, Tylenol, Advil, etc.)
- Anti-inflammatory agents (hydrocortisone)
- Topical anaesthetic agents (lidocaine)
- Immerse affected area in hot water (45°C maximum) for 30-90 minutes.
- 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 may be helpful in removing 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. Apply steroid ointment if available.
6. Cover with sterile dressing and bandage.
7. If eye contact occurs, flush with fresh water.
8. Monitor for signs of allergic reaction or infection.

SKILL: Pressure Immobilisation Technique

Objective

- *Demonstrate the proper technique for applying a pressure immobilisation bandage*

For wounds from sea snakes, cone snails and blue-ringed octopus:

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 above the bite, and continue wrapping to at least 15 cm on the far side of the wound (if there is insufficient space to wrap 15 cm 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, colour and a 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 until at a medical facility.

NOTE

The pressure immobilisation 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 immobilisation technique include wounds from blue-ringed octopus, sea snakes and cone snails.

27 First Aid For Hazardous Marine Life Injuries
Envenomations and Toxins

SKILL 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 to control most external bleeding?
5. When should a tourniquet be used?
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.

Most human-associated marine animal bites 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 and with little support will stop blood loss. 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 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 an absorbent pad or dressing and gloved hands. 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 (2.5-5 cm if possible). Wrap the bandage from the distal side (farthest from the heart) of the wound site toward the heart
- 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 colour under the nails to return quickly after pressure is released. It should return to its normal pink colour in 2-3 seconds. In cold conditions, colour refill may take slightly longer. If colour does not return in a timely manner, loosen the bandage and rewrap

Tourniquets

If direct pressure fails to control massive bleeding, the next step may be to use a tourniquet if the injury is on an extremity. Tourniquets are a primary intervention when the bleeding is a massive arterial (spurting) bleed and is life-threatening.

A tourniquet is a wide band 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.

A tourniquet should be

- used only when direct pressure is not effective
- wide (at least 5 cm wide if an improvised tourniquet is used)
- well-padded (6-8 layers of a bandaging material)
- placed 2.5-5 cm proximal to the wound

A tourniquet should NOT be

- placed directly over knees, elbows or other joints. If there is not room to place a tourniquet between a wound and a joint, place the tourniquet 2.5-5 cm 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

Applying a tourniquet

Before applying 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 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 patient'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 advanced medical care is available.
- Death of tissue below the tourniquet is possible after two or more hours
- Tourniquets may cause pain in the extremity

Haemostatic 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 haemostatic agents.

Remove any other dressing materials so the agents can have direct contact with the bleeding site. Cover the entire bleeding surface with the haemostatic dressing and continue to apply direct pressure. Apply additional layers of haemostatic dressings if necessary. Hold dressings in place with a pressure bandage.

Advise medical personnel that a haemostatic agent was used to assist with control of bleeding. Retention of the dressing's packaging material may be helpful to emergency personnel. Haemostatic dressings should not be left in place more than 24 hours.

Special Circumstances

Bandaging Joints
When applying bandages across joints, maintain the area in a comfortable position and try to keep the joint immobilised to minimise further discomfort or bandage displacement.

Eyes
With eye injuries, it may be necessary to cover the injured eye to minimise 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 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 minimise 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 and is instead referred to as “contamination.”

An infection is when bacterial populations thrive and become large enough to interrupt healing or cause further tissue damage.

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.**

- **P**ain
- **R**edness
- **I**mmobilisation (loss of function)
- **S**welling
- **H**eat (elevated warmth of the infected area)

Other signs of infection include the following:

- pus and yellowish discharge
- foul smell
- swollen lymph nodes
- fever
- chills
- non-healing wounds

Marine-acquired wounds, particularly in people with compromised immune systems (e.g., diabetes, cancer, AIDS), 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.

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 2.5-5 cm 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: tourniquets

- Place the tourniquet 2.5-5 cm 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
- Twist the stick until bleeding stops and secure it in place with an additional bandage
- Mark the victim's forehead with a "T" and the time the tourniquet was placed
- Leave the tourniquet in place until the victim is under medical care

First aid: haemostatic 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 2.5-5 cm beyond the edge of the dressing, if possible
- Do not leave the dressing in place more than 24 hours
- Seek medical care

CHAPTER 27 REVIEW QUESTIONS

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 line of action to control external bleeding?**
   a. Direct pressure
   b. Tourniquets
   c. Haemostatic 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. 2.5-5 cm 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, sweating, hyperthermia
   b. prickly feeling, rash, increased thirst, sweating, heat
   c. pain, redness, loss of function, swelling, heat

Review answers are on Page 244.

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, attacking for no apparent reason. Due to their relatively small size, bites are usually more of a nuisance than a threat.

Octopus – Injuries from octopus bites result from handling. The beak at the confluence of the tentacles results in a double V-shaped pattern with the "Vs" in opposite directions. Octopus bites are associated with pain and mild to moderate swelling.

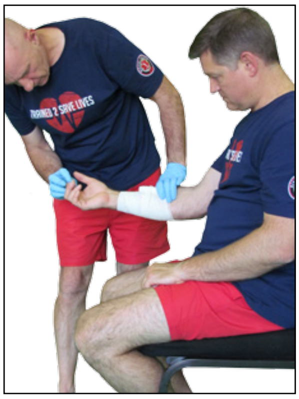
Stingrays – Stingrays use the barb in their tail to defend themselves against perceived threats. The puncture wounds and lacerations may result in bleeding and infection.

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. Skin irritations are a frequent occurrence. 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.

SKILL: Traumatic Injuries (Control of External Bleeding)

Objectives

- *Demonstrate applying direct pressure to control bleeding on a simulated patient*
- *Demonstrate bandaging to secure a dressing in place once bleeding has stopped on a simulated patient*



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
- Once bleeding has stopped, use conforming bandage and roller gauze or tape to secure the dressing and make sure there are no loose edges
- Remove all jewellery 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 patient 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 centimetres 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 immobilised to minimise further discomfort or bandage displacement*

SKILL: Applying a Tourniquet

Objective

- *Demonstrate applying a tourniquet to control bleeding on a simulated patient*

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 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 victim's forehead use of a tourniquet and time of placement
- In an actual injury, leave a tourniquet in place until the patient 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 localised injury, do not tighten a tourniquet during practice beyond the point your practice partner starts to feel changes in sensation.**

28 First Aid For Hazardous Marine Life Injuries
Seafood Poisonings

CHAPTER 28 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 minimised?

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” odour resulting from the breakdown of certain fatty acids. However, odour alone 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.

NOTE
Of particular importance, most of these toxins are heat stable, which means cooking does not reduce their toxicity.

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 three primary foodborne syndromes covered here are

- ciguatera
- tetrodotoxin poisoning (or tetrodotoxism)
- scombroid fish poisoning (also known as histaminoid syndrome)

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 gastrointestinal and neurological systems (sometimes the heart), and is caused by ingestion of various species of tropical reef fish.

Cause

Certain dinoflagellate (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 individuals who have suffered previous exposure. Onset usually occurs within two to six hours after ingestion.

Common gastrointestinal signs and symptoms

- abdominal pain and gastroenteritis
- nausea, vomiting
- diarrhoea

These initial symptoms typically resolve without intervention within a few hours.

Common neurological signs and symptoms

- numbness and tingling
- lack of muscle co-ordination (ataxia)
- vertigo

Symptoms may include skin itching, which can persist for weeks and worsen with activities that increase skin temperature, such as exercise and alcohol consumption.

Musculoskeletal symptoms

- joint pains
- muscle pains and weakness

Decompression sickness should be considered as a differential diagnosis in individuals with a recent history of scuba diving.

Other signs and symptoms

One of the most well-identified symptoms is the patient'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% of patients 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 whole 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; 1 drop every 1 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

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. Predators (such as barracudas, eels, groupers, etc.) contain more toxins due to bioaccumulation
- Symptoms are primarily neurological (could mimic DCS) but rarely fatal
- Fish appears, smells and tastes normal (no fishy odour)
- Cooking does not alter toxin potency
- Avoid eating large reef predators
- Treatment focuses on symptom management

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.

BONUS CONTENT

The name ciguatera refers to a disease caused by the Spanish name ***cigua*** (for sea snail), associated with a less common but similar syndrome in the Caribbean's 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 Captain William Bligh. He describes symptoms consistent with ciguatera after eating mahimahi, although this is an uncommon source. Captain 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 were 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 depolarisation 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
    - diarrhoea

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 so activate EMS immediately upon symptom presentation
- Mechanical ventilation may be necessary due to the patient's inability to breathe on his own

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 Tetrodontiformes
- It causes systemic paralysis, which can lead to death
- Cooking does not alter toxin potency
- Avoid eating these fish in any form or preparation

The goal is prevention through education. Avoid eating these species and seek medical evaluation if TTX poisoning is suspected. 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. The Japanese consider the expert chefs artists when they prepare sashimi well enough to leave 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 Japanese. This practice is considered the Japanese counterpart of Russian roulette, 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 or mackerel, mahi-mahi, and others such as anchovies, sardines and herrings. Scombroid poisoning accounts for 5% of food poisoning reported to the U.S. Centres for Disease Control and Prevention (CDC).

NOTE
A key contributing factor to the prevalence of this condition is the absence of an associated flavour 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
- diarrhoea
- 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 rarely required
- Since histamine is not being released as a result of an allergic reaction, corticosteroids are ineffective

Prevention of scombroid fish poisoning

Scombroid 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 at all points during the fish supply chain.

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 allergic-like 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 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.*

CHAPTER 28 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 244.

29 First Aid For Hazardous Marine Life Injuries
Life-threatening Complications

CHPATER 29 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?

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 victim with administration of allergy medications.

Most allergic reactions are fortunately less severe and are characterised by local skin reactions. Once you have ensured the victim is breathing normally, thoroughly clean and rinse the affected area. In some cases, allergy medications may be useful but it requires familiarisation or medical guidance.

Signs and symptoms (mild/moderate)

- generalised itching (pruritis)
- localised redness, swelling, raised rash that may change with time (urticaria/hives)
- bloodshot, puffy eyes
- facial swelling (eyes, lips)
- localised or diffuse swelling (oedema)

Signs and symptoms (severe)

- airway narrowing
- respiratory distress
- cardiac arrest

First aid

- Anaphylactic shock is a medical emergency. Call 10177 or your local EMS number immediately. Do not call DAN first
- Assist the injured person with administration of allergy medications if prescribed for him 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 (also note that 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

- hypotension (low blood pressure)
- pale, cool, clammy skin
- cold hands and feet
- severe shortness of breath
- weak pulse
- chest pain (can radiate to the arms, shoulder, neck or back)
- altered mental status
- reduced urinary output
- nausea and vomiting
- unconsciousness
- cardiac arrest

First aid

- Cardiogenic shock is a medical emergency. Call 10177 or your local EMS number immediately. Do not call DAN first
- Have the person lie down on his 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 results in a deficiency of blood supply to vital organs. Blood loss is secondary to internal or external bleeding. In the marine environment, the most likely cause is large animal bites (sharks, seals, eels), but acute blood loss can also occur due to non-traumatic events such as intestinal disease.

To control external bleeding, use universal precautions and apply direct pressure. Universal precautions include barrier devices such as non-latex, medical gloves plus protective eyewear or a surgical-style mask if there is blood being sprayed.

Signs and symptoms

- anxiety or agitation
- pale, cool, clammy skin
- confusion
- generalised weakness
- rapid breathing
- decreased urine output
- unconsciousness

First aid

- Hypovolemic shock is a medical emergency. Call 10177 or your local EMS number immediately. Do not call DAN first
- Attempt to stop all external bleeding by applying direct pressure
- Have the person lie down on his 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

CHAPTER 29 REVIEW QUESTIONS

1. **The signs and symptoms of allergic reaction include**
   a. itching
   b. localised 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 him
   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 244.

SKILL: Severe Allergic Reactions

Objective

- *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.

SKILL: Shock Management

Objective

- *Demonstrate the proper technique for managing shock by placing the victim on his 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 victim on his back or in a position of comfort.
   - Consider elevating the legs 15-30 cm as long as neck, spine or pelvic injuries are not suspected
7. Protect the victim 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 him in the most comfortable (sitting) position
- Do not elevate the legs if it will make another injury worse

30 Avoiding Hazardous Marine Life Injuries

CHAPTER 30 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 from 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 practise perfect buoyancy control. This helps 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 hood, gloves and boots. While gloves protect you from potential injury, they may also increase the likelihood of touching the reef. It is for this reason that some dive operators ban the use of gloves.. However, they should be work when wreck diving, diving in strong currents or when needed for thermal protection
- Shuffle your feet and wear thick-soled boots when entering waters that have sandy or muddy bottoms
- 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 are 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 stabilisation
- 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 are in jellyfish-inhabited areas. Avoid holding onto the ascent/descent line without gloves as 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 due to lack of training, skills or experience than are caused by marine life.

CHAPTER 30 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 minimise 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. a, b and c

Review answers are on Page 244.

31 Summary

This programme's material has addressed factors that can contribute to a dive accident. We have discussed and emphasised preventive measures. Practise these measures and encourage others to embrace safe diving habits.

Dive accidents are rare and when they do occur, simple first aid procedures are all that is required most of the time. However, prompt action 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 should be constantly considered during an emergency. Life-threatening 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 EMS in the area, administer oxygen and call the DAN Emergency Hotline at 0800 020 111 (local) or +27 82 810 6010 (international).

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 practising the skills learned in this course. Review signs and symptoms presented in the preceding chapters. Keep up to date on blood-borne pathogens training and any other training your organisation may require. Check expiration dates on first aid supplies and immediately replace items used.

Finally, refresh your skills and keep your certification current by participating in a recertification course at least every two years.

Appendix 1: First aid Equipment

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 Pack

This standard DAN Oxygen unit is specially developed to treat injured divers and includes a 2,5 litre Pin-index oxygen cylinder.

The Unit Delivers

- 100% oxygen using the demand valve
- about 75% when using the non-rebreather mask
- about 50% when using an oronasal resuscitation mask

This unit can provide oxygen to two divers simultaneously and has the option to connect an extra demand valve, which allows for the delivery of oxygen to three divers, or to two divers using the demand system only. The demand valve is the preferred oxygen-delivery system as it provides the highest concentration of oxygen and it ensures that none of it is wasted.

The Pin-index system is the most common oxygen-cylinder-valve system for small cylinders and it is available worldwide. Check if this valve is available in your country. If in doubt, contact DAN-SA for advice.

Dimensions

Internal: 480 mm x 360 mm x 198 mm
External: 550 mm x 420 mm x 215 mm

Included Items

- Waterproof DAN Oxygen Unit case (for a 43 cm cylinder)
- “Oxygen on Board” Sticker
- Pin-index medical oxygen cylinder (empty)
- DAN demand valve with white hose
- DAN oronasal resuscitation mask
- Tru-fit mask
- Non-rebreather mask
- Pin-index multifunction oxygen regulator (CE version)

Mini Oxygen Unit
This Pin-index mini oxygen unit, also called charter boat unit, contains the same oxygen components as the standard Pin-index oxygen unit but is housed in a smaller, orange, waterproof case. This unit is particularly useful for those who have a big, fixed, oxygen cylinder on their boat.

The Unit Delivers

- 100% oxygen using the demand valve
- about 75% when using the non-rebreather mask
- about 50% when using an oronasal resuscitation mask

This unit can provide oxygen to two divers simultaneously and has the option to connect an extra demand valve, which allows for the delivery of oxygen to three divers, or to two divers using the demand system only. The demand valve is the preferred oxygen-delivery system as it provides the highest concentration of oxygen and and it ensures that none of it is wasted.

The Pin-index system is the most common oxygen-cylinder-valve system for small cylinders and it is available worldwide. Check if this valve is available in your country. If in doubt, contact DAN-SA for advice.

Dimensions

Internal: 305 mm x 230 mm x 137 mm
External: 335 mm x 290 mm x 155 mm

Included Items

- Waterproof Case
- “Oxygen on Board” Sticker
- DAN demand valve with white hose
- DAN oronasal resuscitation MASK
- Tru-fit mask
- Non-rebreather mask
- Pin-index multifunction oxygen regulator

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

- protective case (waterproof if used in wet environments)
- resuscitation barrier device (face shield or mask)
- examination gloves
- cleansing wipes
- sterile saline for wound irrigation
- bandages
- sterile dressings – various sizes
- sterile gauzes
- sterile eye pads
- adhesive tape
- scissors (strong enough to cut away clothes)
- triangular bandage
- safety pins
- tweezers
- adhesive dressings (several sizes)

Optional, but recommended, items:

- wound-closure strips (Steri-Strips)
- isothermal blanket
- irrigation syringe
- infectious waste bag
- penlight
- splint to immobilise fractures
- thermometer
- NuMask® or oronasal resuscitation mask
- disposable razor
- first aid manual
- cold and hot compresses
- a list with emergency numbers

Medications and ointments may also be helpful but may require input from your doctor to ensure appropriate use. While this list suggests some common over-the-counter medications, first aid providers are not legally authorised to dispense medications or share their own prescriptions.

Recommended medications include the following:

- antiseptic solution
- eyewash
- hydrocortisone ointment
- antihistamine tablets
- antibiotic ointment
- pain reliever

Appendix 2: Aquarium and Zoonosis Resources

ASSOCIATION OF ZOOS AND AQUARIUMS. *Infectious diseases.* http://www.aza.org/infectious-diseases/

U.S. GEOLOGICAL SURVEY NATIONAL WILDLIFE HEALTH CENTER. *Medical Alert Wallet Card.* http://www.nwhc.usgs.gov/outreach/medical_alert_wallet_card.pdf

ELASMOBRANCH HUSBANDRY. *Conservation and ethical care of sharks, skates, rays and chimeras.* http://www.elasmobranchhusbandry.org/

Appendix 3: Contaminated Water Resources

NAVY EXPERIMENTAL DIVING UNIT. *Survey of Best Practices for Diving in Contaminated Water.*
http://www.epa.gov/region10/pdf/diveteam/usn_cdw_practices.pdf

NOAA Diving Programme, *Contaminated Water Diving Reports.*
http://www.ndc.noaa.gov/rp_cwd.html

OSHA CODE OF FEDERAL REGULATIONS 1910.210. *Hazardous waste operations and Emergency Response.*
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9765

OSHA OCCUPATIONAL SAFETY AND HEALTH GUIDANCE MANUAL FOR HAZARDOUS WASTE SITE ACTIVITIES.
http://www.osha.gov/Publications/complinks/OSHG-HazWaste/4agency.html

US NAVY. *Naval Sea Systems Command, Guidance for Diving in Contaminated Waters Technical Manual.*
http://www.ndc.noaa.gov/pdfs/contaminated_water/USN_Contaminated_Water_Dive_Man.pdf

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Glossary

abrasion – a superficial excoriation with loss of in under the form of small shreds

acute – rapid onset and/or short-term duration (as opposed to chronic)

adaptic gauze – non-adhering dressing

agonal breathing – an abnormal pattern of breathing characterised by gasping, laboured breathing, accompanied by strange vocalisations and involuntary muscle twitching

alveoli – microscopic air sacs in the lungs where gas exchange occurs with the circulatory system

ambient – surrounding on all sides

anaesthesia – general or local insensibility to pain and other sensations induced by certain interventions or drugs

anoxia – absence of oxygen in the circulating blood or in the tissues

anticholinesterase activity – a 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 vessel of the systemic arterial system from which the main arteries carrying oxygenated blood branch out and subdivide into smaller and smaller vessels

aphonia – voice loss, inability to phonate sounds

arachnoid – the serous membrane forming the middle of the three coverings of the brain and spinal cord

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 co-ordination; inability to co-ordinate voluntary muscle movements; unsteady movements and staggering gait

atelectasis – the collapse of all or part of a lung

atrium – chamber of the heart that provides access to another chamber called the ventricle

audiovestibular – of or pertaining to the auditory functions of the inner ear and the vestibule of the ear

axons – 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 surrounding fluid

bioaccumulation – the accumulation of substances in nature, organisms or the environment

blood-borne pathogens – infectious microorganisms in human blood that can cause disease in humans

blood brain barrier (BBB) – a separation of circulating blood and cerebrospinal fluid in the central nervous system. It occurs along all capillaries and consists of tight junctions around the capillaries that do not exist in normal circulation.

bronchi – plural of bronchus, which is a division of the trachea

bronchiole – small branch of the bronchus that carries air to and from the alveoli

bronchospasm – bronchoconstriction, or the sudden narrowing of the smaller airways, of a spasmodic nature

capillary – microscopic blood vessels in which the gas exchange takes place between the bloodstream and the tissues or the air in the lungs

carbon monoxide – a highly poisonous, odourless, tasteless and colourless gas formed when carbon material burns with restricted access to oxygen. It is toxic by inhalation since it competes with oxygen in binding with the haemoglobin, 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 characterised 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 characterised by replacement of liver tissue by fibrosis, scar tissue and nodules, leading to loss of liver function

clades – a group of organisms that are classified together as descendants of a common ancestor

cutaneous – of, relating to or affecting the skin

cyanosis – bluish colour 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

defibrillation – a therapeutic dose of electrical energy to the affected heart with a device called a defibrillator, which depolarises a critical mass of the heart muscle, terminates the arrhythmia and allows normal sinus rhythm to be re-established by the body's natural pacemaker

dehydration – an abnormal depletion of water and other body fluids

denaturation – a structural change in macromolecules, such as proteins, caused by extreme conditions such as heat or external stress such as a strong acid or base or a biological solvent such as alcohol or chloroform

Diameter Index Safety System (DISS) – intermediate pressure port where a hose attaches, leading to a 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

dysaesthesia – distortion of any sense, especially 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 phonate sounds)

dyspnoea – difficult, painful breathing or shortness of breath

oedema – swelling caused by excess fluid in body tissues

electrolyte – minerals in your blood and other body fluids that carry an electric charge which affects 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

epideral – a form of regional analgaesia involving injection of drugs through a catheter placed into the epidural space

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 synthesised mainly in the kidneys and stimulates red blood cell formation

oesphagus – 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 localised 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 individual 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 – the difference in pressure, oxygen tension or other variable as a function of distance, time or other continuously changing influence

grand mal – tonic-clonic seizure; a type of generalised seizure that affects the entire brain and causes massive muscular spasmic convulsions (See seizures)

haemolytic – that which causes haemolysis, dissolution of red blood cells

haemorrhagic – pertaining to bleeding or the abnormal flow of blood

haemotoxic – capacity of a toxin to destroy red blood cells, disrupt blood clotting and/or cause organ degeneration and generalised 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

hyperaesthesia – increased sensitivity to stimulation, particularly to touch

hyperoxia – excess oxygen or higher than normal partial pressure of oxygen

hypoaesthesia – 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 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

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

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 colour 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

localised – restricted to the site of origin, without evidence of spread

lpm – litres per minute; a measurement of a flow rate of gas or liquid

lymphatic – pertaining to, containing or conveying lymph

maxilla – the principal bone of the upper jaw (the bone of the lower jaw is the mandible)

mediastinum – the space within the chest located between the lungs, containing the heart, major blood vessels, trachea and oesphagus

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 long-continued 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 endplate 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 on fixation or on ocular movement

oblique – an indirect or evasive angle

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

paraesthesia – 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 medicine 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"), meaning these cells 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 centre 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 oesphagus, usually characterised 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 – resting directly upon the main stem or branch, without a petiole or footstalk (as a sessile leaf or blossom)

sign – any medical or trauma condition that can be observed

siphon – tubular organ through which water is ejected from the gill cavity of a cephalophoid; 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 in subcutaneous tissues

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 co-operative arrangement (as opposed to parasitosis)

symptom – any non-observable 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 combinations of vaccines that provide immunisation 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 – 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 specialised 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 principle right and left bronchi

transverse – crossing from side to side

trauma – a serious injury or shock 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 manoeuver – 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 gasses 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 fibres

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 ventricles' cardiac muscles, making them quiver rather than contract properly

venules – small veins

vertebra – the bones forming the spinal column

vertigo – a sensation of whirling motion, either of oneself or of external objects

vestibular – relating to the sense of 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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3. A
4. A
5. B
6. A
7. D
8. E

Chapter 18, Page 113

1. B
2. B
3. A
4. C

Chapter 19, Page 123

1. B
2. A
3. C
4. B
5. A
6. C
7. D
8. D

Chapter 20, Page 131

1. B
2. B
3. B
4. B
5. A
6. A
7. B

Chapter 21, Page 136

1. B
2. B
3. A
4. C
5. C
6. A
7. B
8. A
9. A
10. A

Chapter 22, Page 147
1. D
2. E
3. B
4. D
5. B
6. A
7. E
8. B
9. B
10. D

Chapter 23, Page 154
1. A
2. E
3. A

Chapter 24, Page 159
1. D
2. A
3. E
4. D

Chapter 25, Page 165
1. D
2. A
3. B
4. A
5. D

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1. E
2. C
3. A
4. E
5. C

Chapter 26:2, Page 191
1. A
2. D
3. E

Chapter 27, Page 199
1. A
2. A
3. A
4. D
5. B
6. C

Chapter 28, Page 210
1. A
2. E
3. D
4. B

Chapter 29, Page 214
1. D
2. D
3. B
4. A
5. D
6. E

Chapter 30, Page 218
1. D
2. F

NOTES:

Divers Alert Network Southern Africa

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.

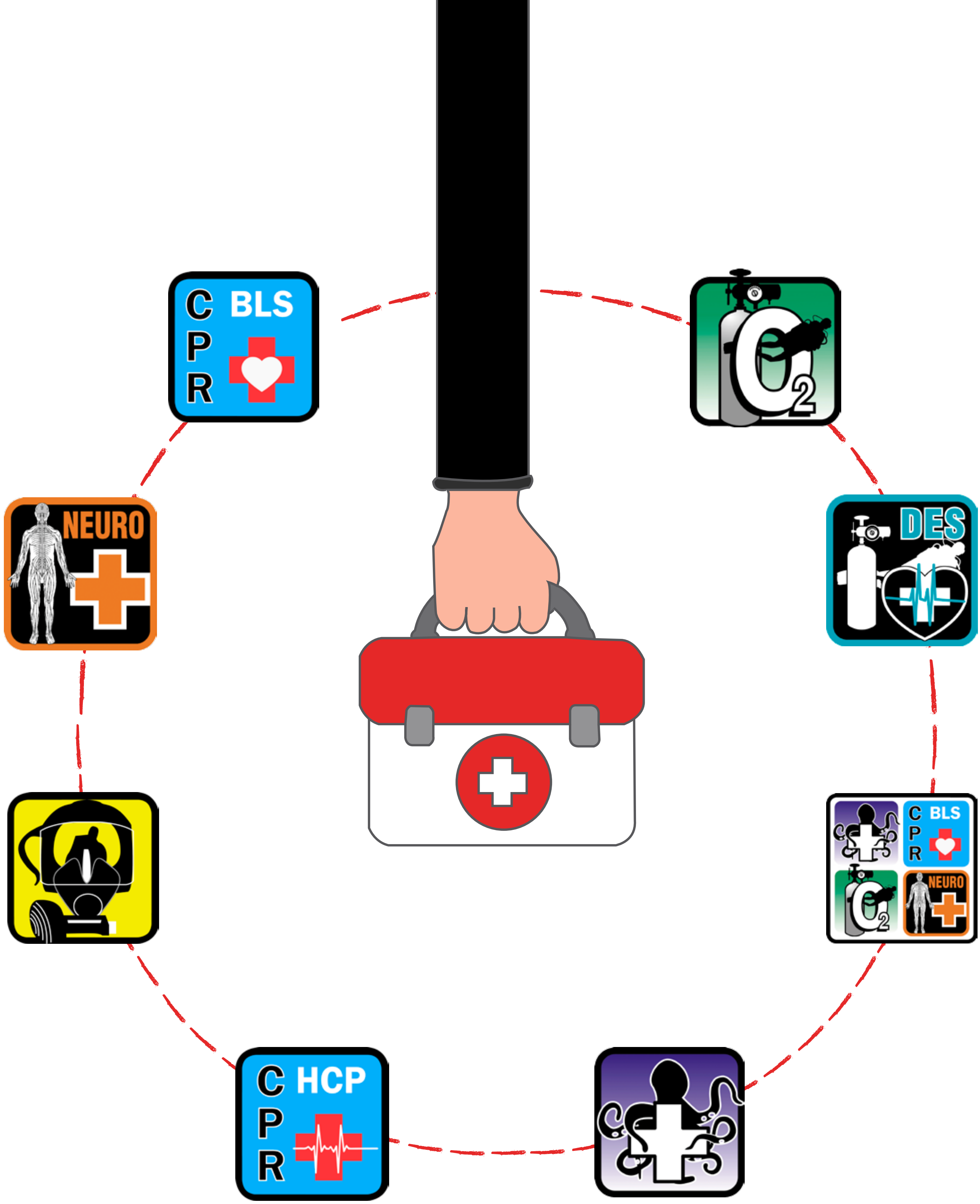
Among the services DAN-SA provides to the diving public is the DAN Emergency Hotline (0800 020 111 (local) or +27 828 10 60 10 (int.)). This hotline is available 24 hours a day, seven days a week for anyone who suspects a diving injury, requires assistance or needs to activate ***your DAN evacuation benefits*** (an exclusive benefit of DAN membership). Callers are connected directly with a member of DAN's Medical Services department, who can facilitate medical consultation with dive medicine specialists and co-ordinate evacuation to ensure appropriate care.

DAN-SA's non-emergency safety resources include the DAN Medical Information Line DAN-SA (0800 020 111 (local) or +27 828 10 60 10 (int.)), the online Health & Diving libary (http://dansa.org/dan-resources.htm) and ***Alert Diver*** magazine, the DAN Shop, the DAN-SA Podcast, a blog and more.

Membership dues and dive cover support DAN's nonprofit efforts. DAN members enjoy benefits such as access to the DAN Dive Accident Cover, medical evacuation support, access to the electronic *Alert Diver* magazine, safety guides and more.

Your participation in this DAN training course demonstrates your commitment to dive safety. Continue your education and your commitment by supporting **the industry's only organisation dedicated solely to improving dive safety**. Join DAN today.

To learn more about DAN and the multitude of resources it provides, or to become a member, please visit dansa.org.



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DAN SOUTHERN AFRICA