DIVING EMERGENCY MANAGEMENT PROVIDER

STUDENT HANDBOOK

DAN
SOUTHERN AFRICA

DIVING EMERGENCY MANAGEMENT PROVIDER STUDENT HANDBOOK

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DAN SOUTHERN AFRICA

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Section 1 Diving Emergency Management Provider Course Overview

Dive accidents are rare, but they may require prompt, specific action. No single set of skills will meet all the various demands a dive accident may present. The Diving Emergency Management Provider (DEMP) programme combines skills from four first aid courses offered by your instructor to streamline and put into context the care that may be necessary.

Starting with basic life support (Section 2), participants will become familiar with the signs and symptoms associated with cardiovascular diseases such as heart attack as well as with other diseases and conditions that may also pose an immediate threat to life.

If there is any question about whether an injury may be present, a neurological assessment (Section 3) may help identify abnormalities that should prompt first aid care and further evaluation.

Oxygen first aid has long been established as the primary first aid for dive accidents. Recognising the signs and symptoms indicative of decompression illness can facilitate prompt intervention with oxygen therapy, as taught in Emergency Oxygen for Scuba Diving Injuries (Section 4).

Finally, at some point most divers will experience injuries, usually minor, from encounters with marine life while diving. Most of these injuries require only simple interventions. However, more involved first aid is necessary on occasion. First Aid for Hazardous Marine Life Injuries (Section 5) covers both general care and more specific interventions that may be required.

Successful completion of the Diving Emergency Management Provider course includes demonstrating skill competency and passing a final knowledge assessment for each section of the course.

Upon successful completion of the course, you will receive a provider card indicating that you have been trained in cardiopulmonary resuscitation (CPR), use of automatic external defibrillators (AEDs), how to conduct a basic neurological assessment, administration of oxygen for scuba diving and drowning injuries as well as first aid procedures for injuries caused by marine life.

First-Responder Roles and Responsibilities
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. All skills performed in an emergency should be within the scope of one's training. Maintain skills and knowledge proficiency by reading current literature and participating in supervised practice sessions. Talk to your DEMP Instructor for options.

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

Course Prerequisites
There are no course prerequisites for participation in this course. However, some countries, provinces and local municipalities may have minimum age stipulations for the use of emergency oxygen and/or AEDs.

Scuba Certification
Scuba diving certification is not a course prerequisite. This course teaches scuba divers and interested non-divers how to provide appropriate first aid to injured divers. Familiarity with diving equipment and diving terminology will make understanding the material easier. Nonetheless, interested and informed non-divers should be able to master the material.

Retraining
Since emergency-response skills deteriorate with time, retraining is required every two years to maintain the Diving Emergency Management Provider credential. In addition, regular practice is encouraged to retain skill proficiency.

Continuing Education
Continuing education is encouraged in the form of taking additional training courses, participating in supervised practice sessions, reading current literature and undergoing refresher training. Your DEMP 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 learning objectives. 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 those students who want to know more

Terminology
The Diving Emergency Management Provider 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.

Section 2 Basic Life Support: CPR and First Aid

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Section 2

1 Basic Life Support: CPR and First Aid Overview

According to the World Health Organisation, cardiovascular diseases are the most common cause of death worldwide and account for about one-third of deaths.[1] As our population ages, the prevalence of these diseases is expected to increase. This programme will help prepare participants to handle these events and other life-threatening incidents.

The Basic Life Support: CPR and First Aid provider programme is designed to provide participants with foundational knowledge and teach skills needed to perform cardiopulmonary resuscitation (CPR) and other lifesaving skills.

In this section, participants will become familiar with the signs and symptoms associated with cardiovascular diseases such as heart attack and respiratory arrest, as well as other diseases and conditions that may also pose an immediate threat to life. These conditions (such as shock, choking and external bleeding) are included in this section.

Section 2

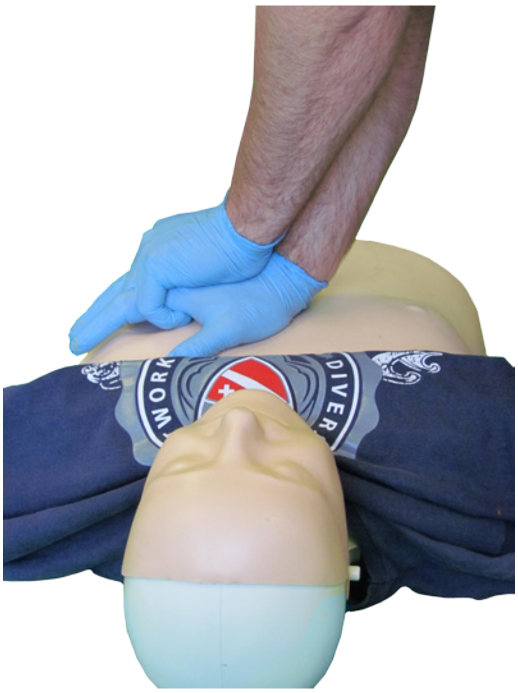
2 Basic Life Support

CHAPTER 2 OBJECTIVES

1. What is the goal of CPR?
2. Why is asking permission necessary before rendering care?
3. What are the five links in the chain of survival in their proper sequence?
4. What is the first step for a single rescuer once unresponsiveness has been established?
5. What is the first step for a rescuer if the injured person is a child or the victim of a drowning incident?
6. What can a rescuer do to deal with emotional stress?

Maintenance of tissue oxygen supply is vital for life, and establishing and keeping an open airway is a critical first step when caring for an unconscious or non-breathing person. Airway obstruction impedes or prevents oxygen delivery to our lungs, which then prevents delivery to our blood and subsequently to tissues.

When oxygen supplies are interrupted, our organs will suffer and eventually die. Without oxygen, particularly vulnerable tissues, such as the brain, may start dying after 4-6 minutes. Therefore, the need for immediate need for action is crucial.



During basic life support (BLS), rescuers provide and maintain oxygen supplies to victims by using chest compressions to maintain blood circulation, and ventilations to maintain oxygen levels.

Key steps in BLS include the following:

1. Check for responsiveness and activate emergency medical services (EMS).
2. Quickly check for normal breathing.
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 ventilations to deliver air to the lungs.

The goal of BLS and 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.

C irculation

A irway

B reathing

NOTE

The exhaled air used during ventilations contains about 16% oxygen compared to 21% in the normal air we breathe. Despite this reduction in oxygen concentration, ventilations still provide adequate oxygen supplies to sustain vital organs.

Also worth noting is the difference between sudden cardiac arrest (SCA) and myocardial infarction (MI), or heart attack. Sudden cardiac arrest, as its name implies, is sudden and can happen without warning or may be preceded by brief, generalised seizures. In this circumstance, the heart has either completely stopped or is in a dysrhythmia, such as ventricular fibrillation, that cannot support life. Check for normal breathing once seizure activity has stopped and activate EMS. Initiation of CPR and implementation of an automated external defibrillator (AED), if available, is critical.

Heart attacks are serious cardiac events as well but may not result in unresponsiveness or the need for CPR. For an individual experiencing a heart attack, activate EMS and monitor the person continuously. Be prepared to initiate CPR if the victim loses consciousness.

Duty of Care

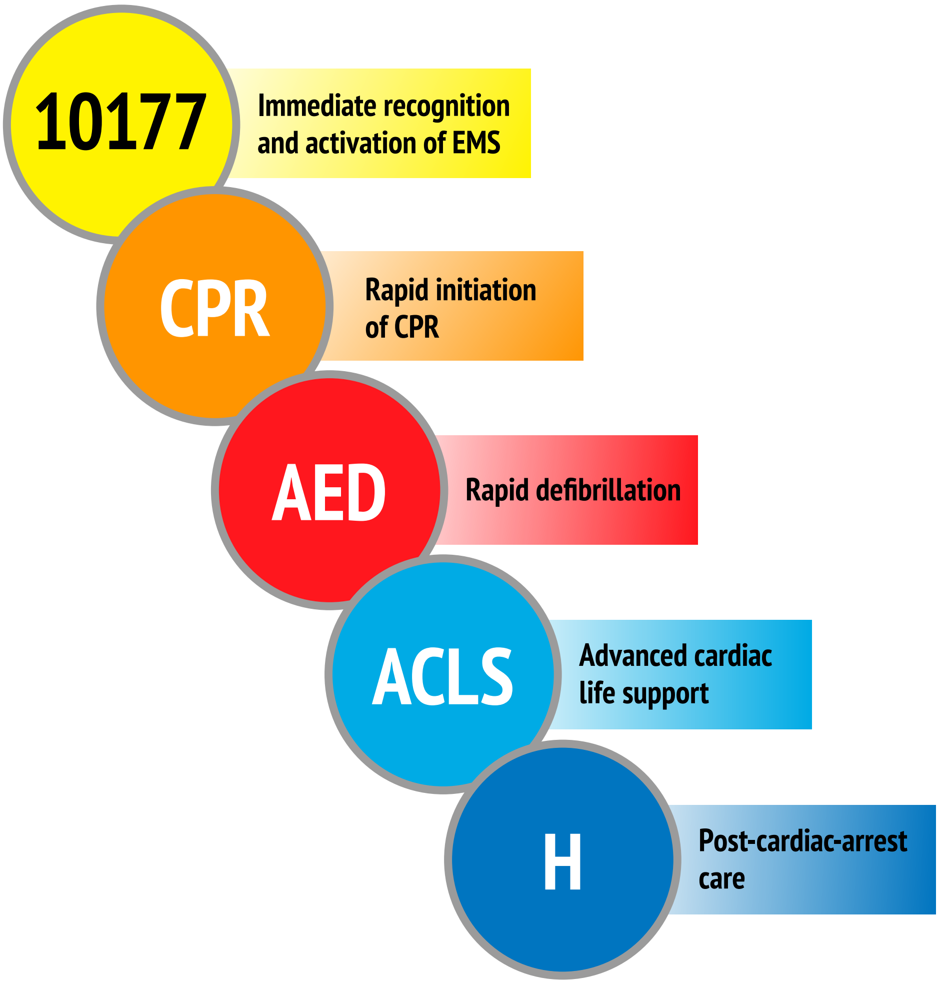
As a potential first responder, you have no legal obligation to provide medical care. In some areas, however, you may have an obligation to notify authorities that someone is in need of medical assistance. If you engage in basic life support, be sure to provide care within your scope of training.

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

Chain of Survival

There are five key steps in the chain of survival.



Immediate Recognition and Activation of EMS

Recognition of a medical problem should be followed by prompt action. Once unresponsiveness is established, call EMS. By activating local EMS, the chance of survival increases. Either call EMS yourself or ask a bystander or other rescuer to call EMS.

If you are alone, EMS can be activated using your cell phone on speaker setting as you initiate CPR. 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 or infant victim
- drowning victim

The use of a cell phone to activate EMS while initiating CPR is still recommended to expedite the arrival of advanced medical care. If a cell phone is unavailable, the lone rescuer should perform two minutes of CPR before calling for help. Since cardiac arrest is typically secondary to respiratory arrest in these two groups, this slight alteration in procedural order is recommended. Children and drowning victims may spontaneously recover if CPR is initiated immediately. Additional information on drowning victims is covered later in this section. For information on conducting CPR for children and infants, please consider taking the CPR Health-Care Provider with First Aid course.

In contrast, acute coronary syndromes (heart attacks) often cause unstable heart rhythms that respond best to rapid defibrillation. Activating EMS and getting an automated external defibrillator (AED) on scene as soon as possible together provide the best chance of re-establishing a life-sustaining heart rhythm. However, CPR should not be delayed if an AED is not immediately available.

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

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

Do not hang up until the operator releases you to return to the patient. It is important to answer all of the dispatcher's questions to ensure an appropriate response team and resources are sent to the site.

The operator may repeat critical information before ending the call, which ensures that the message was received and key facts conveyed. If someone else calls EMS, be sure to have that person return to the scene after making 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. Chest compressions temporarily take over the function of the heart by manually circulating blood in the body. Ventilations deliver air to the lungs and ensure a supply of oxygen for the body, especially critical areas such as the heart and brain.

Rapid Defibrillation

Rapid defibrillation is the single most important intervention in the case of an unstable cardiac rhythm and provides the greatest chance of restoring normal heart function. CPR will not restart the heart but may delay tissue damage associated with inadequate oxygen supplies.

Most cases of adult respiratory arrest are due to cardiac arrest. 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.

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 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 person and make the patient ready for hospital transport.

Remember: Advanced cardiac life support will not arrive until local EMS is activated.

Post-Cardiac-Arrest Care

If 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. Unstable heart rhythms that lead to unconsciousness or death may recur without warning.

Emotional Stress and Fear of Doing Something Wrong

Helping others in need gives you a good feeling, but it might also create emotional stress before, during and after the rescue.

When a person has an accident or is in sudden cardiac arrest, bystanders commonly wait for someone to take charge and provide aid.

Hesitation is often caused by the following:

- fear of doing something wrong, causing harm or not being able to bring back life
- fear of being sued
- fear of infection (in the next section you will learn how to avoid infection)

Anxiety is a normal emotion for both the rescuer and patient during an emergency. Some potential rescuers may avoid such situations so as to avoid making mistakes or providing imperfect care. On the whole, providing some care (even if not "perfect") is a much more effective approach than providing no care at all.

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 it is performed perfectly. CPR increases the chances of survival but does not guarantee it.

Unsuccessful rescues may cause emotional distress. Rescuers may blame themselves for not saving a life and/or think they did something wrong. Some rescuers may benefit from a critical-incident debriefing or professional counselling to help work through such concerns.

A key point to remember if you ever have to perform CPR is that a person in cardiac arrest (no signs of life) is in the worst possible condition. If no one initiates CPR, someone in cardiac arrest is certain to die; you cannot make them any worse. CPR is only one link in the chain of survival.

CHAPTER 2 REVIEW QUESTIONS

1. **The goal of CPR (without defibrillation) is to maintain 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. **To avoid legal problems, always ask a patient for __________ before you provide first aid. This may be done by stating: __________________________**
   a. permission; "My name is... I am a first aid provider. May I help you?"
   b. autograph; "My name is... I am a first aid provider. May I help you?"
   c. certification card; "My name is... I am a first aid provider. May I help you?"

4. **The correct order of the five links in the chain of survival 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

5. **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

6. **During CPR, the function 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

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. **Emotional stress may occur before, during or after a rescue**
   a. True
   b. False

9. **In most cases, the heart restarts after someone performs CPR**
   a. True
   b. False

Review answers are on Page 74.

Section 2

3 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?

It has already been noted that CPR takes over the function of the heart and lungs when someone is in cardiac arrest. A basic understanding of respiration and circulation is beneficial to understanding how CPR can help as well as the impact of injury first aid.

Cardiovascular System

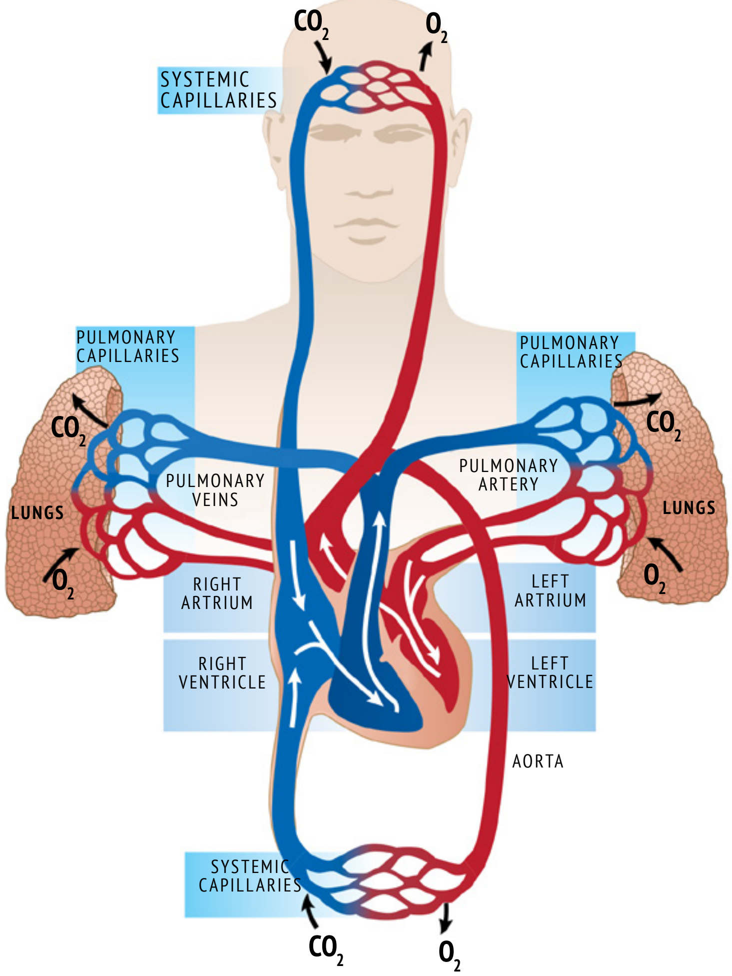
The cardiovascular system includes the heart and blood vessels. It is a closed-circuit system with the primary purpose of pumping blood, transporting oxygen and nutrients to tissues, and removing waste products.

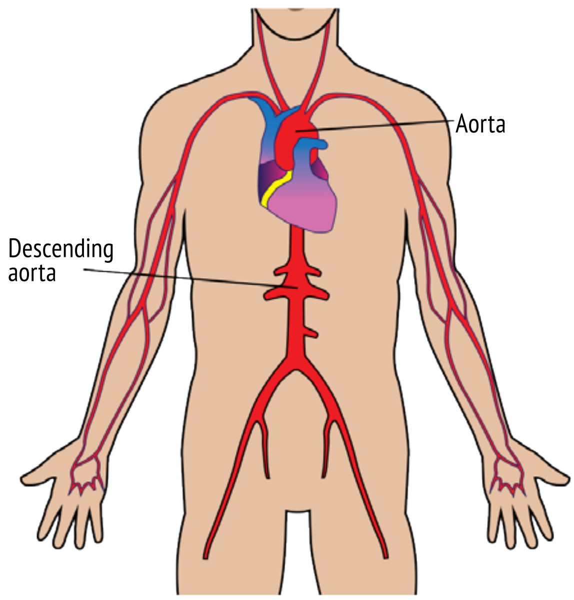
The heart is a hollow, muscular organ situated in the thoracic cavity, between the lungs, in a space called the mediastinum. A thin, connective tissue sac called the pericardium surrounds it. The pericardium reduces friction between the heart and surrounding structures.

The heart is a strong, muscular pump that, in the average adult, has the capacity to beat spontaneously at a rate of about 70 times per minute (the normal resting heart rate is 60-100 beats per minute and may be as low as 40 beats per minute in athletes[2]). Every minute, approximately 6 litres of blood is pumped throughout the body. When exercising, this output may double or triple depending upon the amount of exertion.

The heart is divided into a right- and left-pump system (also known as the right heart or pulmonary circuit and the left heart or systemic circuit). The right heart receives deoxygenated blood from the venous system and pumps it to the pulmonary circuit to exchange 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 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 leading 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, which are responsible for supplying tissues with oxygen and nutrients, and removing carbon dioxide (CO_2) and other metabolic waste products.





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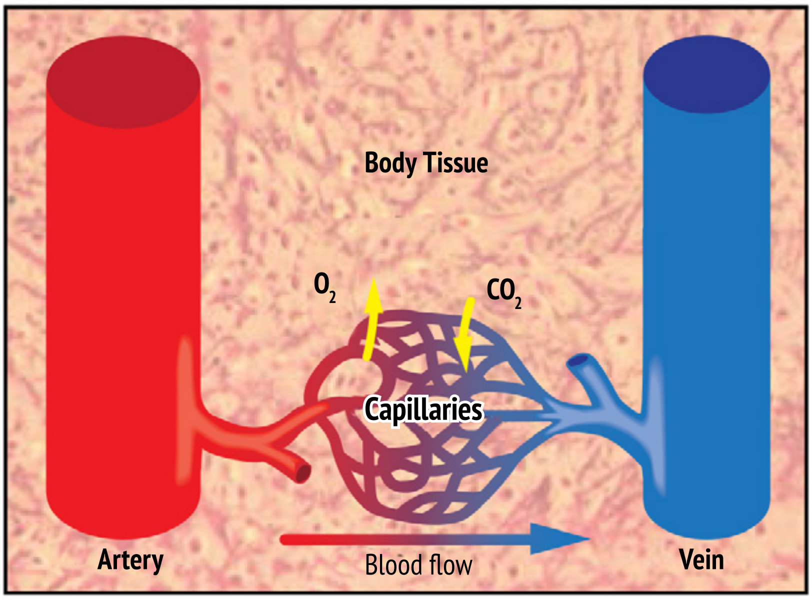
From the peripheral capillaries, the blood is gathered into small, thin-walled veins and returned via larger veins to the atria of the heart. Most veins direct blood flow by means of one-way valves that prevent blood from travelling in the wrong direction or pooling due to gravity.

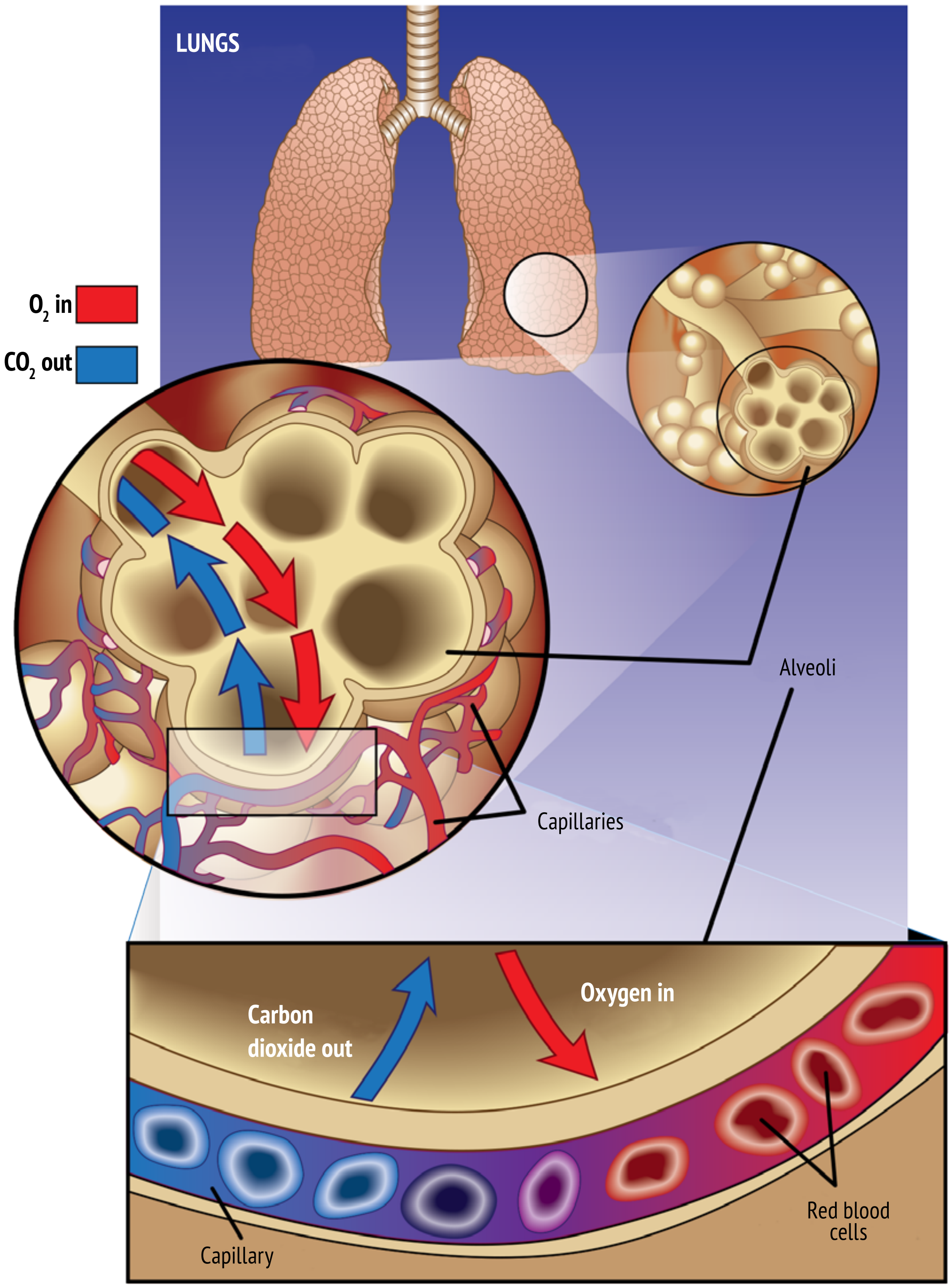


Respiratory System

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 membranes is a potential space that contains a thin layer of fluid which 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 oesophagus.

The opening to the trachea is protected from food (solids and liquids) during swallowing by a flexible flap of tissue called the epiglottis. The oesophagus, located behind the trachea, is a conduit for food and fluids on their way to the stomach. It is the proximity of these two structures that makes appropriate lung volume critical during CPR. Overventilation can lead to stomach distention and regurgitation of stomach contents. If this happens, stomach contents can enter the lungs and compromise recovery. 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 bronchial tree, have extremely thin walls and are surrounded by the pulmonary capillaries. The alveoli have been likened to tiny balloons or clusters of grapes. In both lungs, millions of alveoli cover a combined surface area of around 70 m^2 – roughly the size of a tennis court.



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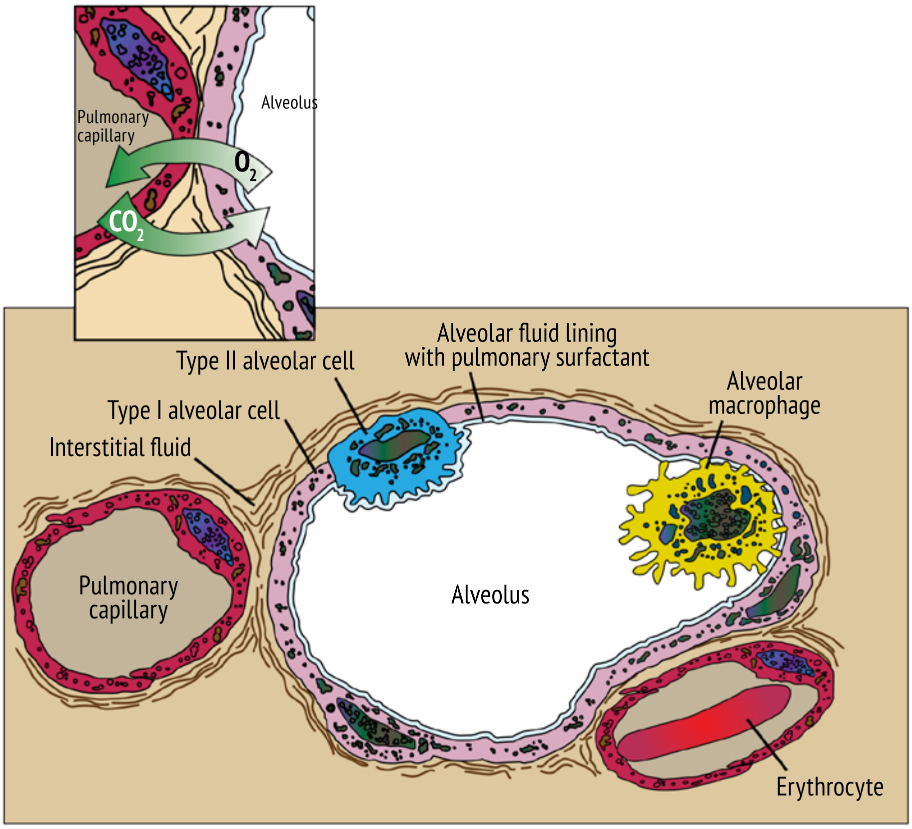
The average adult alveolus has an estimated diameter of 200-300 micrometers and is only a cell layer thick. Alveoli lie adjacent to capillaries that are also one cell layer thick and this proximity enables the rapid exchange of CO_2 and O_2. The thin alveolar-capillary membrane separates the content of the lung from the bloodstream. If this membrane tears or becomes compromised due to trauma, 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.



CHAPTER 3 REVIEW QUESTIONS

1. **The respiratory system includes the**
    a. heart, lungs, brain
    b. arteries, spinal cord, nose
    c. nose, trachea, lungs
    d. bones, muscles, skin

2. **The cardiovascular system includes the**
    a. veins, arteries, heart
    b. mouth, lungs, stomach
    c. skin, bones, muscles
    d. nose, lungs, pharynx

3. **Gas exchange takes place at the**
    a. vein-artery interface
    b. long bone joints
    c. alveolar-capillary membrane
    d. muscle-nerve junctions
    e. lungs

Review answers are on Page 74.

Section 2

4 Scene Safety Assessment

CHAPTER 4 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. The ability to provide first aid is impaired if the rescuer 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 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 the following:
  - fire
  - chemicals
  - electricity or gas
  - traffic
  - animals (tentacles from a jellyfish or a pet that feels threatened)
- Find your DAN first aid kit, oxygen unit and AED
- Exposure protection: Avoid contact with blood and other body fluids
  - Locate and don barriers such as gloves, eye shields and resuscitation masks

S Stop
- Stop
- Think
- Act

A Assess the Scene
- Scene safe?
- Safe to approach?
- Any hazards?
- Additional risks?

F Find the first aid kit, oxygen unit and AED, and take them to the injured person
- First aid kits contain critical supplies such as barriers

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

Risk of Infection

Anyone in a position to provide medical 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.

For individuals who may provide CPR and first aid as part of their occupational duties, the U.S. Occupational Safety and Health Administration (OSHA) has created a blood-borne pathogen standard to help minimise occupational exposures. This standard addresses the immediate safety of those who may come in contact with human blood, body fluids, body tissues, human waste, vomitus or organs.

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

- Milk the wound, encouraging 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
- Seek medical evaluation and counselling regarding exposure at a local medical facility (emergency department)

Report the exposure immediately to your personal physician and follow local protocols. If the incident occurred in the course of work activity, report the exposure immediately to your supervisor and follow your employer's exposure control plan.

There are three main blood-borne infection concerns: Viral hepatitis types B and C and, human immunodeficiency virus (HIV).

Hepatitis B[3]

Hepatitis B (HBV) is an infection that 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 HBV are themselves potentially infectious, although only about a quarter of them actually show symptoms. 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.

Symptoms

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

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

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

Transmission

HBV is transmitted via blood and other bodily fluids including 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 from a puncture wound with a contaminated object will become infected. The virus is also very stable on surfaces outside the body. It can last for up to seven days, making decontamination and clean up very important. There is a vaccine available for HBV that is 97% effective and is required for most health-care workers.

Hepatitis C[4, 5]

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 people, 20% develop cirrhosis and up to 20% of those who develop cirrhosis develop liver cancer.[4]

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.

Symptoms

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

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

4

Transmission

Routes of transmission/infection for HCV are the same as for HBV. The most common source for infection is shared needles by IV drug users who share needles. People also have contracted HCV from blood transfusions (prior to July 1992), needle sticks in health-care settings and through sexual intercourse.[5]

The likelihood of an infection from HCV (a 1 in 20 risk) is less than with HBV. The virus can remain viable outside the body, but it is not as sturdy as HBV. Currently, no immunisation is available for HCV.

HIV/AIDS

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

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 the following:

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

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 1 in 300. No immunisation or known cure for HIV is currently available.

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 the following:

- 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

NOTE

In the event of an accidental needle stick or cut from a potentially infected sharp, immediately wash the area with copious irrigation and warm, soapy water. Further medical attention is warranted to determine if an infection occurred.

Responsibility for standard precautions lies with the rescuer. To minimise your risk, carry protective barrier devices in every first aid kit. Gloves should be a standard part of your emergency response kit and should be donned before providing care. Replace them if they become torn, punctured, contaminated or compromised.

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. The skills-development section provides details about how to remove gloves safely.

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


4

CHAPTER 4 REVIEW QUESTIONS

1. **Potential dangers at the scene of an accident or injury requiring assistance may include**
   a. fire, downed power lines, overcast skies
   b. animals, fire, chemicals
   c. chemicals, sunny skies, open beaches
   d. all of the above

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 during removal**
   a. True
   b. False

Review answers are on Page 74.

5 Initial Assessment and Positioning for Care

CHAPTER 5 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 three primary steps:

- Assess for responsiveness and activate EMS
- Determine if the victim is breathing normally
- Adjust the patient's position for ongoing care, if necessary

Assessing Responsiveness

Once a rescuer ensures the scene is safe, assess the victim's level of responsiveness. Tap the victim's collarbone and shout, "Are you OK?"

Remember to introduce yourself, state you are trained in first aid and express your desire to help. 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 victim can answer, initially he should be left in the position in which he was found. Call EMS and conduct a secondary assessment (discussed later in this section) to determine if any injuries are present. If no evidence of injury is present, then the rescuer can place the victim in the recovery position or a position of comfort. The rescuer should reassure the patient and try to find out what happened.

If the patient does not respond, call EMS, turn him on his back and assess for normal breathing.

To turn a 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.

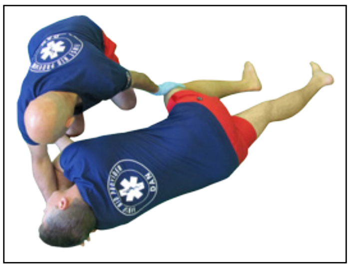
Recovery Position

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 if blood or other fluids are present in the mouth, gravity will aid in their removal and minimise the chance of aspiration.

Remember to call local EMS. Until help arrives, continually check to confirm 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 up the knee, 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



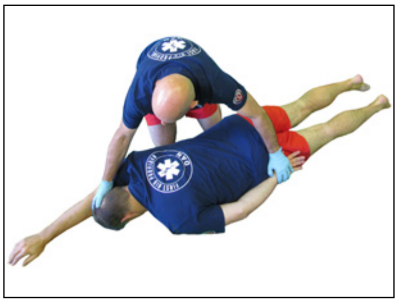
NOTE
Do not place people with suspected spinal or pelvic/hip injuries in the recovery position because movement increases the risk of further injury.

If you use the recovery position, monitor the peripheral circulation of the patient's lower arm and ensure that the duration for which there is 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 injured person's arms and legs, place the arm closest to you above the person's head and place the other arm against his torso
- Support the patient's head and neck with one hand
- Place the other hand on the opposite elbow and pull it gently into his side
- Roll the victim 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 5 REVIEW QUESTIONS

1. **Any breath sounds at all are considered normal**
   a. True
   b. False

2. **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

3. **Persons with back, neck or pelvic injuries should not be placed in the recovery position**
   a. True
   b. False

Review answers are on Page 74.

Section 2

6 Cardiopulmonary Resuscitation

CHAPTER 6 OBJECTIVES

1. What are the signs and symptoms of heart attack?
2. What is the recommended rate for compressions during CPR?
3. What is the recommended depth for CPR compressions on an adult?
4. What is the compression/ventilation ratio?
5. When is full CPR always recommended?
6. What barrier devices (exposure protection) are recommended when doing rescue breathing?
7. How long should ventilations last?

Heart Attack

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

When 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. 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 individual with taking his own medicine, but do not attempt to give nitroglycerine to anyone who does not have a prescription. When assisting someone with taking 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. If the person becomes pale or feels faint, do not administer subsequent doses of nitroglycerine. 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.

Possible symptoms of a heart attack:

- heavy pressure or squeezing pain in the centre of the chest or centre of the back
- shoulder, arm, neck or jaw pain
- nausea and vomiting
- shortness of breath
- indigestion, heartburn
- sweating
- sense of impending doom
- feeling weak or faint

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. "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.

Starting CPR – Support Circulation

When normal breathing is not present, activate EMS immediately. Inform them that the patient is not breathing normally. After notifying EMS, begin CPR starting with 30 compressions followed by two ventilations. For drowning victims, if you are alone, perform CPR for two minutes before getting help.

Begin chest compressions by stacking the hands, with the fingers of both hands interlocked, and the heel of the bottom hand on the centre of the chest, between the nipples. Keep the fingers raised off the chest wall and compress the chest 30 times at a rate of 120 per minute.

The depth of the compression should be 5-6 cm. Excessive depth during chest compressions can reduce survivability due to internal damage. Regardless of the size of the individual, limit compression depth to 5-6 cm. It is important to release the pressure on the chest between the compressions but without losing contact with the chest. Avoid leaning on the chest between compressions because it will inhibit full recoil of the chest wall. Full recoil is required for adequate circulation. The skills section covers the exact hand position and compression technique in detail.

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 will take 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 the resulting volume that flows out of the heart is decreased. When compressions are too slow, the amount of circulating oxygen available to tissues is decreased. When compressions are not deep enough, the amount of blood pushed out of the heart may be inadequate to support tissue oxygen demands.

Ventilations, described on the next page, follow chest compressions. Together they are delivered at a ratio of 30 compressions to two ventilations.

NOTE
If there is more than one rescuer present, alternate the role of performing chest compressions about every one to two minutes to minimise rescuer fatigue.

Drowning

Drowning is the third-leading cause of accidental death worldwide.[6] Responding to these incidents promptly and effectively can help reduce the mortality of drowning. It has already been noted that for victims of drowning a lone rescuer should conduct CPR for two minutes before activating EMS.

A irway
B reathing
C irculation

Another shift in protocol for drowning victims is for rescuers to initiate CPR with ventilations (not compressions) after determining unresponsiveness. This change is due to the hypoxic condition of drowning. It also is possible that prompt oxygenation of tissues with the use of a ventilations-first protocol can prevent cardiac arrest (if it has not already occurred). The rescuer can also consider using supplemental oxygen, if available.

Begin CPR for drowning victims by establishing an open airway, delivering two ventilations and then performing 30 compressions – a protocol acronym of A-B-C. Continue with two ventilations after every 30 chest compressions. Hands-only CPR is not appropriate in this situation.

Ventilations

Ventilations deliver oxygen to the lungs to oxygenate the blood and are an important part of CPR. For effective ventilations, tip back the victim's head and extend the jaw. This position 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. They are available in forms such as a simple face shield that it so small it can be carried in a minimal space, such as a wallet. Larger barriers include various oronasal resuscitation masks and devices. Mouth to mouth may be the only option if no barrier aids are available.

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

After each cycle of 30 compressions, provide two ventilations. Each ventilation should last about one second. Allow the chest to fall (exhalation) for about one second, then deliver a second ventilation. If the first ventilation does not cause the chest to rise, reposition the victim's head and try again. Regardless of effectiveness of ventilations, compressions should not be interrupted for more than 10 seconds. If ventilations 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 in order to ventilate should not last more than 10 seconds.

NOTE

Remove the 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.

Full CPR

Full CPR is accomplished by using chest compressions and ventilations together, as this chapter describes. The skill-development portion of this course will provide an opportunity to develop compression and ventilation techniques as well perform full CPR on manikins.

Use of Oxygen During Resuscitation

Supplemental oxygen improves the delivery of oxygen to tissues during resuscitation. When used effectively, the concentration of delivered oxygen may increase to levels approaching 100%.

The use of oxygen is very important for victims of drowning and scuba diving accidents, where hypoxia is a major concern. Oxygen therefore should be present at every swimming pool and dive site. Oxygen administration for scuba diving injuries is included as part of this DEMP course.

What About Children?

Many children do not receive resuscitation because rescuers fear harming them. The current CPR compression and ventilation ratio (30:2) is also used for children. The lone rescuer should perform CPR for approximately two minutes before going for help (or while simultaneously calling EMS via cell phone). For children, compress the chest by approximately one-third its depth using one or two hands. For infants under one year, use two fingers. Training on CPR for children and infants is available in the CPR: Health Care Provider course.

Special Circumstances with Resuscitation[7]

Pregnancy

While cardiac arrest is rare in pregnant women, 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 pressure in return circulation 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 of death. 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 naxolone is available, administer 0.4 mg with an auto-injector as well as an inhaled nasal mist and continue CPR. The dose may be repeated every four minutes. Watch for purposeful movement or regular breathing to indicate the patient's becoming responsive.

Continue to monitor the patient's 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.

CHAPTER 6 REVIEW QUESTIONS

1. **Possible signs and symptoms of heart attack include**
   a. heavy pressure or squeezing in the chest
   b. shortness of breath
   c. shoulder, arm or jaw pain
   d. all of the above
   e. a and b only

2. **The recommended rate of compression for an adult is**
   a. 60-80 per minute
   b. 120 per minute
   c. at least 140 per minute
   d. rate is not important as long as compressions are being done

3. **The recommended depth of chest compression 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

4. **The compression-to-ventilation ratio for an adult is**
   a. 30:2
   b. 15:2
   c. 5:1
   d. 50:2

5. **Full CPR is always recommended for drowning and scuba diving injuries**
   a. True
   b. False

6. **Each ventilation should last about**
   a. two seconds
   b. one second
   c. five seconds

7. **CPR for drowning victims should follow an A-B-C protocol**
   a. True
   b. False

Review answers are on Page 74.

Section 2

7 Use of AEDs During CPR

CHAPTER 7 OBJECTIVES

1. Why are AEDs recommended when they are available?
2. What is the reduction in survival rate when AED use is delayed?
3. What specific condition does an AED help resolve?

The heart has an inherent electrical system that stimulates heart muscle contractions. As these electrical impulses fire and the muscles contract, blood is pumped from the heart to the lungs and 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 called 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.

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 automated external defibrillators (AEDs), the use of defibrillators required a lot of training and only highly trained professionals could use them. Fortunately, AEDs available to the general public are simple to use and reduce the time from initial collapse to initial shock delivery. AEDs available in public areas differ but all provide audible user prompts. Turn on the AED and follow the directions provided by the unit. The skill-development portion of this section will introduce the process using an AED training unit.

When defibrillation is provided in conjunction with CPR within minutes of VF beginning, the person's chances for survival are at the highest rate. Survival rates drop by about 7-10% for every minute a person is in VF without CPR.[8] The longer a person remains in an unstable rhythm, the lower the chances of successful defibrillation and subsequent survival.

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.

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 pad 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 will advise 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 the 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.

Take time to notice the locations of AEDs in businesses and other areas you frequent so you will know where to find one if it is needed. Also 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 DEMP Instructor about possible restrictions on AED use where you live or work.

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 care for the patient, discontinue it and move it away from the patient.

Troubleshooting

AEDs are typically trouble free, but when problems do 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 make 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.

CHAPTER 7 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

Review answers are on Page 74.

Section 2

8 Foreign-Body Airway Obstruction

CHAPTER 8 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. How should a rescuer respond to a severe airway obstruction?
6. What action should be taken if a choking victim becomes unconscious?
7. When can a finger sweep be used?

Foreign bodies are the main cause of blocked airways and choking. Food is the most frequent culprit in adults. 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.

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.

First Aid

In the case of a partial or mild airway obstruction (the victim can speak, cough or 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) in the following way:

- Stand behind the patient, and put both of your arms around the upper part of his 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 patient 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 ventilations)
- Look in the mouth for the obstruction before each ventilation. 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.

Victims of Drowning: Aspiration of Water

The aspiration of water can be suspected in cases of drowning. However, removal of water is not part of first aid treatment. 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. 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.

CHAPTER 8 REVIEW QUESTIONS

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

2. **Grasping the throat is a common sign made by choking victims**
   a. True
   b. False

3. **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

4. **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 to speak 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

5. **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

6. **If the victim at any time becomes unconscious, the rescuer should ___________**
   a. allow the victim to drop to the floor 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

7. **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

Review answers are on Page 74.

NOTES:

Section 2

9 First aid Assessments

CHAPTER 9 OBJECTIVES

1. How is first aid distinguished from basic life support?
2. How is level of consciousness assessed?
3. What is S-A-M-P-L-E?
4. What is a secondary assessment?

First aid is the care you provide for injuries or illnesses that are not immediately life threatening. Before initiating care, perform a general assessment.

General Patient Assessment

a. State of health: Obtain a general impression of the patient's health and well-being. Is he in physical distress or pain?
b. Observe respiratory effort, chest expansion, pulse rate and use of accessory muscles.
c. Notice if the skin is pale or red and flushed.
d. The level of consciousness can be evaluated using the **A-V-P-U** acronym.

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

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.

To help you remember what information to gather when taking a history, use the mnemonic S-A-M-P-L-E:

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

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

In a medical emergency, determine the patient's complaints and when they started. Examples of common concerns include the following:

- breathing difficulties
- chest pain
- abdominal pain
- altered level of consciousness

Secondary Assessment

After you have stabilised a patient and addressed immediate life-threatening concerns, perform a secondary assessment to see if there are any other injuries of which you were not initially aware. Conduct the assessment with the patient in the same position in which he was found. Do not move the patient if the nature of the injury or their position indicates there may be a neck, spine, hip or pelvic injury. Talk to the patient to determine if he has any pain or particular discomfort and focus on those areas.

Before you begin this secondary assessment, remember to be S-A-F-E and protect yourself from bodily fluids with personal protective equipment. The assessment involves touching the patient, so ask for permission before you begin.

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.

If the patient experiences pain, stop the assessment and notify EMS if you have not already called them.

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 under the skin. This 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.

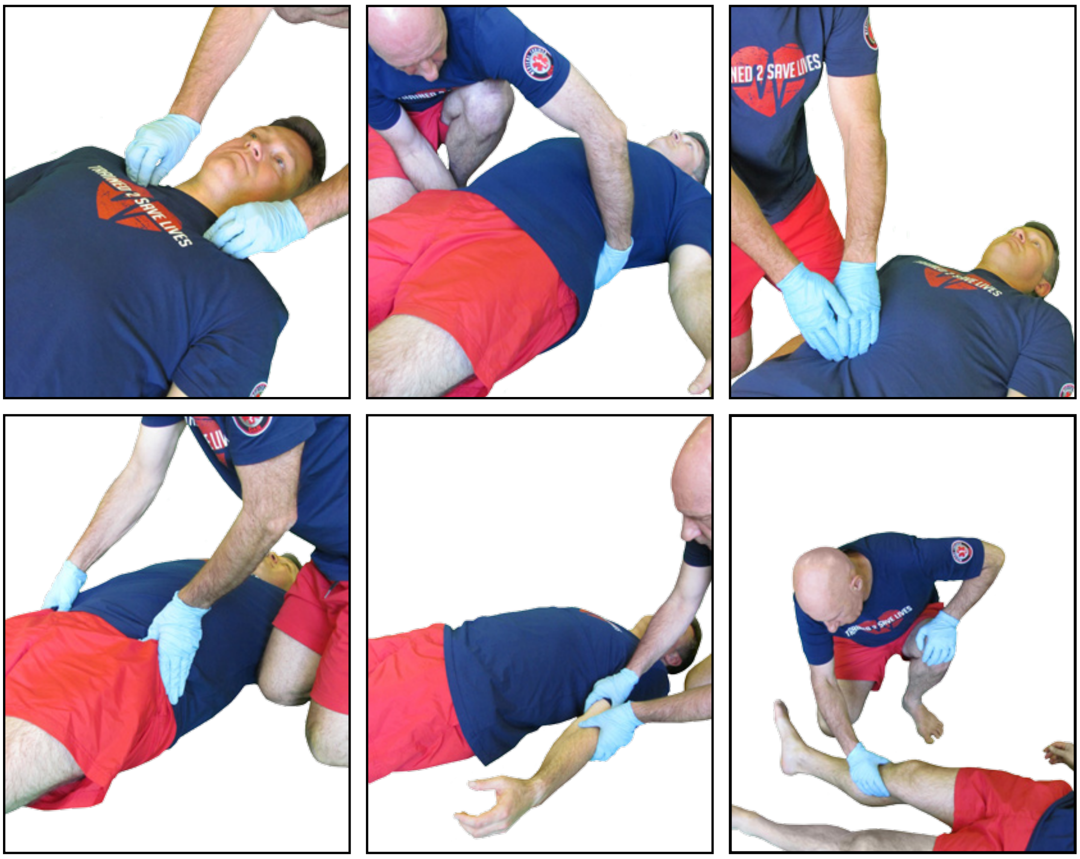
Next, palpate the patient's collarbone to check for deformities or discolouration. Press your fingers along each collarbone individually to assess movement or reaction to your examination.

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. Ask the patient to wiggle his fingers and toes.



CHAPTER 9 REVIEW QUESTIONS

1. **First aid is care provided for injuries or illnesses that are not life-threatening**
   a. True
   b. False

2. **The A in S-A-M-P-L-E stands for**
   a. allergies
   b. asthma
   c. anxiety
   d. aneurism

Review answers are on Page 74.

9

Section 2

10 Temperature-related Injuries

CHAPTER 10 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

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 fall below 28°C. At this point coma and unconsciousness are likely and victims 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 the clothing 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 this is a condition that may stabilise with rewarming. This 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.[9] The current theory for this phenomenon states 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 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 to dehydration

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 simultaneous use of multiple methods 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 can be provided by wind chill or an indoor fan.

- ***Cooling methods:*** Use a fan, air-conditioning vent or exposure to wind. It works best if combined with a cool mist spray to 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. As an 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 for any of the following situations:
- symptoms are severe
- history of heart problems or high blood pressure exists
- symptoms worsen or last longer than one hour

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

Heat Rash

Heat rash, which is commonly seen around the neck, groin, elbow creases and beneath breasts, looks like small pimples and is caused by excessive sweating. While seen in all ages, it is most common in young children. Treatment is simple and involves cooling and keeping areas dry. This rarely requires medical attention and usually resolves on its own.

Heat Cramps

Heat cramps are muscle spasms resulting from excessive fluid and electrolyte loss. They are often associated with strenuous activity and may be a sign of heat exhaustion.

Immediate first aid measures include the following:

- Stop all activity and rest in a cool place
- Drink clear liquids, preferably with electrolytes (sports drinks)
- Do not return to strenuous activity for several hours
- If symptoms do not resolve within about an hour, seek medical attention

Heat Exhaustion

Heat exhaustion occurs as a result of excessive fluid and electrolyte loss. Those most prone to heat exhaustion include the elderly, people taking diuretics (medications that cause fluid and electrolyte loss) and people working or exercising in hot environments where fluid and electrolyte loss are most likely to exceed the rate of replacement.

Warning signs of heat exhaustion:[10]

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

Untreated, heat exhaustion can progress to heat stroke and should therefore 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 from heat source
- Rest
- Place in a cool environment
- Remove unnecessary clothing
- Replacement of 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[11]

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

10

NOTE

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

Immediate first aid measures include the following:

- Remove from 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 (IV fluids, administered by EMS personnel, are usually advised as airway management may be compromised)
- Cooling methods: Evaporation, conduction, convection and radiation
  - Apply cold packs to the 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

Continually monitor for airway compromise, seizure, unconsciousness or cardiac arrest.

CHAPTER 10 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 74.

Section 2

11 Lifting and Moving

CHAPTER 11 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 need to move an injured person. In fact, moving a patient is strongly discouraged because the attempt could cause additional injury. You should leave the person in the position in which he was found.

There are two exceptions:

- The person needs to be moved onto his back for CPR
- The person is in imminent danger (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 not recommended.

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. 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

When lifting, protect yourself and remember important principles of body mechanics, including maintenance of a straight, rigid back and bending at the hips and not at the waist. Also keep your head in a neutral position and not flexed forward or extended backward. Use your legs, not your back, to lift.

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 victim 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 rescuer lifts from behind the patient, reaching under the arms and grasping the patient's opposite wrists. The other rescuer lifts at the patient's knees by wrapping his arms around the person's legs.

CHAPTER 11 REVIEW QUESTIONS

1. **Patient movement should be avoided except to move the person onto his back to perform CPR or when the current location places the victim or rescuer at risk of further injury**
   a. True
   b. False

2. **Body mechanics to be followed by the rescuer when lifting include**
   a. keeping the back straight and bending from the hips
   b. lifting with the legs
   c. keeping the head in a neutral position
   d. all of the above

Review answers are on Page 74.

Section 2

12 Basic Life Support: CPR and First Aid Skills Development

SKILL OBJECTIVES

1. **Scene Safety Assessment**
   - List the steps in performing a scene safety assessment
   - Perform a scene safety assessment in a scenario
   - Use appropriate firs aid barrier devices in a scenario
2. **Donning and Doffing Gloves**
   - Demonstrate donning of gloves without tearing or compromising glove integrity
   - Demonstrate removal of gloves without contaminating exposed skin
3. **Initial Assessment**
   - Demonstrate the technique for establishing unresponsiveness
4. **Recovery Position**
   - Demonstrate rolling a patient from his back into the recovery position, keeping the spine aligned
5. **Chest Compressions**
   - Demonstrate proper hand positioning for chest compressions
   - 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
6. **Ventilations**
   - Demonstrate proper ventilation technique on an adult CPR manikin
7. **Full Cardiopulmonary Resuscitation (CPR)**
   - Perform two minutes of full CPR on an adult CPR manikin, completing at least five cycles of 30:2 compressions/ventilations
8. **Automated External Defibrillator (AED)**
   - 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
9. **Foreign-Body Airway Obstruction**
   - Demonstrate proper abdominal thrust technique for management of an obstructed airway in an adult
10. **Secondary Assessment**
    - Demonstrate the technique for head-to-foot secondary assessment, using a gentle touch and caring manner

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

S Stop
- Stop
- Think
- Act

A Assess the Scene
- Scene safe?
- Safe to approach?
- Any hazards?
- Additional risks?

F Find the first aid kit, oxygen unit and AED, and take them to the injured person
- First aid kits contain critical supplies such as barriers

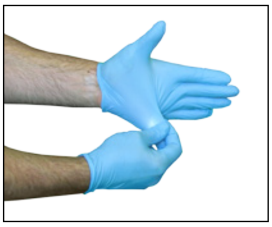
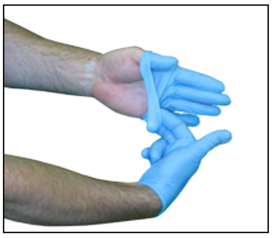
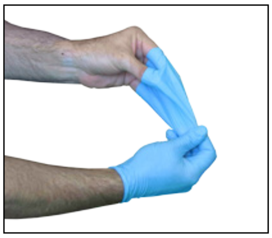
E Exposure Protection
- Use barriers such as gloves and mouth-to-mask barrier devices
- Don gloves and inspect them for damage

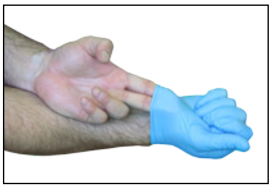
Donning and Doffing Gloves After Use

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 them
    - This bag can also be used for the disposal of all other infected materials after use




Initial Assessment

Objective

- *Demonstrate the technique for establishing unresponsiveness*

Circulation
Airway
Breathing

Remember S-A-F-E.

- State your name, training and desire to help
- Ask permission to help
- Tap the patient on the shoulder, and say or shout, "Are you all right?"

If the person responds:

- Have him remain where he is unless urgent evacuation is necessary to avoid further danger
- Try to find out what is wrong and activate EMS if needed
- Re-assess frequently until the circumstance resolves or EMS arrives

If the person does not respond:

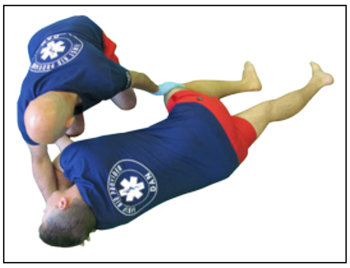
- Shout for help or call EMS
- Turn the patient on his back
- Check for normal breathing
- If the patient is not breathing normally, send someone for help. If you are on your own, leave him and alert EMS, then return and start CPR, beginning with chest compressions

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



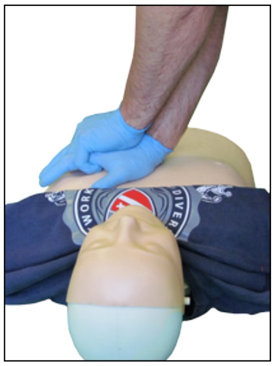
Chest Compressions

Objectives

- *Demonstrate the proper hand positioning for chest compressions*
- *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*

- Kneel by the patient's side
- Place the heel of one hand in the centre of the chest, between the nipples
- Place the heel of your other hand on top of the first hand
- Interlock the fingers of your hands, raising the fingers off the chest wall
- Do not apply pressure over the upper abdomen or the bottom end of the sternum (breastbone)
- Position yourself vertically above the chest, with your arms straight and shoulders directly above your elbows. Using your hips as a pivot point and the weight of your whole body, forcefully but smoothly press down on the lower half of the sternum 5-6 cm
- After each compression, release all the pressure on the chest without losing contact between your hands and the chest wall. Do not lean on the chest during recoil. Repeat at a rate of 120 per minute
- Compression and release should take the same amount of time






Ventilations

Objective

- *Demonstrate the proper ventilation technique on an adult CPR manikin*

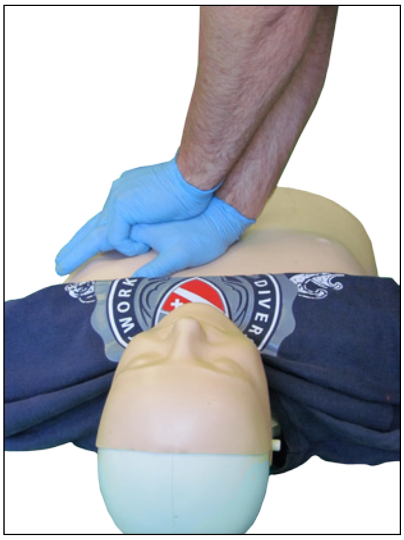
- Remain at the patient's side
- Place the face shield or resuscitation mask on the patient's face, using the bridge of the nose as a guide for correct positioning
- Seal the mask by placing your index finger and thumb along the upper border of the mask. Use the hand that is closest to the top of the patient's head along the upper 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
- Tilt back the patient's head so the chin is lifted into the mask and pointing up
- Seal your lips around the one-way valve and blow through it. Each ventilation should last about one second. Watch for the chest to gently rise
- Take your mouth away from the mask and watch for the chest to fall as the breath is exhaled
- Deliver a second ventilation as before
- If ventilations do not make the chest rise:
  - Reposition the patient's head using the head-tilt, chin-lift technique, making sure the head is adequately extended to open the airway and re-attempt to ventilate
  - Check the patient's mouth and remove any obstruction
  - Do not attempt more than two ventilations each time before returning to chest compressions
  - When in doubt, ventilate less, not more
- Do not interrupt compressions for more than 10 seconds during ventilations

Full Cardiopulmonary Resuscitation (CPR)

Objective

- *Perform two minutes of full CPR on an adult CPR manikin, completing at least five cycles of 30:2 compressions/ventilations*

- Using the compression and ventilation techniques from the previous skills, deliver chest compressions at a rate of 120 per minute to a consistent depth of 5-6 cm, followed by effective ventilations using a ratio of 30:2 for a minimum of five cycles/ two minutes
- After completing the two-minute cycle, reassess the patient



12

NOTES:

Automated External Defibrillator (AED)

Objectives

- *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

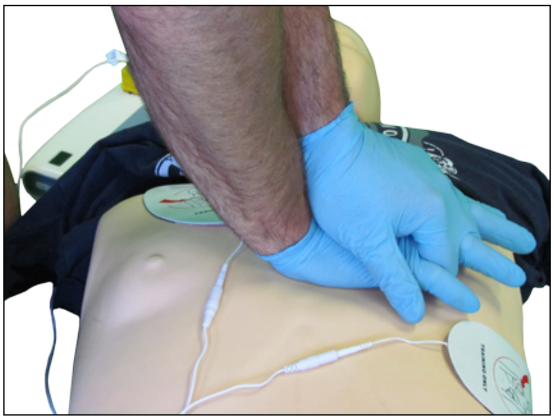
If the person is not breathing normally:

- Send someone for an AED or get one yourself
- Perform CPR 30:2 until 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
    • 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.



Foreign-body Airway Obstruction

Objective

- *Demonstrate the proper abdominal thrust technique for management of an obstructed airway in an adult*

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 victim and put both of your arms around the upper part of the abdomen
- With one hand, locate the victim'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 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 victim loses consciousness

If the victim at any time becomes unconscious, do the following:
- Carefully lower the victim to the ground
- Activate EMS
- Begin CPR (chest compressions followed by ventilations)
- Look in the mouth for obstruction prior to giving ventilations
- Finger sweep only if the object is visible

Secondary Assessment

Objective

- *Demonstrate the technique for a head-to-foot secondary assessment using a gentle touch and caring manner*

Remember S-A-F-E.

- Ask permission to conduct an assessment
- Note any areas that cause pain or are uncomfortable to the patient
- Palpate the patient's head and face to check 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 the pupils for reaction to the changing light exposure
  - Determine if the eyes dilate in response to the shade
- If the injury is related to scuba diving, gently palpate the front of the patient's neck to check for air bubbles and a crackling sound coming from underneath the skin
- Inspect the patient's collarbone for injuries or discolouration
  - Gently slide the fingertips of your index and middle fingers, one on each side of one collarbone, to check for movement or reaction to your examination. Repeat the action on the other collarbone
- Examine the chest
  - Place your hands on either side of the patient's 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 patient's 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

Section 2 Summary

Prompt action is always important with any sudden illness or injury. Remember, however, to protect yourself and any other rescuers by completing a scene safety assessment before rendering aid. Using protective barriers is another critical step to rescuer safety.

Life-threatening conditions are the first priority of care. Circulation, airway and breathing are the initial steps for an unresponsive, non-breathing individual. Use of an AED, if available, can increase the chances of survival for someone in cardiac arrest.

Once life-threatening conditions have been addressed, there are other steps the rescuer can take to assist an ill or injured individual. Secondary assessment of illness and injury should not be overlooked. It can direct your next steps of care and provide additional information that may be of use later as the patient goes into advanced medical care.

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Review answers

Chapter 2, Page 13
1. c
2. b
3. a
4. a
5. e
6. a
7. d
8. a
9. b

Chapter 3, Page 19
1. c
2. a
3. c

Chapter 4, Page 26
1. d
2. d
3. a
4. d
5. a

Chapter 5, Page 30
1. b
2. a
3. a

Chapter 6, Page 37
1. d
2. b
3. b
4. a
5. a
6. b
7. a

Chapter 7, Page 41
1. b
2. b
3. b
4. b

Chapter 8, Page 44
1. b
2. a
3. c
4. c
5. a
6. b
7. a

Chapter 9, Page 49
1. a
2. a

Chapter 10, Page 56
1. a
2. e
3. a

Chapter 11, Page 59
1. a
2. d

NOTES:

Section 3 Neurological Assessment

TABLE OF CONTENTS

1 Neurological Assessment Overview

According to the American Heart Association 2011 update, stroke is the third-leading cause of death and the leading cause of long-term disability.[1] Decompression illness (DCI) is a much less common cause of neurological injury. The overall incidence of this scuba-diving-associated injury is two to four cases per 10 000 dives.[2] For purposes of the Dive Emergency Management Provider course, the focus of this portion will be on diving manifestations of neurological injury.

Regardless of underlying cause, the presence of a neurological injury is frequently revealed by performance of a neurological assessment.

The Neurological Assessment course trains participants to perform a basic neurological examination as part of the initial medical evaluation.

There are two primary goals of this programme:

1. Provide first responders with the skills necessary to discover signs of acute neurological injury.
2. Minimise treatment delays through rapid activation of emergency medical services (EMS).

2 Nervous System Overview

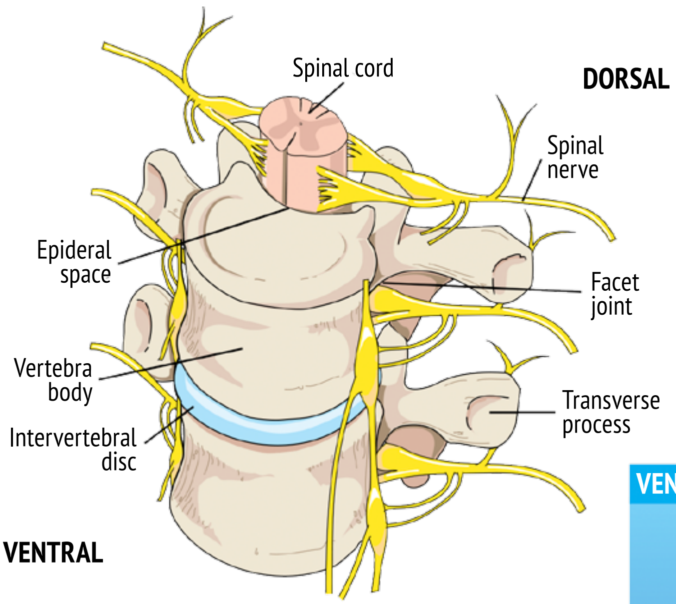
CHAPTER 2 OBJECTIVES

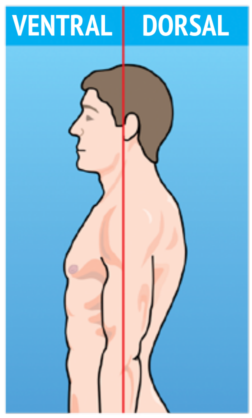
1. What are the primary components of the nervous system?
2. What is the functional unit of the nervous system?
3. What are possible causes of interruptions along neural pathways?

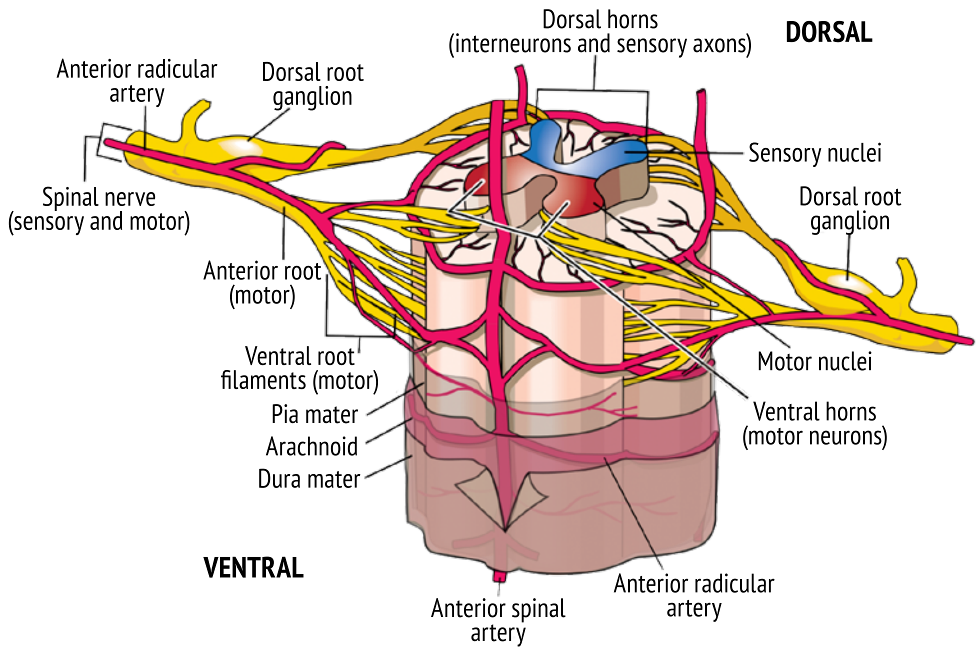
The primary components of the nervous system are the brain, spinal cord and nerves. The brain and spinal cord form the central nervous system, and the nerves that extend from the spinal cord or brain out to the body is the peripheral nervous system. The functional unit of this system is the nerve cell 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 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 will provide you with the skills needed to test for and recognise prominent signs of possible neurological compromise.


Spinal cord
DORSAL
Spinal
nerve
Epidural
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
Ventral horns
(motor neurons)
Pia mater
Arachnoid
Dura mater
VENTRAL
Anterior radicular
artery
Anterior spinal
artery

CHAPTER 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 108.

Section 3

Decompression Illness

CHAPTER 3 OBJECTIVES

1. What two conditions compose decompression illness (DCI)?
2. What are the most common signs and symptoms of 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 encompasses two different, but potentially linked, processes

- decompression sickness (DCS)
- arterial gas embolism (AGE)

Decompression Sickness

DCS results from bubbles of dissolved inert gas (nitrogen or helium) that form within tissues or blood. 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 (narrowing of blood vessels). 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 presence of bubbles affect on us on a systemic level, specific signs and symptoms are thought to result from either bubble accumulation or its impact on specific areas. Examples include joint pain, motor dysfunctions and skin rash.

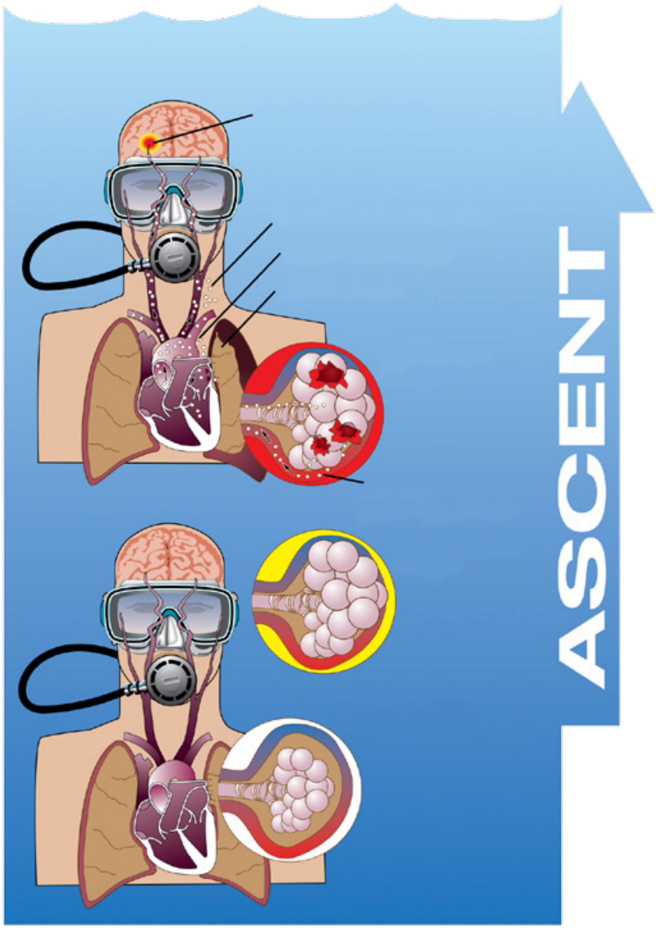
Important aspects about DCS to remember include:

- Symptom onset usually occurs after surfacing but can occur during ascent
- Factors contributing to bubble formation include excess nitrogen, rapid ascent and decreasing ambient pressure (such as when flying after diving)
- DCS symptoms may differ throughout the body
- Any area of the body may be involved

Arterial Gas Embolism

In contrast to DCS, AGE is commonly associated with lung-overexpansion injury (pulmonary barotrauma). 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 returning to the heart (pulmonary veins). These bubbles can cause rapid and dramatic effects if they are transported to the brain. AGE is the most severe result of pulmonary barotrauma and often presents suddenly either near or at the surface.

The primary risk factor for AGE is breath-holding during ascent. Other potential risk factors include any condition that could trap air, such as lung infections, asthma and previous lung trauma.



Pulmonary barotrauma with subsequent AGE and representation of brain (cerebral) injury. Recreated by Divers Alert Network from Lancet.[4]

Common Signs and Symptoms of DCI

Injured divers may have one or more of the following signs and symptoms, which are ranked in order of initial presenting symptom. This frequency is based on Project Dive Exploration (PDE) data from 2 346 recreational dive accidents reported to DAN between 1998 and 2004.[4]

- **Pain** (initial symptom in 40% 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 the diver associates with the discomfort and may be referred to as unusual or just a "different" type of pain
  - 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, or fatigue from exertion and other non-specific discomforts

- **Numbness and paraesthesia** (initial symptom 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 most often occur in the limbs and may be associated with complaints such as a cold, heavy or swollen sensation
- **Constitutional symptoms** (initial symptom in 14% of cases). These are generalised symptoms that do not impact 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
- **Balance and equilibrium** (initial symptom in 6% of cases)
  - *Vertigo (spinning sensation):* Vertigo presenting during or after the dive should be considered a serious symptom suspicious of inner-ear/vestibular involvement. There are several causes not related to DCI for such symptoms, and 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:* A feeling of unsteadiness, which may also be characterised as lightheadedness, is commonly associated with nausea
- **Muscular weakness** (initial symptom in 4% of cases). This symptom may present as difficulty walking due to decreased muscular strength or limb paralysis
- **Cutaneous (skin) symptoms** (initial symptom in 3% of cases). Skin signs are often located on the chest, abdomen, back, buttocks or thighs. Rashes commonly migrate (move to different parts of the body). 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 nonsensical speech)
- **Bowel and bladder** (initial symptom in 0.04% of cases). Spinal cord DCS may injure the nerves responsible for bladder and bowel control. Sometimes people will require urinary catheterisation

NOTE

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

Other Signs and Symptoms of DCI

- **Lymphatic DCS:** Identified as an initial symptom in 0.3% of cases, this symptom is often characterised as localised swelling affecting the trunk and shoulders
- **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
- **Visual disturbance:** Loss or blurring of vision or loss of visual fields
- **Difficulty breathing due to DCI:** This 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 elicit medical evaluation
- **Convulsions** are rare

ADVANCED CONCEPTS

A separate but related concern is AGE that occurs secondary to venous bubbles by passing the pulmonary filter and directly entering the arterial system. The process by 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 patent foramen ovale (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 system are undesirable, their presence does not automatically cause symptoms. Bubbles have been seen in the left heart following decompression in subjects who have not gone on to develop symptomatic DCI.

Oxygen and the Importance of Proper Medical Evaluation of DCI

The diagnosis of DCI is based on the diver'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 oxygen use leads to symptom resolution, which may prompt the diver to forego medical assessment. DAN recommends seeking prompt medical evaluation in all cases of suspected DCI regardless of the response to oxygen first aid. Symptoms may recur and hyperbaric treatment may reduce the risk of recurrence.

Epidemiology of Decompression Illness

DCI is an uncommon event that nonetheless warrants attention and concerted efforts for prevention. 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%.[3, 4]

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 was 2/10 000 (0.0002) from warm-water liveaboards and 28/10 000 (0.0028) among coldwater wreck divers in the North Sea.[5]

DCI 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.

Recompression Therapy

An injured diver may feel better or experience reduced symptom severity after receiving emergency oxygen (covered in the next section of this course). 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, which is one of the reasons DAN recommends transportation to the nearest medical facility for evaluation and not necessarily to the nearest hyperbaric chamber.

This action is advised for several reasons, including the following:

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

Every dive injury is unique and crucial medical decisions must be made individually by a physician trained in dive medicine. The decision about where to treat an injured diver can be made only after a thorough medical evaluation and appropriate consultation. DAN is always available to provide information to emergency medical staff regarding diving injuries and the potential benefit of hyperbaric treatment. DAN also provides evacuation assistance and care 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 3 REVIEW QUESTIONS

1. **Decompression illness includes AGE and DCS**
   a. True
   b. False

2. **Pain, numbness and paraesthesia are the most common signs of decompression illness**
   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 proper medical evaluation in cases of suspected DCI because**
   a. symptom resolution with oxygen first aid does not mean DCI has been resolved
   b. symptoms may return without hyperbaric treatment
   c. recurrence of symptoms may be reduced with 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

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 consultation with a physician knowledgeable in dive medicine**
   a. True
   b. False

Review answers are on page 108.

Section 3

4 Conducting a Neurological Assessment

CHAPTER 4 OBJECTIVES

1. When should an emergency assistance plan be activated if you suspect a neurological injury?
2. What does the mnemonic F-A-S-T mean?
3. What are the four areas of a neurological assessment?
4. What functions are evaluated in the "mental function" part of the neurological assessment?
5. What functions are evaluated in the "cranial nerves" section of the neurological assessment?
6. How do motor function deficits manifest?
7. How are balance and co-ordination evaluated?

Perform a neurological assessment only on a conscious, breathing person and always ask permission prior to initiating any physical contact. As with most medical assessments, it is a good idea to have a third party present during the examination to help eliminate concerns about improper contact. A typical neurological assessment should take about 10 minutes.

The neurological assessment begins with simple conversation. This introduction facilitates some initial evaluation and builds rapport. As you move through the assessment, be sure to record your findings as well as the time when the assessment was performed. If subsequent assessments are performed, each should be recorded in the same manner.

When faced with a possible neurological injury, remember the F-A-S-T first principle. F-A-S-T is a mnemonic to assist with remembering the steps for this key initial assessment.

F Facial droop

A Arm weakness

S Speech difficulty, sudden severe headache

T Time (note the time and call EMS immediately)

Facial Droop

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

Arm Weakness

The presence of arm weakness can be assessed by asking the injured person to raise both 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.

Image depicts a normal response.

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

Time
Call 10177 (or your local emergency medical services number) immediately if any of these symptoms are present.

The F-A-S-T assessment is an easy way to determine if signs of neurological injury are present. Once a problem is identified or an injury is likely, take the following initial actions:
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 (CPR).

Once EMS has been activated, conduct the neurological assessment described in this chapter. A neurological assessment should be completed only on conscious individuals. Their responses and your observations facilitate the process. The information you gather may influence the initial treatment and subsequent impact of the injury. 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 during which 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, including oxygen administration.

Taking a History
The patient's history is a critical aspect of all medical evaluations. 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,** described in the previous section, provides a guide to collecting relevant information. This portion of the evaluation is done first and precedes the actual neurological examination.

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.

To check for a pulse, use the first two fingers of either hand to press gently on the radial artery. Check the radial pulse by placing the same two fingers into the groove between the bone and tendons at the base of the patient's thumb. 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.

While the carotid artery is an option for determining a pulse, for purposes of this assessment the radial pulse is preferred. If you need to locate the carotid artery, place your first two fingers on the "Adam's apple" of the victim's throat, and slide your fingers to the side 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.

Respiration rate can be determined by counting the rise and fall of the chest. Prior to counting breaths per minute, you should 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.

In an attempt 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. Avoid staring at the chest, especially if the diver is female. Alternately, it may be helpful to have a bystander count respirations.

NOTE

Normal pulse and respiratory rates are based on statistical norms. Values outside these ranges are not necessarily causes for concern or may not indicate abnormality. Factors such as 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 he is presenting.

4

Dive History

In the case of injured divers, additional, important information to gather 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.

Symptoms are often under-reported 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.

The Four Functional Areas of a Neurological Assessment

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

- Mental function
- Cranial nerves
- Motor function
- Co-ordination and balance

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

In the case of severe neurological injury, assessment of certain vocal or motor responses may not be possible. 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, 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 orientated (A&O) x 4" when the individual answers each question appropriately. In the event that questions are answered incorrectly, note what was asked and the response.

The level of consciousness the injured person is exhibiting should be recorded during the assessment, using the terms

- **A**lert
- **V**erbal stimulus
- **P**ainful stimulus
- **U**nresponsive

These terms are abbreviated as A-V-P-U on the neurological assessment slate. Be aware that 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 happened.

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 to note 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

There are 12 pairs of nerves emanating from the skull that control the special senses and muscles of the eyes and face. Neurological injury from DCI or 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 may range from weakness to paralysis. Proper examination of strength entails comparison with the other side of the body. This process often detects or confirms subtle abnormalities.

DCI rarely affects both sides of the body simultaneously. When it does, the abnormality is obvious and can affect both arms and/or legs. Strokes are usually confined to the brain and these effects typically influence one side of the body, including the head and neck.

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.

4

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 104). To assess balance, have the injured person walk a straight line and then perform a Romberg (or Sharpened Romberg) test (see Page 104).

NOTE

Balance, speech and co-ordination may also suffer temporary impairment from alcohol intoxication or use of certain medications.

ADVANCED CONCEPTS

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

ADVANCED CONCEPTS

Nerve tracts refer to "bundles" of nerve fibers within the spinal cord that convey messages either to or from the brain. Sensory nerve tracts, located primarily in the 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 4 REVIEW QUESTIONS

1. **F-A-S-T stands for**
   a. facts, attitude, sensitivity, talent
   b. face, arms, speech, time
   c. feet, arms, spine, toes
   d. face, ankles, stability, touch

2. **EMS should be called**
   a. as soon as you suspect a neurological injury
   b. after you have conducted a neurological assessment
   c. a period of time after the first assessment so you can advise EMS if there are changes
   d. only if requested by the injured person

3. **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

4. **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

5. **Which of the following is not part of the cranial nerves evaluation?**
   a. Facial droop
   b. Eye movements
   c. Grip strength
   d. Slurred speech

6. **Motor functions may be classified as normal, evidence of weakness or paralysis**
   a. True
   b. False

7. **The Romberg test assesses**
   a. motor function
   b. cranial nerves
   c. mental status
   d. balance

Review answers are on Page 108.

Section 3

5 Neurological Assessment Skills Development

CHAPTER 5 OBJECTIVES

1. **F-A-S-T assessment**
   - Conduct a F-A-S-T assessment on a simulated patient suspected of having a neurological impairment
2. **History**
   - 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
3. **Vital signs**
   - Demonstrate the proper technique to determine a person's pulse rate and breaths per minute, counting each for 30 seconds and then multiplying by two
4. **Mental function**
   - 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
5. **Cranial nerves**
   - Assess control of the eyes and facial muscles using simple commands.
   - Assess an individual's ability to hear by rubbing or snapping your fingers 30 cm from the ear
6. **Motor function (strength)**
   - Assess strength of muscle groups using muscle isolation and resistance
7. **Co-ordination and balance**
   - Assess an individual's co-ordination using a finger-nose-finger exercise
   - Determine the presence of functional balance using a straight walk and a Romberg test

The skills overview for this course provides general information. Specific technique elements will be covered in the skill-development portion of the class.

FAST Assessment

F Facial droop

A Arm weakness

S Speech difficulty, sudden severe headache

T Time (note the time and call EMS immediately)

Objective

- *Conduct a FAST assessment on a simulated patient suspected of having a neurological impairment*

Have the patient remain seated during the assessment.

- Ask the patient to smile. Observe his face for asymmetry. Is one side drooping? Is the smile equal on both sides?
- Ask the patient 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 patient 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

Taking a History

Objectives

- *Interview a patient in a simulated scenario using the SAMPLE 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, getting information about conditions that may influence the individual's assessment is important.

To help you remember what information to gather when taking a history, use the mnemonic SAMPLE.

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

The neurological assessment slate includes an area for recording your findings.

5

Taking Vital Signs

Objective

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

Take the individual's pulse, and note his respiratory rate. Each measurement 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 patient's 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 in your 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. Count respirations by observing the rise and fall of the person's chest. Try to count without letting the individual know that you are monitoring his breathing or discretely ask a bystander to count respirations while you check the pulse. Another option is to continue to hold the individual's wrist while you count pulse and respirations for 30 seconds each.

Normal adult resting respiratory rates are between 12 and 20 breaths per minute.

Signs and symptoms. Record any signs and symptoms. In the case of pain, attempt to describe the severity, quality (sharp, dull, throbbing), its location and association with movement. Document symptom-onset times, their progression and a description of all first aid provided.

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)

On your slate, indicate the person's level of consciousness using the AVPU acronym:

- **A**lert
- **V**erbal stimulus
- **P**ainful stimulus
- **U**nresponsive

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)
  - You may need to shout at times
- Responds to painful stimuli (painful)
  - If he is unresponsive to verbal stimuli, check for a response to painful stimuli such as a sternal rub
- Unresponsive
  - If the person is unresponsive, immediately begin basic life support

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)

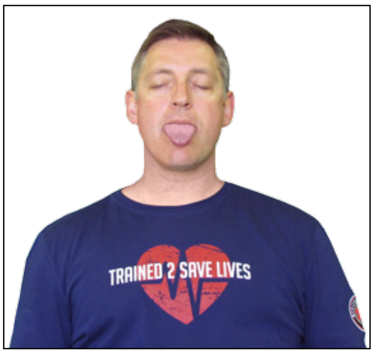
Example of a sternal rub on an unresponsive person

- **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 x 4 (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 asking him to 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 ask the individual to tell you what they are. Examples may include a mask, pen, watch, light, scuba tank, snorkel or 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 patient's ability to perform simple arithmetic by asking the 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 they can figure out the next answer. Most evaluators do not force people to count down to single digits

100	99	98	97	96	95	94	**93**	92	91
90	89	88	87	**86**	85	84	83	82	81
80	**79**	78	77	76	75	74	73	**72**	71
70	69	68	67	66	**65**	64	63	62	61
60	59	**58**	57	56	55	54	53	52	**51**
50	49	48	47	46	45	**44**	43	42	41
40	39	38	**37**	36	35	34	33	32	31
30	29	28	27	26	25	24	**23**	22	21
20	19	18	17	**16**	15	14	13	12	11
10	**09**	08	07	06	05	04	03	**02**	01

Short-Term Memory
Ask the injured person to repeat back to you the three objects previously identified during the speech and language examination.

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 m away from his face and, while he keeps his head 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, start by asking 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. Any asymmetry should be noted.

Hearing
Test hearing by holding your hand about 30 cm from the injured person's ear and rubbing together your thumb, index and middle fingers. Check each ear separately. Do not attempt to determine hearing loss; instead assess if 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.

5

Motor Function (Strength)

Objective

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

Evaluate the strength and symmetry of specific muscle groups. Note any differences between right and left sides. Hand dominance as well as a history of previous injury are important items 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 strength as normal, weak or paralysis.

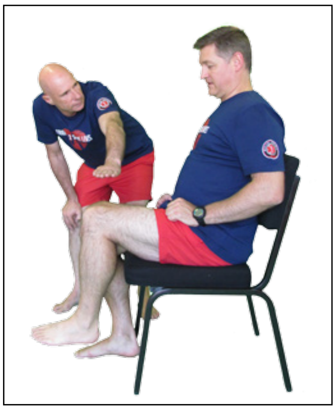
Assess shoulder strength by first bringing up the elbows level with the shoulders and hands level with the arms. Instruct the individual to resist while you push down and then pull up on the elbows.

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

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

Test grip strength by asking the person to grip two of your fingers in each hand and squeeze as tightly as he can.

To test hip flexors, ask the person to raise his foot off the ground. Then apply gentle downward pressure above the knee and ask the person to raise his knee. Do this for each side.



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

Test the quadriceps and hamstrings by asking the injured person to 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, ask him to pull up his foot against your hand and to 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.

Co-ordination and Balance

Objectives

- *Assess an individual's co-ordination by using a finger-nose-finger exercise*
- *Determine the presence of functional balance by 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 Test

To test co-ordination, stand or sit in front of the person, holding your finger approximately 45 cm from the person's face. Ask him to touch your finger with his index finger and then to touch his nose and 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 asking the person to walk forward about 3 m while looking straight ahead.

Note if 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.

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

- Romberg
  - Ask the person to stand with her feet together and arms up and 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 he is stable, ask him to 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 to perform for many "neurologically normal" people. It is a more sensitive test than the Romberg but may lead to false signs of acute neurological deficit.

NOTES:

Section 3 Summary

As with any injury or sudden illness, prompt action is always important. Remember to use F-A-S-T first. Any sign of obvious injury should prompt immediate activation of EMS.

Performing this neurological assessment soon after an incident may provide valuable information to the physician responsible for treatment. If the results of any of these tests are abnormal, you should suspect injury to the nervous system.

In some cases you may be unable to perform certain aspects of a neurological assessment. If this occurs, simply note which tests were omitted and the reason they were not performed.

If assistance is not readily available, repeat the neurological assessment (excluding the history) and record findings every 60 minutes, or more frequently if the condition visibly changes. Repeating examinations can help emergency personnel appreciate how a person's condition has changed over time.

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Review answers

Chapter 2, Page 80

1. a
2. d

Chapter 3, Page 87

1. a
2. a
3. c
4. b
5. d
6. d
7. d
8. a
9. a

Chapter 4, Page 95

1. b
2. a
3. b
4. d
5. c
6. a
7. d

NOTES:

Section 4 Emergency Oxygen for Scuba Diving Injuries

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Section 4

1 Emergency Oxygen for Scuba Diving Injuries Overview

Scuba diving injuries are rare and are often subtle when they occur. In the unlikely event of an injury, being able to recognise the problem and initiate appropriate action can speed the diver's recovery and minimise lasting effects. Oxygen first aid is the first response for diving injuries.

During this sections, participants will review the signs and symptoms associated with decompression illness (DCI), become familiar with the signs and symptoms of non-fatal drowning and learn the proper administration of supplemental oxygen. Proper assembly, disassembly and use of all component parts of a DAN oxygen unit are all discussed in the skills-development section.

Section 4

2 Overview of Atmospheric Gasses

CHAPTER 2 OBJECTIVES

1. What is oxygen (O_2)?
2. How much oxygen is in both inhaled and exhaled air as we breathe?
3. How is oxygen transported to body tissues?
4. What is carbon dioxide and how is it eliminated from the body?
5. What is nitrogen gas?
6. What is carbon monoxide and why is it dangerous?

The air we breathe is made 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)

Oxygen is a colourless, odourless, tasteless gas that makes up approximately 21% of the Earth's atmosphere. It is a vital element for survival and is needed for cellular metabolism. Essential for life, we may experience discomfort, unconsciousness or death within minutes when oxygen supplies are inadequate (hypoxia) or absent (anoxia).

Inhaled oxygen is primarily transported from the alveolar capillaries throughout the body by red blood cells (erythrocytes). Haemoglobin is the oxygen-carrying molecule within erythrocytes responsible for binding both oxygen and carbon dioxide. At rest, humans consume approximately 5% of the 21% 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 effect has practical importance for rescue breathing, as 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 ventilations.

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. Hypoxaemia (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.

2

Carbon Dioxide (CO_2)

Normal air contains very little CO_2, only about 0.033%. CO_2 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 shortness of breath, drowsiness, dizziness and unconsciousness – this is especially true when diving or breathing under increased atmospheric pressure.

ADVANCED CONCEPTS

CO_2 is heavily concentrated in blood as bicarbonate (HCO_3-) and serves a critical role in acid-base buffering. The remaining CO_2 is found either dissolved in plasma or bound to haemoglobin.

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 cases where ventilations 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) and indicate cellular respiration and adequacy of airway management.

Nitrogen (N_2)

Nitrogen exists in different chemical forms. As a gas, N_2 comprises about 78% of the Earth's atmosphere and in this form is physiologically inert, 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, since nitrogen is an inert gas, it does not interfere with resuscitation efforts during rescue breathing.

Inert gas (nitrogen and helium) absorption is associated with decompression sickness (DCS). Further discussion of DCS and the role of oxygen occurs later in this course.

ADVANCED CONCEPTS

Ingested or organic nitrogen (taken in as a solid, liquid or supplement) is compounded with hydrogen and other ions to form amines – the foundation of amino acids, which make up proteins. These amine groups are broken down and absorbed by our digestive system but do not enter our tissues or bloodstream as absorbed gas (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.

Carbon Monoxide (CO)

Certain gasses such as carbon monoxide (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 the breathing gas of a diver 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.

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 2 REVIEW QUESTIONS

1. Oxygen is a clear, 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 ____ % 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 plasm

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

6. Nitrogen comprises ____ % 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 152.

NOTES:

NOTES:

Section 4

3 Oxygen and Diving Injuries

CHAPTER 3 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 arterial gas embolism (AGE) and decompression sickness (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.

While the underlying cause of these two conditions may be different, their 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.

Oxygen administration for a suspected diving injury creates a partial pressure gradient that helps in two key ways. First, it accelerates inert gas (nitrogen and/or helium) elimination, which may reduce bubble size and improve circulation. Second, the gradient enhances oxygen delivery to injured or ischemic tissues (areas with poor circulation), which can reduce pain and limit or reverse hypoxic injury. Oxygen administration may also reduce oedema (swelling), which can further improve the efficiency of tissue oxygen delivery.

Once oxygen delivery to an injured diver has started, continue oxygen use until the injured diver has reached a definitive care facility or until the oxygen supply is depleted. Do not reduce oxygen flow to the injured diver to make the supply last. High concentrations of inhaled oxygen, even if delivered over a shorter period of time, will be more beneficial. Lower concentrations of inspired oxygen may not be as effective, even though the rescuer can deliver oxygen for a longer period of time.

Vomiting or seizures can occur during first aid care. Temporarily discontinue oxygen use until after vomiting has ended, then evaluate the airway, clear if necessary and resume providing emergency oxygen at the earliest possible moment. If the injured diver has a seizure, the rescuer may have to remove the oxygen. Seizures occurring during surface oxygen administration are usually the result of a hypoxic event to the brain. Resume oxygen delivery as soon as possible.

Oxygen administration in this 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.[8]

Symptoms of non-fatal drowning may include difficulty breathing, bluish discolouration of the lips, abdominal distention, chest pain, confusion, pink frothy sputum, irritability and unconsciousness. Victims may also be anxious or cold and would benefit from removal of wet clothes and possibly treatment for hypothermia.[8]

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

NOTE

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

Oxygen Flow Rates

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

Two variables affect delivered oxygen concentrations: Mask fit and flow rate (measured in litres per minute or lpm). When using demand valves, proper mask fit and seal are critical because the flow rate is not adjusted manually. 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.

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%)

+ 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.
**May vary with respiratory rate*
***Less variation with changes in respiratory rate*

Simple face masks may deliver fractions of 0.5-0.6 at flow rates between 10 and 15 lpm. Non-rebreather masks can deliver a higher fraction but probably still no greater than 0.8. Demand valves are appropriate for conscious and spontaneously breathing divers, and with careful mask management may deliver fractions up to 0.9-0.95.

Accidents frequently occur in remote locations or far away from medical services and oxygen supplies are generally limited. Rescuers face the dilemma between 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.

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

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

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.

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 the 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 to 16 hours of exposure at 1 ATA.[5] The time to initial symptom onset is expected to reduce at higher partial pressures (greater than 1 ATA). Symptoms may be seen from 8 to 14 hours at 1.5 ATA[6] and from 3 to 6 hours at 2 ATA.[7,8] At higher pressures, symptoms may occur more quickly but are often less severe, due to limited exposure times. The prevailing concern with PO2 levels greater than 2.5 ATA and 3 ATA is CNS toxicity.[5,6,9]

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.

3

CHAPTER 3 REVIEW QUESTIONS

1. **Providing a high concentration of oxygen to an injured diver may provide the following benefits**
   a. acceleration of inert-gas elimination
   b. reduce bubble size
   c. enhance oxygen delivery to tissues
   d. reduce swelling
   e. all of the above

2. **The primary goal of providing 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

3. **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

4. **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

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

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

7. **Which of the following is not a symptom of non-fatal drowning**
   a. Difficulty breathing
   b. Rapid pulse
   c. Cyanosis (bluish-coloured lips)
   d. Abdominal distention
   e. Chest pain

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

Review answers are on Page 152.

Section 4

4 Handling Oxygen Safely

CHAPTER 4 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?

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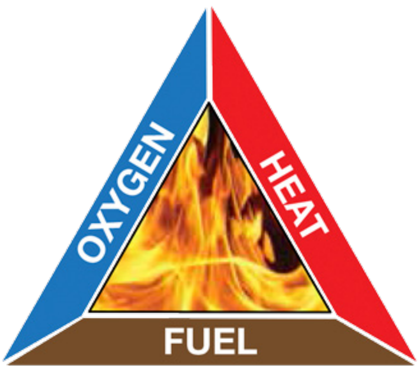
Oxygen is not flammable, but all substances need oxygen to burn and may burn violently in an environment of pure oxygen. Problems associated with the use of properly maintained emergency-oxygen devices are rare. Three elements (heat, fuel and oxygen) are required for a fire to exist. This is commonly called the fire triangle. Emergency-oxygen systems will always have at least one element: Oxygen.

Emergency Oxygen Providers should reduce the risks of handling oxygen. Be sure that the hazards from both the fuel (oil deposits and hydrocarbons are commonly used as lubricants for diving and are found on dive boats) and 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 vapour. 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 for Emergency Oxygen Providers 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 be 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 from 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 (for example, 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 at least one full turn
- Remember to provide adequate ventilation when using oxygen. In a confined, poorly ventilated space (the cabin of a boat, for example), the oxygen concentration may build up and create a fire hazard
- Use only equipment (cylinders, regulators, valves and gauges) made to be used with oxygen. Avoid adapting scuba equipment for use with oxygen
- Visually inspect the condition of valve seats and oxygen washers, and make sure the materials are compatible for oxygen use
- Keep the valves closed with the system purged when the unit is not in use. Close valves on empty cylinders. Empty cylinders should be refilled immediately after use
- An oxygen cylinder should always be secured so that it cannot fall. When carrying an oxygen cylinder by hand, carry it with both hands, and avoid holding it by the valve or regulator. When transporting an oxygen cylinder in a car, secure and block the cylinder so it does not roll

Oxygen Cylinder Filling

Medical-grade oxygen is considered a prescription drug in many areas, which can make it difficult to refill your emergency oxygen cylinder. The most common method of documenting the need for oxygen is a prescription. However, prescriptions are for diagnosed medical conditions and they only allow for use 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. Like your scuba diving certification card, your Emergency Oxygen Provider card is your documentation of appropriate training. Since retraining is required every two years, you will need to maintain your skills by taking an oxygen refresher programme. Ask your EO_2 Instructor about retraining opportunities.

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

Some countries, provinces 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 facilities' 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 an oxygen unit in excellent working conditions 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
- Clean any removable plastic oxygen unit parts and reusable oxygen masks thoroughly 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 4 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 often kept on dive boats
   b. slowly opening the oxygen cylinder
   c. keeping the unit away from the heat of the sun
   d. all of the above

3. **Contact with grease and exposure to high temperatures are of no concern with oxygen equipment**
   a. True
   b. False

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 152.

Section 4

5 Oxygen-delivery Systems and Components

CHAPTER 5 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 which 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?
8. What are the advantages and disadvantages of the following
   a. Manually triggered ventilator
   b. Bag valve mask

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.

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

Ask your DEMP 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 minutes to 60 minutes. Non-portable oxygen cylinders can last up to eight hours or more. DAN Oxygen Units come with either an M9 (248 litres) or a Jumbo-D (636 litres) oxygen cylinder.

A 15-minute oxygen supply may be all that is needed if diving from shore where emergency medical services (EMS) are in place 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 EO_2 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 litres per minute, the cylinder will last approximately 43 minutes. At 10 litres per minute, the same cylinder will last 64 minutes.

When a diver uses a demand inhalator valve (discussed later), it is more difficult to determine an exact time of supply. The rate at which the oxygen is used will depend on the injured diver's breathing rate and volume. Generally, the average oxygen use on a demand valve is equivalent to 8-10 litres per minute. 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. However, if only one cylinder is available, 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 DEMP 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.

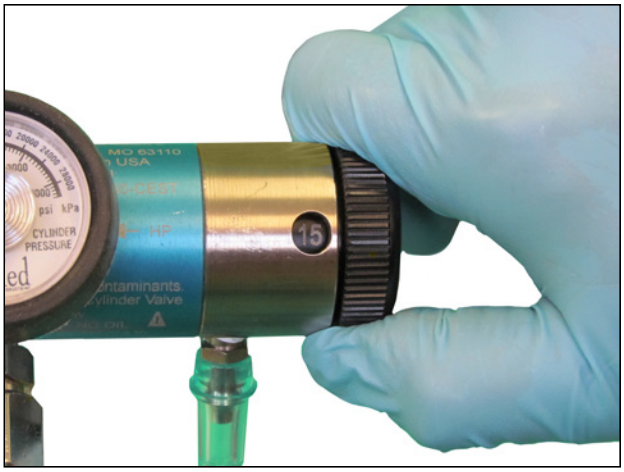
Flow meter. The flow meter, an integral part of the pressure regulator, indicates the oxygen flow rate delivered through the barbed outlet to the constant-flow device (non-rebreather mask or oronasal resuscitation mask with supplemental oxygen inlet). Oxygen flow is measured in litres per minute (lpm).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

The DAN multifunction regulator is designed to deliver up to 25 lpm. DAN recommends an initial flow rate 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 home-made 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, where 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. However, this mask 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.

Bag valve mask (BVM)

The BVM is a versatile mask-reservoir combination that provides oxygen when available, or regular air via the constant-flow barb on the oxygen regulator. It aids rescuers in providing ventilations to both a non-breathing or inadequately breathing, injured diver or in circumstances when physical contact may not be desired.

It has a self-inflating bag that is connected to a mask by means of a mechanism with several one-way valves. When the bag is compressed, oxygen or air is directed through the mask and into the injured diver's lungs. When BVMs are used to 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. However, the concentrations of oxygen are substantially reduced when the mask seal is poor.

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 each time the bag is compressed.

The bag and the mask are available in sizes suitable for adults, children and infants. Most adult self-inflating bags have a volume of 1600 mL. A system for an adult should never be used on a child because the bag can overexpand a child's lungs. Some systems include a mechanism 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.

The mechanics of the BVM make it a two-person skill. Many studies have clearly shown that, in general, the technique as 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. BVMs are a good choice when two rescuers are available because it is less fatiguing than providing ventilations.

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 earlier recommendation to limit tidal volume to 400-600 ml.

Newer versions of the bag valve mask have a stop valve to help prevent overinflation. It restricts air flow from the bag to the injured diver if it meets resistance, such as if the lungs are overfilled, during ventilations. The stop valve also may be activated if too much pressure is being used to operate the system. Either way, the stop valve prohibits administration of further air volume.

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 BVM models 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 from 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 mechanism 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 if there is insufficient gas to allow the ventilation bag to refill.

Manually Triggered Ventilators

The manually triggered ventilator (MTV), also known as a flow-restricted, oxygen-powered resuscitator, is a dual-function regulator. It allows the rescuer to provide emergency oxygen to a non-breathing or inadequately breathing, injured diver with optimal oxygen levels. 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.

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__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. Some older versions of oxygen-powered ventilators even exceeded 160 lpm in delivered oxygen. Previously it was thought that this amount was necessary to ventilate an injured diver. However, such a high flow rate can easily cause distension of the stomach, which can lead to regurgitation and the aspiration of stomach contents. In addition, a high flow rate can potentially damage the lungs and the older models did not allow for pressure release, possibly impeding exhalation.

The MTV-100, the model of MTVs DAN uses as an option in its oxygen units, is designed to terminate either the flow or the pressure if excessive pressure is detected in the airways. It automatically limits the flow rate to 40 lpm. This corresponds with American Heart Association recommendations to use a lower flow rate to reduce complications. It terminates the flow completely when it detects a mounting pressure of greater than approximately 60 cm H_2O. Additionally, a redundant valve was added for use in the event that the first one fails.

Finally, 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. If the device does not have an alarm mechanism, the operator may not become aware of the resistance during resuscitation, leading to an airway obstruction or an undetected overexpansion of the lungs. The MTV-100 has an acoustic alarm that alerts the operator of excessive levels of pressure in the airways.

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

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)

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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

CHAPTER 5 REVIEW QUESTIONS

1. **Which of the following is not part of an oxygen-delivery systems?**
    a. Oxygen cylinder
    b. Pressure-reducing regulator
    c. Lubricants to facilitate assembly
    d. Oxygen hose
    e. Face mask

2. **What is the primary consideration when choosing an oxygen cylinder?**
    a. Capacity
    b. Distance to medical aid
    c. Cylinder markings

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. **An oxygen cylinder should be switched during care when the pressure drops below 14 bar if another cylinder is available or, if another cylinder is not available, 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 on 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. **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

10. **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

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

Review answers are on Page 152.

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Section 4

6 Emergency Oxygen for Scuba Diving Injuries Skills Development

CHAPTER 6 OBJECTIVES

1. Oxygen equipment identification, disassembly and assembly
   - Identify the component parts of the DAN Oxygen Unit
   - Disassemble and reassemble the DAN Oxygen Unit or equivalent with minimal assistance
2. Demand inhalator valve
   - Provide emergency oxygen to a responsive, breathing, injured diver using the demand inhalator valve and oronasal mask
3. Non-rebreather mask
   - Provide emergency oxygen to a simulated unresponsive, breathing, injured diver using the non-rebreather mask
   - Discern when options for oxygen delivery are not working adequately and switch to another as appropriate
4. Bag valve mask
   - Provide emergency oxygen to a simulated non-breathing or inadequately breathing, injured diver using the bag valve mask on a CPR manikin
5. MTV
   - Provide emergency oxygen to a simulated non-breathing or inadequately breathing, injured diver using an MTV and oronasal mask on a CPR manikin

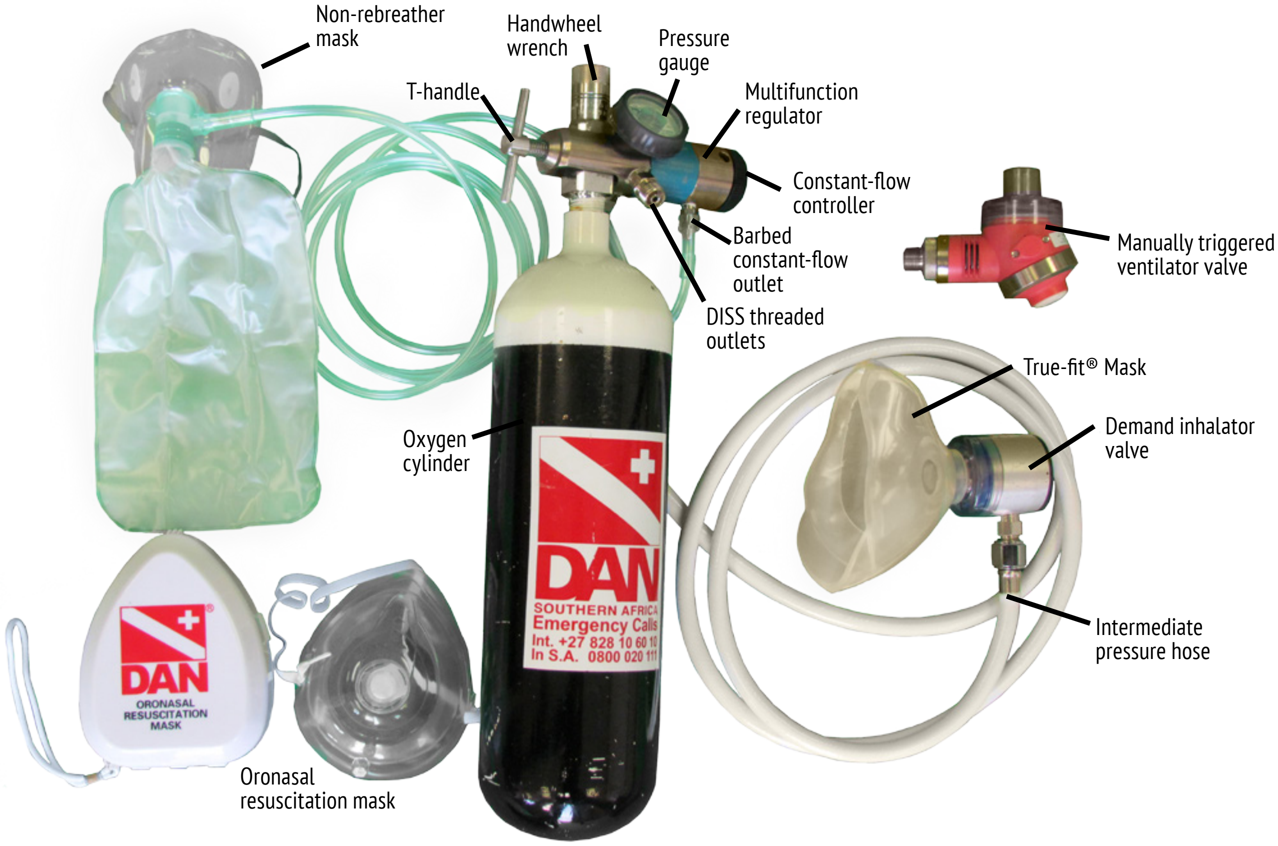
Oxygen Equipment Identification, Disassembly and Assembly

Objectives

- *Identify the component parts of the DAN Oxygen Unit*
- *Disassemble and reassemble with minimal assistance the DAN Oxygen Unit or equivalent*

Oxygen Equipment Identification

DAN Oxygen Unit components:



6

Follow these simple steps to disassemble and assemble the DAN Oxygen Unit.

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

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.

- Check the mask for any leaks around the injured diver's face

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Instruct the injured diver to breathe normally from the mask.
- Reassure and comfort the injured diver

Instruct the injured diver to hold the mask 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 other appropriate medical facility
- Contact DAN for consultation and co-ordination of hyperbaric treatment

Non-rebreather Mask

Objectives
- *Provide emergency oxygen to an unresponsive, breathing, injured diver using the non-rebreather mask*
- *Discern when options for oxygen delivery 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 the 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 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 responsive, instruct the injured diver to hold 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 the chest rise during inhalation and fall with exhalation
- Activate the emergency action plan
- Call EMS and DAN

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Resuscitation with a Bag Valve Mask

Objective:
- *Provide emergency oxygen to a non-breathing or inadequately breathing, injured diver using the bag valve mask (BVM)*

Follow these steps to resuscitate a non-breathing or inadequately breathing, injured diver using a BVM. 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 to a depth roughly 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
- Deliver chest compressions between ventilations if the BVM is being used as part of CPR

Rescuer two
The second rescuer prepares the oxygen equipment while the first rescuer performs CPR. When the equipment is ready, the second rescuer should do the following:
- Connect the BVM tubing to the constant-flow barb on the oxygen regulator
- Turn on constant flow to initial setting of 15 lpm and allow the reservoir bag to inflate
- Seal the mask in place using the 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

Using an MTV

Objective:

- *Provide emergency oxygen to a non-breathing or inadequately breathing, injured diver using an MTV and oronasal mask*

Follow these steps to resuscitate a non-breathing or inadequately breathing, injured diver using a MTV. Two rescuers are required for this skill.

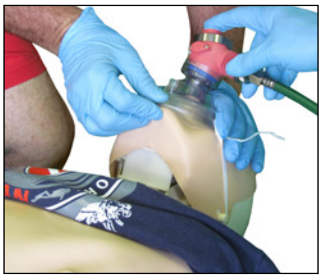
Remember S-A-F-E.

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 pressing the resuscitation button carefully while observing the chest, releasing the button quickly.

- Watch for a rise in the chest and abdomen
  - Ventilations should take about one second
- Release the resuscitation button as soon as the chest begins to rise. Deliver two ventilations
  - 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 or her 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

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Section 4 Summary

Administration of oxygen is the primary first aid for scuba diving injuries and non-fatal drowning incidents. Its use enhances both oxygen delivery to hypoxic tissues and inert gas washout. Oxygen first aid can also help minimise or eliminate existing symptoms and reduce further injury. A benefit of hyperbaric oxygen therapy is its ability to minimise the inflammatory responses triggered by bubbles arising from decompression.

Even when symptoms appear to have resolved, medical evaluation and intervention is still critical. Further evaluation is essential to prevent symptom recurrence and provide a full scope of care. The chances of complete recovery are enhanced with appropriate first aid followed by medical care, which may include hyperbaric oxygen therapy.

As a final note, remember the following instructions:
- Only use oxygen in well-ventilated areas
- Extinguish all burning materials before using oxygen
- Never combine oxygen and flammables, such as petroleum products
- Treat the injured diver, and the diver's family and friends with respect
- Act in a decisive manner and perform to the best of your abilities according to your knowledge and skill level

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Review answers

Chapter 2, Page 115
1. a
2. c
3. b
4. b
5. a
6. d
7. b

Chapter 3, Page 122
1. e
2. a
3. d
4. b
5. b
6. a
7. b
8. d

Chapter 4, Page 128
1. a
2. d
3. b
4. d
5. d
6. b
7. d
8. b

Chapter 5, Page 141
1. c
2. a
3. a
4. a
5. a
6. b
7. a
8. a
9. d
10. d
11. a

NOTES:

Section 5 First Aid for Hazardous Marine Life Injuries

TABLE OF CONTENTS

Section 5

1 Emergency Oxygen for Scuba Diving Injuries Overview

One reason many people learn to dive is to interact with and observe marine life. However, this is the same reason some people are afraid to scuba dive. Fortunately, injuries caused by hazardous marine life are rare and are usually the result of a diver's actions. Any time we enter the marine environment there is always the risk of being stung, bitten or lacerated by aquatic animals. These injuries are usually mild and require only simple interventions by first aid providers. On rare occasions, more involved care is necessary.

The First Aid for Hazardous Marine Life Injuries course is an entry-level training programme that teaches participants how to identify potentially hazardous marine life, how to provide first aid when injuries occur and techniques for avoidance.

In addition to the Note and Advanced Concept boxes, this section also includes bonus content, which provides related material that may be useful but is not required for course completion.

Section 5

2 Introduction to Hazardous Marine Life Injuries

CHAPTER 2 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?

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/toxin or 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 book.

Traumatic injuries – Bites account for most of the trauma associated with marine life injuries. Fortunately, these occurrences are extremely rare and 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 inserted 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 Phylum: Chordata Class: Actinopterygii (ray-finned fish) Order: Scorpaeniformes Suborder: Scorpaenidae *Pterois* spp. *Scorpaena* spp. Suborder: Synanceiidae *Synaceja* spp. **Stingrays** Phylum: Chordata Class: Chondrichthyes Order: Myliobatiformes Family: Urotygonidae **Sea snakes** Phylum: Chordata Class: Reptilia Order: Squamata Suborder: Serpentes Family: Elapidae Subfamily: Hydrophiinae	**Cnidarians (jellyfish, corals and anemones)** Phylum: Cnidaria Class: Hydrozoa *Millepora* spp. (fire coral) *Physalia* spp. (Portuguese man-of-war) Class: Cubozoa (box jellyfish) *Chironex fleckerii* *Chiropsalmus* spp. *Carukia* and *Malo* spp. (Irukandji) Class: Scyphozoa (true jellyfish) Class: Anthozoa (anemones and corals) **Mollusks** Phylum: Mollusca Class: Gastropoda *Conus* spp. (cone snails) *Glaucus* spp. (blue ocean slug) Class: Cephalopoda (octopuses and squids) *Hapalochlaena* spp. (blue-ringed octopus) **Echinoderms (urchins, starfish and sea cucumbers)** Phylum: Echinodermata 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 just as 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. If protective eyewear or masks are available, they should be used as well.

CHAPTER 2 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 is the result of contaminated food or liquids**
   a. True
   b. False

Review answers are on Page 223.

Section 5

3 Envenomations and Toxins

CHAPTER 3 OBJECTIVES

1. By what mechanisms do envenomations occur?
2. Why do most envenomations occur?
3. What factors may impact 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 impact 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 maintenance of an open airway or include provision of 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.

NOTE

All wounds acquired in or subjected to a marine environment carry the risk of infection with the bacteria that causes tetanus. The Centers 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 is well-camouflaged (or mimetic, indicating attempts to mimic their surroundings). This group 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.

Summary: Lionfish, stonefish, scorpionfish and other Scorpaena
- Envenomation results from direct contact/puncture
- Mimetic species tend to cause more serious reactions
- Oedema can rapidly become 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 and applying topical antibiotics

Stingrays

Phylum: Chordata
Class: Chondrichthyes
Order: Myliobatiformes
Suborder: Myliobatoidei

Stingrays are usually shy fish 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, therefore the creation of a specific antivenom is not possible. The initial concern with stingray injuries is the trauma and pain from the barb puncture wound. The risks 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
- 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 30-90 minutes (repeat as needed)
- Apply topical antibiotic ointment or cream, if available
- Apply bandaging as necessary
- If necessary, administer pain-control medications
- Seek professional medical evaluation as medical management may include sedatives, tetanus vaccination and antibiotics. Advanced life support may be required in rare instances

NOTE

The use of heat to the affected area is effective for pain control and can be repeated as needed. Cold packs can also be used, and may provide relief and reduce or 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 be necessarily 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 therefore 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 while avoiding scalding. Do not rely on the victim's assessment, as intense pain may impair his/her 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 – 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. However, their venom does contain neurotoxic components, which can cause paralysis. Venom may have muscle-specific toxic effects that can result in a condition known as rhabdomyolysis*. This is a serious condition that can cause loss of kidney function and requires medical intervention. Symptoms usually appear within two hours after the bite; more serious poisonings may present sooner. A bite victim should be kept under observation in a medical facility. If a bite victim remains symptom free for more than eight hours, envenomation is unlikely, but continued medical supervision may still be warranted.

Fatalities associated with snake bites are unknown among divers, but fatal bites have occurred among Southeast Asian fishermen while attempting 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

3

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 – do not antagonise the animal
- Bites can be painless and difficult to detect
- Most bites do not result in envenomation
- Neurotoxic venom may cause:
    - 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.

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) have all the same features as, and therefore 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 as long as half the length of the animal's head. Fangs are retractile, folding backward, and these animals can open their mouths to almost 180 degrees, which means that when they attack, their fangs can thrust forward toward their prey. Though the venom of these animals poses a different type of toxicity than that of proteroglyphs, the effectiveness of the venom-delivery mechanism enables them to inject large quantities very quickly.

CHAPTER 3 - PART 1: VERTEBRATES REVIEW QUESTIONS

1. **Envenomations may occur in all of the following ways except**
   a. bites
   b. stings
   c. ingestion
   d. punctures
   e. barbs

2. **Envenomations occur only during accidental contact**
   a. True
   b. False

3. **The health status of the injured person, sensitivity to the venom and delays in receiving first aid impact the victim's response to the injury**
   a. True
   b. False

4. **First aid steps for treating venomous fish injuries include all of the following except**
   a. wash area
   b. remove foreign material
   c. control bleeding
   d. induce vomiting
   e. control pain

5. **Pressure immobilisation is recommended for which vertebrate injury**
   a. Stingrays
   b. Nurse sharks
   c. Sea snake
   d. Goliath grouper

Review answers are on Page 223.

PART 2: INVERTEBRATES

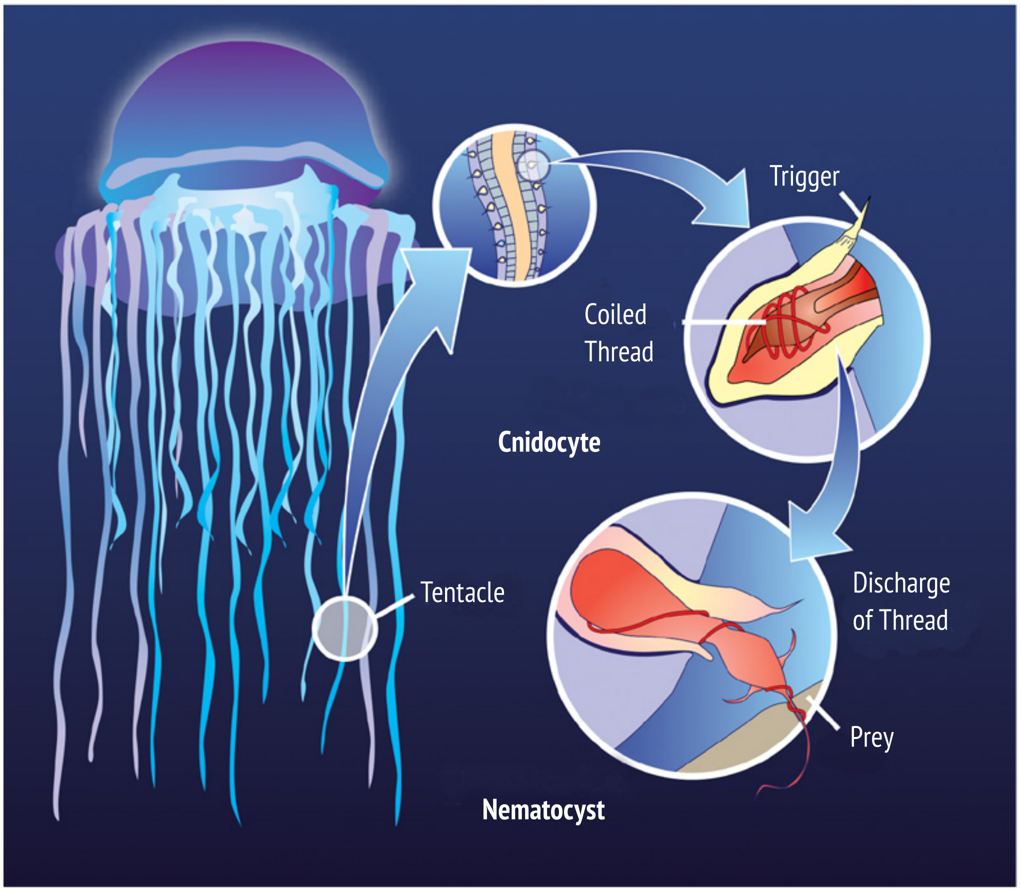
Invertebrates are animals without backbones and make up more than 98% of earth's animal species. Injuries arising from contact include envenomation and localised tissue trauma (cuts and scrapes). The mechanisms of envenomation are stings and punctures.

As with venomous-vertebrate animals, individual invertebrate animal groups have unique features that impact 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. However, some species may require additional interventions. Be aware that treatment protocols vary in different parts of the world (see Note box for Portuguese man-of-war on Page 22).



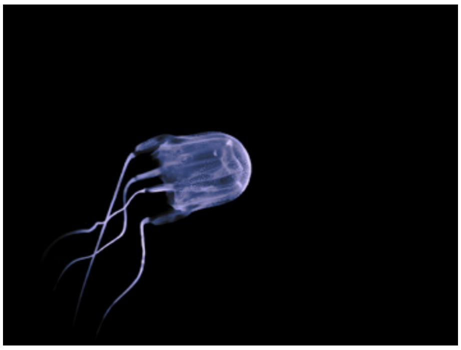
Jellyfish

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 only result in mild to moderate skin irritations. Stings can be avoided by proper exposure protection.

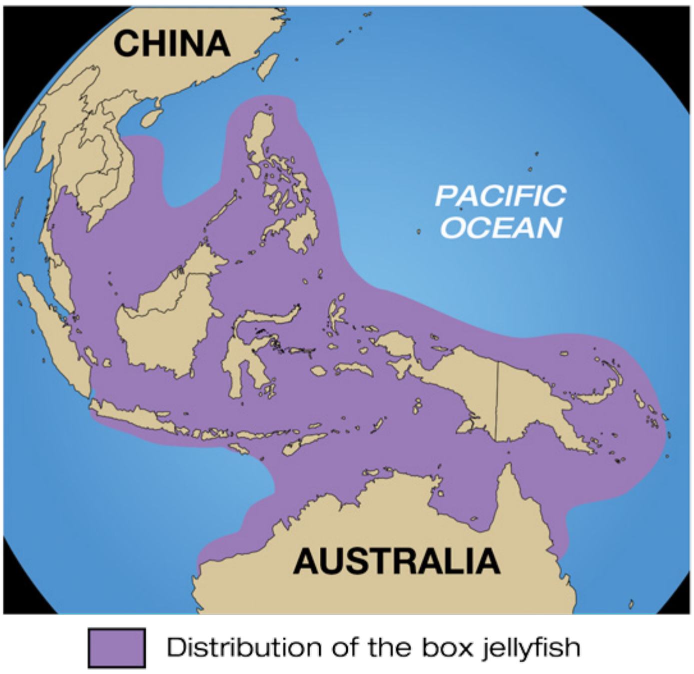
Box jellyfish

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 impacts 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 is therefore 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, but stings are nonetheless extremely painful and can cause systemic symptoms that should prompt immediate medical attention.

First described in northern Australia, reports of Irukandji-like syndromes have also come from Hawaii, Florida, French West Indies, the Caribbean, Timor-Leste and Papua New Guinea.

Irukandji syndrome occurs within 5-45 minutes after 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 bladder 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 may contain up to 90% carbon dioxide (CO_2).

3

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 to 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.

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. However, in the case of Physalia *spp. (Pacific Portuguese man-of-war or bluebottle), 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 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 undergo refinement, this text will be updated.*

BONUS CONTENT
Despite its appearance, the Portuguese man-of-war technically is not a jellyfish, it's a siphonophore. These differ from jellyfish in the sense 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 respectively take up the roles of defense (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 also 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 hazard is mechanical injury such as cuts and scrapes. These injuries 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.

3

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 (cnidarians)

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.** Visible tentacles or filaments should be carefully removed with the aid of fine tweezers or protective barriers. Gloves, women's stockings or any 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 and 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

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.

Local effects
- 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.

3

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 g specimen possesses enough venom to paralyse at least 10 regular adults.

Initial signs and symptoms

- Painless or difficult to find bite site
- 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

(Cone snails and blue-ringed octopus)

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 6-8 hours.

Tetanus coverage is always recommended and antibiotic therapy may be necessary. Monitor for infection. There is no available antivenom.

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

Summary: Mollusks

(Cone snails and blue-ringed 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 injured person
- **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 under "Seafood Poisonings" on Page 194). 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 comprised 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 is contact with the 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. Physical contact with sea urchins should always be avoided 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 180). 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. Fisherman themselves have developed skin rashes after cleaning high volumes of these animals.

BONUS CONTENT

When threatened, some sea cucumbers can expel their stomach contents or their whole stomach to provide an alternative meal to potential predators and give the slow sea cucumber time to escape.

Treating Echinoderm Injuries

(Sea stars, sea urchins and sea cucumbers)

Signs and symptoms

- Sharp, stinging pain
- Local swelling
- Redness (erythema)
- Tissue damage and/or spines protruding from skin
- In severe cases there have reports of muscle weakness, nausea, vomiting and paraesthesia

First aid

- Thoroughly wash the area with soap and fresh water (tap water is fine)
- Remove foreign material
    - Seek medical attention if spines have entered joints
- Monitor for signs of infection (see additional information in Chapter 4)
- Tetanus coverage is recommended

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

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 cold abyssal plains, to the extreme heat of hydrothermal vents, to tropical tide pools. Injuries typically result from accidental contact or deliberate handling. Such contact can result when the worm's bristles, located along the sides of the animal, embed in the contact skin.

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

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 3 - PART 2: INVERTEBRATES REVIEW QUESTIONS

1. **The correct order for first aid for jellyfish stings is**
   a. inactivation, removal, washing/irrigation of the injury site, treatment of the symptoms
   b. washing/irrigation of the injury site, treatment of symptoms, inactivation, removal
   c. removal, washing/irrigation of their injury site, inactivation, treatment of the symptoms

2. **Pressure immobilisation is recommended for which invertebrate marine life injuries?**
   a. Anemones and blue-ringed octopus
   b. Cone snail and blue-ringed octopus
   c. Bristle worms and sea cucumbers
   d. Fire coral and sponges

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 223.

Section 5

4 Traumatic Injuries

CHAPTER 4 OBJECTIVES

1. For what three reasons do marine animal bites occur?
2. Why are marine animal bites of particular concern?
3. What is the primary method to control most external bleeding?
4. When should a tourniquet be used?
5. How long should a tourniquet be left in place?
6. 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.

4

Bites

Most human-associated marine animal bites result from the following circumstances:

- The animal feels threatened
- The human is mistakenly identified as prey
- Humans are engaged in spearfishing or feeding

All bites have a high risk of infection and should receive prompt cleaning. Marine animals known to bite include sharks, barracuda, moray eels and triggerfish. Injury severity depends on many factors including bite location, size of animal, extent of blood loss and treatment delays. First aid efforts should focus on controlling bleeding and reducing risk of infection.

Control of External Bleeding

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 mechanism is platelet activation which initiates blood clotting. For minor bleeding, this process works extremely well and will stop blood loss with little support. When bleeding is more severe, additional intervention may be needed.

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:

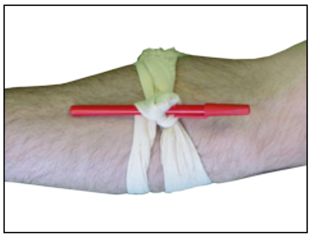
- placed directly over knees, elbows or other joints. If there is no room to place a tourniquet between a wound and a joint, place the tourniquet 2.5-5 cm proximal to the joint
- made of wire or rope. A narrow, excessively tight or insufficiently padded band may cause local damage to tissues in minutes

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. Secure 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 with a second bandage.



Using a marker, 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.

> ***NOTE***
> - *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 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 defence 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, as organic material comes with higher risks of wound infection 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 micro-organisms to replicate beneath the skin, resulting in infection. The presence of bacteria within a wound does not necessarily constitute infection but this is often referred to as contamination. When bacterial populations thrive and become large enough or interrupt healing or cause further tissue damage, then an infection has occurred.

Signs of infection appear within hours, days or even several weeks following injury. Inflammation is one of the cardinal signs of any infection, and the components that are typically present can be easily recalled with the acronym PRISH.

Pain
Redness
Immobilisation (loss of function)
Swelling
Heat (elevated warmth of the infected area)

Other signs of infection include:

- 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., people with diabetes, cancer or AIDS), may require more aggressive treatment. If a marine-acquired wound is beyond your skills to manage or shows any signs of worsening, seek 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" or "TK" 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

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 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 in defense of perceived threats. The puncture wounds and lacerations may result in bleeding and infection.

Coral scrapes and cuts

Surf and surge in shallow water or poor buoyancy control over reefs can result in scrapes and cuts of various degrees. Since bacteria and numerous tiny larvae live on these underwater formations, wound contamination should be assumed. 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.

CHAPTER 4 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 include**
   a. pus, redness, sweating, heat
   b. purple wound borders, red dots on skin, irritability, sensitivity, high temperature
   c. pain, redness, immobility, swelling, heat

Review answers are on Page 223.

Section 5

5 Seafood Poisonings

CHAPTER 5 OBJECTIVES

1. What is the primary cause of seafood poisoning?
2. What kinds of contaminates 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.

There are several marine species, primarily in the tropics, that 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 food-borne 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 by activities that increase skin temperature, such as exercise and alcohol consumption.

Musculoskeletal symptoms

- Joint pains
- Muscle pains and weakness

Decompression sickness (DCS) 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 hot versus cold temperature. 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 eel
- Amberjack
- 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
- Correct possible dehydration
- Support compromised heart or pulmonary function

If ciguatera is suspected, seek medical evaluation. There is no effective treatment or specific antidote for ciguatera poisoning. The best course of action is prevention through education and avoidance of seafood in endemic or suspected areas.

Summary: Ciguatera

- Ciguatera is caused by a neurotoxin produced by microscopic organisms that contaminate reef fish
- The bigger the fish, the more toxic the meat. 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

5

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 is from 1789 from Captain William Bligh. He describes symptoms consistent with ciguatera after eating mahi-mahi, 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 where virtually all reef fish contained the toxin. Later research showed that other dinoflagellates could also play a contributing role in ciguatera, but ***G. toxicus*** appears to be the most toxic.

Four types of ciguatoxin have been identified. Ciguatoxins seem to lower the threshold for opening voltage-gated sodium channels in synapses in the nervous system, which results in 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, and 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
  - Diahrroea

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 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 or her own

The goal is prevention through education. Avoid eating these species in any form or preparation. If TTX poisoning is suspected, seek medical evaluation.

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

Symptoms of TTX poisoning can progress rapidly. 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 Centers for Disease Control and Prevention (CDC) in the United States.

NOTE

A key contributing factor to the prevalence of this condition is the absence of an associated flavor or taste. Some report a slight metallic or peppery taste, but otherwise the fish look, smell and taste normal.

Manifestations of scombroid are usually self-limited and resolve in about eight to 12 hours. Significant discomfort and serious manifestations are possible.

Symptom onset

- Rapid; commonly seen 10 to 30 minutes after ingestion

Symptoms

- Flushing
  - Manifests in the face, neck and upper chest
- Itchiness
- Eye irritation

Severe symptoms in rare cases

- Headaches
- Chills
- Vomiting
- Diahhroea
- Abdominal cramps
- Bronchospasm
- Hypotension

First aid (scombroid)

- 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 it is rarely required
- Since histamine is not being released as a result of an allergic reaction, corticosteroids are ineffective

Prevention

The disease is entirely preventable by immediately storing fresh fish in coolers or ice containers and away from direct sunlight. The CDC recommends temperatures below 4.4°C 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 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 5 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. **The three primary seafood poisonings discussed here do not include**
    a. ciguatera
    b. scombroid
    c. shellfish poisoning
    d. tetrodotoxin

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 223.

Section 5

6 Life-threatening complications

CHAPTER 6 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?
6. What steps should be taken in the case of severe bleeding?

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 assisting the victim with administering allergy medications.

Most allergic reactions are fortunately less severe and are characterised by local skin reactions. Once assured 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)

- This is a medical emergency – alert local emergency medical services immediately (call 10177). Do not call DAN
- 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 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 (of note, stonefish venom may also have vasoactive* effects that cause hypotension, and may result in decreased blood flow to the brain and other vital organs).

Signs and symptoms

- Hypotension (low blood pressure)
- Pale, cool, clammy skin
- Cold hands and feet
- Severe shortness of breath
- Weak pulse
- Altered mental status
- Reduced urinary output
- Nausea and vomiting
- Unconsciousness
- Cardiac arrest
- Chest pain (can radiate to the arms, shoulder, neck or back)

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First aid (cardiogenic shock)

- This is a medical emergency – alert local emergency medical services immediately (call 10177). Do not call DAN
- 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 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 urinary output
- Unconsciousness

First aid (hypovolemic shock)

- This is a medical emergency – alert local emergency medical services immediately (call 10177). Do not call DAN
- Attempt to stop all external bleeding with appropriate measures, as discussed in the last chapter
- 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 anything by mouth

CHAPTER 6 REVIEW QUESTIONS

1. **The signs and symptoms of an allergic reaction include**
   a. itching
   b. redness
   c. swelling
   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. all of the above
   e. 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**
   a. immediately call EMS and 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 223.

Section 5

7 Avoiding Hazardous Marine Life Injuries

CHAPTER 7 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 bump into 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 your fins on in shallow water.

The best way to avoid hazardous marine life injuries during scuba diving activities is to ***practice 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 is present
- Pack a first aid kit. Be sure that the components have not expired (see Appendix 1 for examples of DAN First Aid kits)
- 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, leading to some dive operators banning the use of gloves. However, gloves should be worn when wreck diving, diving in strong currents or when needed for thermal protection
- Shuffle your feet and wear thick-soled boots when entering the water in 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 and if you're busy looking at marine life or taking pictures, be sure to also 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 as this may lead to accidental injury
- Avoid picking up shells. Some hazardous marine animals live inside shells 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 eye out if you are in jellyfish-inhabited areas. Avoid holding onto the ascent/descent line without gloves; jellyfish and other stinging organisms may live 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 happen to divers due to lack of training, skills or experience than are caused by marine life.

> "Far more injuries and fatalities happen to divers due to lack of training, skills or experience than are caused by marine life.

7

CHAPTER 7 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. practicing good buoyancy control
    b. maintaining good situational awareness
    c. avoiding handling or feeding marine life
    d. streamlining yourself and your equipment
    e. all of the above

Review answers are on Page 223.

NOTES:

Section 5

8 First Aid for Hazardous Marine Life Injuries Skills Development

CHAPTER 8 OBJECTIVES

1. **Shock Management**
   - 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
2. **Injury Management**
   - Demonstrate the proper technique in a scenario for managing
     - spiny envenomations
     - stinging envenomations
     - contact injuries
3. **Pressure Immobilisation Technique**
   - Demonstrate the proper technique for applying a pressure immobilisation bandage
4. **Traumatic Injuries (Control of External Bleeding)**
   - 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
5. **Applying a Tourniquet**
   - Demonstrate applying a tourniquet to control bleeding on a simulated patient
6. **Severe Allergic Reactions**
   - Demonstrate the proper technique for assisting with an epinephrine auto-injector in a scenario

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.
7. Protect the victim from cold or heat; 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*

8

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.

IMPORTANT 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.

IMPORTANT NOTE

Spines lodged deeply in soft tissues or in joints may require additional treatment by a health-care professional.

Stinging envenomations (jellyfish, coral, hydroid, 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 analgesics (aspirin, Tylenol, Advil, etc.)
- Anti-inflammatory agents (hydrocortisone)
- Topical anesthetic 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 maybe helpful to remove bristles
- Irrigate with syringe and catheter using clean water or saline solution to provide a steady stream of water that is forceful enough to dislodge debris and bacteria

3. Remove any remaining visible debris with tweezers or forceps.
4. Control bleeding if present.
5. 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.

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 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 nearest medical facility (for antivenom administration, tetanus vaccination, monitoring, IV hydration and respiratory support).
10. Do not remove bandage until at a medical facility.

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 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 as it may disrupt the clotting mechanism of the body
- Once bleeding has stopped, use conforming bandage, 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 inches on either side to ensure coverage and even pressure distribution*
- *To bandage across a joint, maintain the area in a comfortable position but try to keep the joint immobilised to minimise further discomfort or bandage displacement*

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
- Leave a tourniquet used in an actual injury in place until under medical care

NOTE

When performing this skill as part of skill practice for course requirements, the tourniquet should be released immediately after verifying absence of the distal pulse.

Severe Allergic Reaction

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 EpiPen® or Twinject® (epinephrine). Such medication should be administered only if it is prescribed for the individual having the reaction.
3. Activate EMS.

Section 5 Summary

Diving provides many opportunities to observe and interact with the creatures of the sea. Most of these encounters result in experiences that are truly memorable. However, in rare circumstances, certain interactions with marine life can become hazardous.

This section has introduced you to potentially hazardous marine life and the injuries they can cause. It has also covered the fundamentals of identifying and managing injuries caused by marine life. We recommend continuing your marine environment education by taking courses in marine ecology, animal behavior and general biology. Explore online to locate more information about issues involving marine life and the environment.

The more you know about the marine environment and its animals, the greater your chances are for safe and memorable dives.

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Review answers

Chapter 2, Page 159
1. d
2. a
3. b
4. a

Chapter 3: Part 1, Page 170
1. e
2. b
3. a
4. d
5. c

Chapter 3: Part 2, Page 186
1. a
2. b
3. e

Chapter 4, Page 193
1. d
2. a
3. a
4. d
5. b
6. c

Chapter 5, Page 203
1. a
2. d
3. c
4. b

Chapter 6, Page 207
1. d
2. e
3. b
4. a
5. d
6. e

Chapter 7, Page 210
1. d
2. e

Section 6 Dive Accident Management Preparation

CHAPTER OBJECTIVES

1. What equipment should be available at dive sites for use in an emergency?
2. What should be included in an emergency assistance plan?
3. Why is a hyperbaric chamber location not necessary as part of an emergency action plan?

Accidents can and do happen. As a Diving Emergency Management Provider, you are prepared to recognise signs and symptoms of various injuries or illnesses. By completing all sections of this course, you have learned the skills required to provide appropriate interventions.

Support your skills with proper preparation, including equipment and emergency assistance planning.

Oxygen Units

An essential item for dive accident management is an appropriate oxygen unit. Oxygen units were discussed in detail in the Emergency Oxygen for Scuba Diving Injuries section. See Pages 139-140 to review recommendations and options.

First Aid Kits

Another essential item for dive accident management is a first aid kit, which should be appropriate for its intended use and the location of diving activity. There are many commercially available kits on the market, or you can assemble one yourself.

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

Regularly check for and replace items that have been used or have expired. Check both the first aid kits and oxygen units before each outing, and replenish them after every use.

Emergency Assistance Plan

Your next step in being prepared for a dive accident is to create a comprehensive emergency assistance plan (EAP), which can be a vital resource and save valuable time. It may also enable other people to assist you. A sample plan is included at the end of this chapter. Preparing an EAP for a dive site you visit frequently is encouraged both as part of dive safety planning and as practice for less frequently visited sites.

Your EAP should include the following information:

- local resources
  - local EMS contact information
  - location of the nearest medical facility
  - transportation options to the nearest medical facility
- communication equipment and instructions for how to use it
- directions for EMS to get to your dive location, if required
- DAN Emergency Hotline number 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, DAN Member number, if available
  - include gender (and age, if available)
- emergency contact information
- diver's medical history (remember S-A-M-P-L-E)
- 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 or nitrox and the percentage, trimix and the mix percentages, other)
  - open circuit or rebreather

You may also want to include steps for providing care. In an emergency, it is not uncommon for anxiety to overwhelm thought processes, inhibiting the action of providers. The first aid slates available as part of the DEMP programme as well as the DAN Dive Accident Information slate should be kept with emergency equipment and used in rendering care.

Hyperbaric Chambers

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

Other reasons to go directly to a medical facility include the following:

- 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 chamber crew often takes time
- The chamber may already have a patient under care and therefore 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 hyperbaric treatment is identified, DAN can also assist in locating an available chamber.

Anxiety Awareness

When someone is injured, anxiety is a natural reaction for both the injured diver and the rescuers. A pounding heart and breathless feeling are to be expected. These feelings generally do not interfere with the ability to use your skills. Your knowledge and training should reduce the level of any anxiety. Making a serious mistake, harming an injured diver or causing death are all unlikely. The injured diver would likely be in worse shape without your assistance.

While some individuals may have concerns about liability and being sued, you have little to fear as long as you act in good faith, as a reasonably prudent individual would, and render aid within the scope of your training. Even if an injured diver does not improve, that is not evidence that you were responsible or that you performed below standards.

Treat the injured diver, and the diver's family and friends with respect, and perform according to your knowledge and skill level. Be sure the injured diver is referred to medical care or to someone with training equal to or higher than yours. You are not obligated to start first aid but once you do, you must continue until you are relieved. If you choose not to render care, you may be obligated to notify authorities of the injured person's need for immediate care in some areas.

Emergency Assistance Plan

Objectives

- *List the components of an emergency assistance plan*
- *Develop an emergency assistance plan for the local diving area*

The following information is critical in managing scuba diving injuries and illnesses.

Diver information

Name: ______________________________ Age: ________

DAN Member # ______________________________

Address: ______________________________

____

Emergency contact phone: ______________________________

Current complaint: ______________________________

____

Significant past medical history (medications, allergies, previous injuries, etc.):

____

Dive Profile	Depth	Time	Safety Stops/Deco	Surface Interval
Dive #1				
Dive #2				
Dive #3				
Dive #4				
Dive #5				

Exit water time: ________ AM/PM

Open circuit: ____________

Breathing gas: air/nitrox/mix ________%

Rebreather: ______________________

Emergency assistance plan

Emergency contact information: ______________________________

Emergency medical assistance: ______________________________

Nearest medical facility directions: ______________________________

____

Phone: ______________________________

Diving medical consultation information ______________________________

Divers Alert Network (DAN-SA): **0800 020 111 (local) or +27 828 10 60 10 (int.)**

** This number may be called collect in an emergency.*

Other important information: ______________________________

Phone: ______________________________

Notes: ______________________________

____

____

SECTION 6 REVIEW QUESTIONS

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

2. **Emergency assistance 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. all of the above
   f. 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 230.

Review answers

Section 6, Page 229

1.d
2. f
3. b

NOTES:

Section 7 Diving Emergency Management Provider Summary

Throughout this programme, the material has stressed factors that can contribute to a dive accident. Preventive measures have been discussed and emphasised. Practise these measures yourself and encourage others to embrace safe dive habits as well.

Dive accidents are rare, but when they do occur, simple first aid procedures usually are all that is required. However, prompt action is always important. Remember to protect yourself and any other rescuers by completing a scene safety assessment and using protective barriers before rendering aid.

The priorities of care should be constantly considered in 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 emergency medical services in the area, administer oxygen, and call the DAN Emergency Hotline at **0800 020 111 (local) or +27 828 10 60 10 (int.)**

Keep in mind that even injuries that are not life-threatening 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 sections. Check expiration dates on first aid supplies and immediately replace supplies used.

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

Glossary

abrasion – a superficial excoriation, with loss of substance 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 sensation 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, in 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 where 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 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 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 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)

dyspnea – difficult, painful breathing or shortness of breath

electrolyte – minerals in your blood and other body fluids that carry an electric charge that affect the amount of water in your body, the acidity of your blood (pH), your muscle function and other important processes

embolism – a detached intravascular mass clogging capillary beds at a site far from its origin

EMS – emergency medical services

epidural – 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

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 also 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 variables as a function of distance, time or other continuously changing influences

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

hypoesthesia – abnormally decreased sensitivity to touch

hypotension – excessively low arterial blood pressure; causes include blood loss, infection, poisoning, heart failure, neurological injury, endocrine disorders and medications

hypovolemic – a state of decreased blood volume

hypoxemia – inadequate oxygen content in the arterial blood

hypoxia – inadequate oxygen content

incontinence – absence of voluntary control of an excretory function, especially defecation or urination

inert – having little or no tendency to 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 (i.e., 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, mucus 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

Glossary (continued)

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 oesophagus

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 end plate of a muscle; in vertebrates, the signal passes through the neuromuscular junction via a neurotransmitter, acetylcholine

neurotoxic – poisonous to the nerves or nerve cells

nystagmus – spontaneous, rapid, rhythmic movement of the eyes occurring on fixation or on ocular movement

oblique – an indirect or evasive angle

occlude – to close off or stop up; obstruct

oedema – swelling caused by excess fluid in body tissues

oesophagus – portion of the digestive tract that lies between the back of the throat and stomach

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 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, which is 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 body parts

prescription – a written order for dispensing drugs signed by a physician

primary assessment – assessment of the airway, breathing and circulation (pulse) in an ill or injured person; also known as the ABCs

pro-inflammatory mediator – a substance that indirectly mediates or triggers an inflammatory response

prokaryote – from the Greek *pro* (meaning "before") and *karyon* ("nut" or "kernel"), meaning these single-celled organisms 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 oesophagus, 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

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 combination 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 principal 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 passes ventrally from the spinal cord and that consists 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

Dive Accident Information Slate

Date of incident ______ / ______ / ______ (dd/mm/year)

Location of incident: ______

Diver's name: ______

Contact phone #: (______) ______

Email: ______

Diver's age: ______ DOB (dd/mm/year) ______ Gender: ☐ Male ☐ Female

Diving History

How many days of diving?

______

How many dives total?

______

How many dives on last day?

______

Max. depth from diver series?

______

Any problems associated with this dive series?

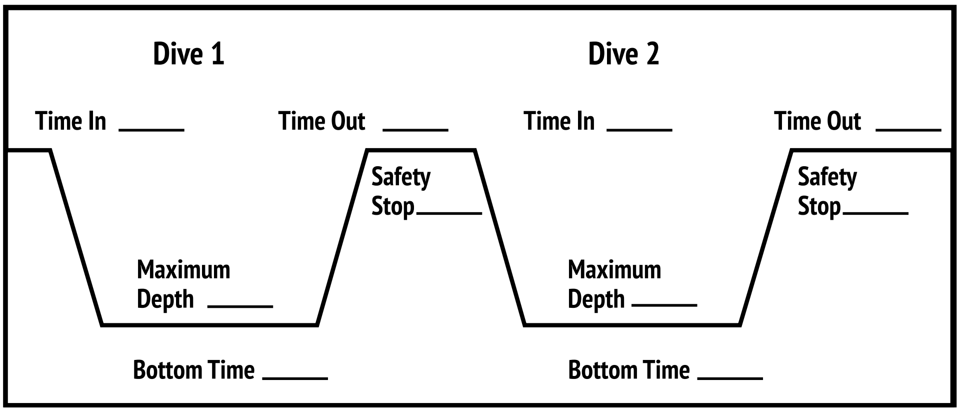
______

______

______

______

Diving History



Breathing gas for last day's dives (circle one): Air EANX ______% Other ______

Time of surfacing from last dive ______ : ______

Reported symptoms: ______

______

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Dive Accident Information Slate

First symptom onset time _______ : _______

Have symptoms changed since onset? _______________________________

Does anything improve or worsen symptoms? _______________________________

____

Any neurological symptoms (i.e., numbness, tingling, paralysis)? _______________________________

If available, please complete a DAN Neurological Assessment and submit additional neuro slate to EMS when they arrive.

Past Medical History

Allergies to medications: _______________________________

Medications (prescription and over-the-counter): _______________________________

____

Any current/recent illnesses, injuries or surgeries: _______________________________

____

Date: _______ / _______ / _______ (dd/mm/year)

Oxygen First Aid

Time oxygen started _______ : _______

Total time/O2 delivery: _______ hrs _______ mins

Symptom relief with oxygen: ☐ all ☐ some ☐ none

Oxygen delivery mode (Check boxes)
- ☐ Demand valve
- ☐ Non-rebreather (mask with bag)
- ☐ Mask (no bag)
- ☐ Nasal cannula
- ☐ Other (explain): _______________________________
- ☐ Do not know

Following the incident, please submit an oxygen use survey card to assist with DAN research efforts.

First aid provider's name: _______________________________
Contact phone #: _______________________________
Email: _______________________________

DAN® SOUTHERN AFRICA

DAN-SA Hotline 0800 020 111 (local) | +27 828 10 60 10 (int.)

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.

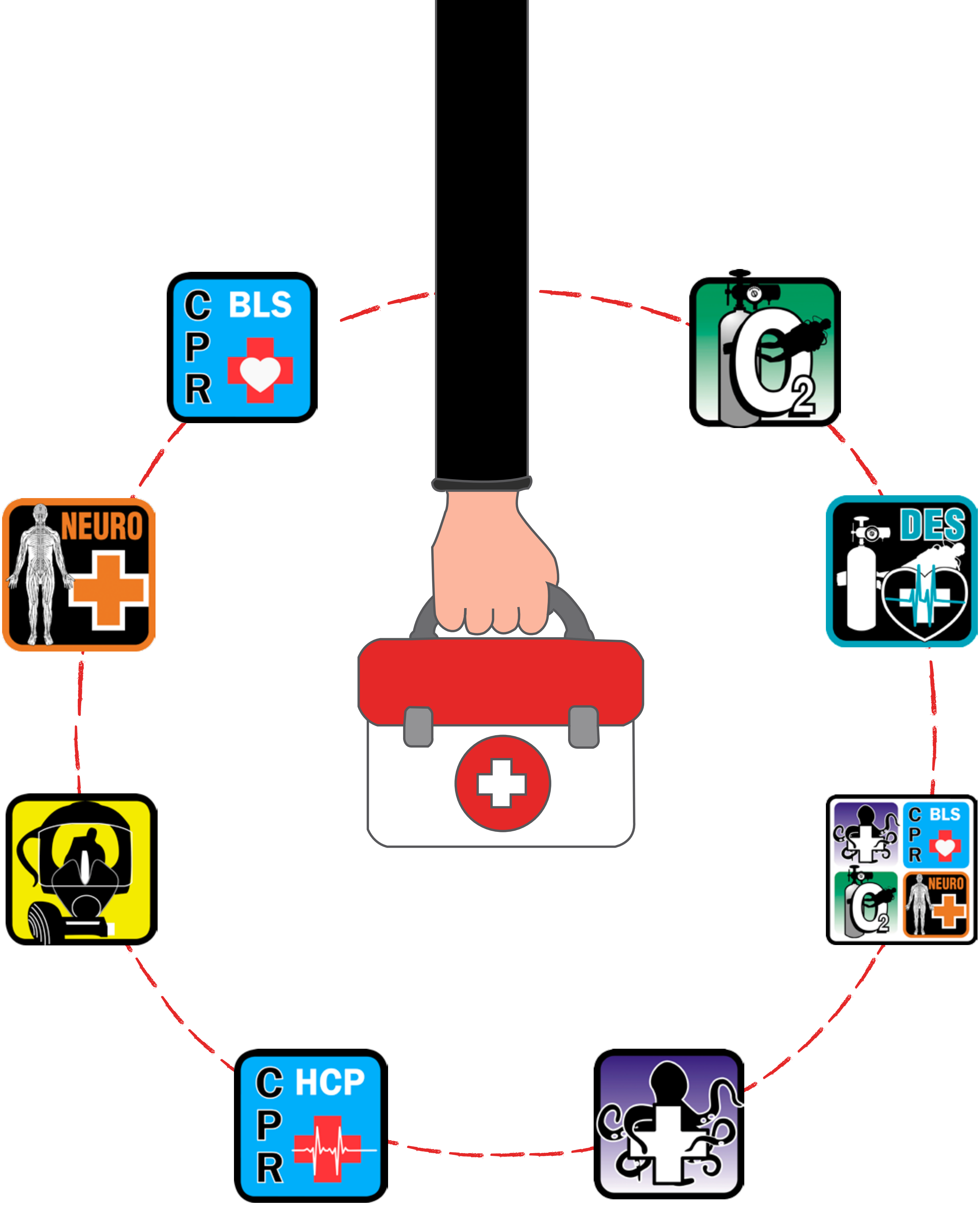
Among the services DAN-SA provides to the diving public is the DAN Emergency Hotline (0800 020 111 (local) or +27 828 10 60 10 (int.)). This hotline is available 24 hours a day, seven days a week for anyone who suspects a diving injury, requires assistance or needs to activate ***your DAN evacuation 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.



Equip yourself
to handle an emergency

DAN Training
www.dansa.org/training

Dive Safety Since 1997

DAN-SA is trusted by more than 7 000 fellow divers
and over 400 000 international divers.

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