



DIVE AND TRAVEL

MEDICAL GUIDE

Revised February 2015

Attention Physicians and Emergency Medical Personnel

Those bringing this Guide to you are concerned about the possibility of a pressure-related underwater diving injury. Part 3 of this Guide (Page 68) provides information that medical personnel may find useful in dealing with scuba diving-related injuries, especially if they are not familiar with them.

Divers Alert Network (DAN) is prepared to assist you in patient treatment. Call +1-919-684-9111 (see Page 1) to consult a physician experienced in managing scuba diving injuries.

International telephone numbers are also at the top of Page 1 for the convenience of travelers in those areas.

DIVER INFORMATION

Full Name _____

Date of Birth _____ Known Allergies _____

Other Medical Problems _____

Daily medications _____

DAN Member Number: _____

DAN Insurance* (Circle): Preferred Master Standard

Other Insurance (Company & Policy Number)

NOTIFY IN EMERGENCY

Name _____ Relationship _____

Address _____

Telephone () _____

* DAN members are eligible to purchase optional DAN Insurance.

The DAN Dive and Travel Medical Guide

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Acknowledgments: Center for Disease Control and Prevention and the World Health Organization.

Attention

FOR EMERGENCIES

DAN EMERGENCY HOTLINE

+1-919-684-9111

Available 24/7 for diving
and non-diving emergencies
(including *TravelAssist* services).

**DAN MUST ARRANGE ALL
TRANSPORTATION PRIOR TO EVACUATION.**

Collect EMERGENCY calls are accepted.

DIVE AND TRAVEL INFORMATION RESOURCES

DAN Medical Information Line:

+1-919-684-2948

medic@DiversAlertNetwork.org

Worldcue® Planner Travel Intelligence® Resource

- Login to your member account at www.DiversAlertNetwork.org
- Click the Worldcue Planner link under “Resources”

DAN Mailing Address:

DAN, 6 West Colony Place, Durham, NC 27705 USA

Website:

www.DiversAlertNetwork.org

DIALING TOLL-FREE NUMBERS FROM OUTSIDE THE UNITED STATES

AT&T Direct™ Service can help you reach toll-free numbers from outside the United States. DAN has arranged for toll-free calling through AT&T Direct.

Toll-free number calling instructions:

1. Enter the AT&T Direct Access Number for the country you are in. (Find access numbers at www.usa.att.com/traveler/index.jsp.)
2. An English-language voice prompt or an AT&T Operator will ask you for the number you are calling.

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WHAT IS DAN?

Divers Alert Network is an international

nonprofit scuba diving safety association. DAN's primary function is to assist scuba divers in the treatment of diving injuries by providing 24-hour emergency telephone access to medical professionals skilled in dive medicine.



Other functions include education on dive safety issues, incident and accident data collection, and dive safety-related research. DAN collects and analyzes data on diving and freediving injuries to understand their causes. The ultimate goal is to improve diver safety by increasing awareness, reducing risk and improving incident management.

Emergency calls to the DAN Emergency Hotline — +1-919-684-9111 — trigger a page to the medical professional on call for DAN. That medical professional trained in the management of dive accidents responds to the call and assists in evaluation and referral to the appropriate treatment facilities. A physician who is an expert in dive medicine is immediately available and can assist with diagnosis and initial treatment of the accident as well as chamber referrals.

DAN does not maintain a treatment facility and does not directly provide treatment, but is a service that complements existing medical systems and acts as a referral center to appropriate medical facilities. DAN's most important function is facilitating the entry of the injured diver into the hyperbaric care system by coordinating the efforts of everyone involved in the care of injured divers.

DAN also works with partners to aid travelers who have serious medical conditions that need urgent treatment or evacuation. In addition to the hotline, DAN provides a nonemergency service for questions related to all phases of dive medicine and safety, including physical qualifications for diving, travel issues, medications and diving, and many other topics. The service operates Monday through Friday from 9 a.m. to 5 p.m. Eastern Time USA [Standard Time, subtract four or five hours Greenwich Mean Time, depending on U.S. Daylight Savings Time]. These information calls go to the DAN Medical Information Line at 919-684-2948. Nonemergency questions can be submitted electronically at any time at medic@DiversAlertNetwork.org, or you may visit the medical section of the DAN website at www.DiversAlertNetwork.org.

DAN does not provide chamber availability information as part of pre-dive preparation, as chamber status changes frequently. If you need information on locating a recompression chamber, call DAN.

WHY THIS GUIDE?

Traveling to different parts of the world requires knowledge and preparation. This guide is not intended just as a general travel guide; it is written to help deal with diving aspects of the trip and presents information that may not be covered in other travel guides — especially conditions that require recompression. This guide is divided into four sections. **Section I** covers necessary preparations before the trip and prevention of common travel-related diseases; **Section II** has treatment information on conditions that do not require recompression; **Section III** covers the recognition and treatment of dive-related injuries for which recompression therapy is needed; **Section IV** covers basic first-aid skills.

This manual is intended as a guide for the diver, paramedic, first aid provider or physician for the recognition and initial management of an injured diver. The information is presented in a simplified manner and is not intended to cover the complete treatment of an injured diver. Definitive treatment of dive injuries should be planned through consultation with medical personnel trained and experienced in dive medicine.

Divers have specialized medical needs, because serious diving injuries are rare. Relatively few physicians are highly trained in the diagnosis and treatment of dive injuries, so the recreational diver must be able to recognize the signs of injury and seek additional diving medicine help when it's needed. Diver training programs may stress this knowledge, but divers may forget this aspect of their training, because it is so seldom required.

Detailed expert medical advice on recompression therapy is continuously available through the DAN Emergency Hotline. Keep this guide in your dive kit. If an injury occurs, send it with the injured diver to the nearest medical facility.

DIVER RESPONSIBILITIES DIVE PLANNING

Responsible divers plan each dive and determine in advance whether a proposed dive or site requires more personal skills or assets than they possess. In addition, divers should determine the level of training and expertise of their dive buddy.

Recreational diving is a social activity and is rarely conducted alone (DAN and major scuba training agencies recommend that you always dive with a buddy). Each diver assumes some degree of responsibility for companions, with essential skills required that go beyond diving.

ESSENTIAL SKILLS

Prepared divers should be able to perform basic first aid procedures, cardiopulmonary resuscitation (CPR), provide emergency oxygen first aid and conduct in-water rescue. Because many dive sites are found in remote locations, knowing how to assist an injured diver until trained medical help arrives can mean the difference between complete recovery and permanent injury.



Rescuer provides oxygen first aid to an injured diver.

Cardiopulmonary Resuscitation (CPR)

CPR is an essential skill for everyone and especially for divers. Although basic CPR is easy to learn, it requires several hours of training and regular skill-refresher courses. Rescuers should know the key steps of CPR, including the head-tilt / chin-lift method of opening an airway as well as other critical skills taught in these courses.

CPR skills require instruction and practice under the supervision of a certified instructor. Hands-on course instruction is the best way to attain the skill level necessary to conduct CPR in the field. Do-it-yourself manuals or following written instructions without having had supervised training can result in providing ineffective aid.

Basic First Aid

Basic first aid skills are necessary for divers for the same reason CPR skills are essential: Knowing how to position an injured person, control bleeding and prevent further injury until medical help arrives can be immensely useful. Contact your local dive center for CPR and first aid course information.

The most important goal in first aid is to support life by assisting an injured or ill person until advanced life support is available. Divers must understand the limitations of their knowledge and first aid procedures they use, however, in order to do no further harm.



Supplemental oxygen is a valuable adjunct in CPR, in drowning, and in a serious accident/injury that impairs the body's ability to transport oxygen to the tissues.

Oxygen First Aid

The ability to provide emergency oxygen is a skill recommended for every diver. Learning to use oxygen is not difficult, but it does require proper instruction and practice with the equipment under the direction of a qualified instructor. DAN has developed an Oxygen Provider Course that teaches emergency oxygen first aid. The principles of providing emergency oxygen are reviewed later in this manual, but divers cannot consider themselves ready to use oxygen in resuscitation or first aid until they have completed adequate training.

Water Rescue

Water rescue is a special subject requiring study, training and frequent practice in order to gain the necessary knowledge and proficiency. Every diver should participate in the scuba lifesaving and accident management courses offered by virtually every diver certification agency.

Do not attempt any procedure beyond your ability.

The most important goal in first aid is to support the life of an injured or ill person until trained medical help is available.

For more information on principles of first aid, oxygen first aid and CPR/Basic Life Support, see pages 81-88.

SECTION I: Trip Planning and Prevention of Travel-Related Disease

MEDICAL FITNESS TO DIVE

Are you medically fit to dive?

DAN can put you in contact with a doctor who can help you make that decision. DAN dive medical experts can talk with local physicians over the telephone in helping them make a fitness-to-dive determination. Planning is key — seek medical clearance well before your trip.



To help determine your fitness for diving, you should discuss with your physician any change in your health status, any injury, or recent surgery. The physician may in turn wish to contact DAN and discuss the condition with one of DAN's medical experts. Your doctor may provide you with a letter stating that you are fit to dive. If the physician has had formal training in dive medicine, this should be pointed out in the letter. If not, then the individuals (and their qualifications) with whom any problems have been discussed should be noted.

This letter may be useful in convincing an anxious resort operator that you are fit to dive. Diabetes and asthma are two diseases that raise questions for many dive resort owners or boat captains. Having written evidence of a proper evaluation may prevent frustration and save time. Remember, the resort operator or boat captain is ultimately responsible for all the divers in their charge and usually has discretion over who dives and who does not. There may also be national policies or trends that will affect your ability to dive. Check with DAN if you have questions.

TRAVEL-RELATED ILLNESS

DAN members travel to dive sites in remote countries as well as in more developed countries. There are certain illnesses associated with travel anywhere, many of which can be prevented, but some of which may be life-threatening. Appropriate prophylaxis and counseling by professionals can reduce the health risk. You may need to make a visit to a physician or a travel clinic, as well as doing some research and planning in advance.

DAN and resources available through DAN can also provide this type of information for DAN Members. Plus, as a DAN Member, you are eligible to access health and travel information by logging into your online member account.



In addition, you can obtain a comprehensive travel medical guide from your local bookstore. Or contact DAN for the most recent edition of *International Travel Health Guide*, a useful book of travel health advisories (published annually by Elsevier). The traveling diver should be current with guidelines provided by the Centers for Disease Control and Prevention (CDC) in Atlanta (USA) — an invaluable resource that’s easy to obtain — and at no cost. Read on.

CDC Information Service

The CDC website (www.cdc.gov/travel) contains the latest information on immunization information and country-specific health information. The information is also downloadable in several formats.

A detailed publication giving immunization guidelines and travel information, called “Health Information for International Travel,” or the “Yellow Book,” is available on the website and updated annually.

Other useful websites are the International Society of Travel Medicine at www.istm.org/ and the American Society of Travel Medicine and Hygiene at www.astmh.org/. These websites include directories of travel medical clinics throughout the United States. Check with your local hospital, as these listings may not include all the clinics in your area. Other sites with country-specific health information are the World Health Organization (WHO) at www.who.int/en/ or www.nathnac.org.

Prophylactic Treatment and Counseling

If you’re planning to visit a travel medicine clinic, ask the staff there to review your complete itinerary to determine the precautions needed: Disease exposure differs according to destination. Schedule your visit at least four to six weeks ahead, as some vaccinations need time to become effective, or they may be given in a series. Lifestyles, pre-existing illnesses and current medications can all influence risk assessment, and this requires knowledge of what the diver will do abroad. We have suggested some drugs you may wish to consider to take with you and have supplied the generic names for these therapies.

Certain factors are associated with an increased risk of acquiring a travel-related illness. Make a complete review of your itinerary and relate the planned activities to the specific risk of acquiring disease for each location and activity. For instance, a planned scuba trip may include the risk of contracting malaria; a bicycle trip can have a higher risk of sustaining traffic injury; a mountain climbing or trekking trip may include the risk of altitude sickness. There are other considerations as well, including pre-existing illnesses or lifestyles.

The lifestyle of the diver is important: For example, the college student helping to build schools in undeveloped areas of an equatorial country is at much greater risk than the diver on a well-organized dive boat operating over the coral reefs of the same area. What this can

mean is that there may be very little risk of acquiring a tropical disease aboard the dive boat offshore but a very high risk for the land-based diver/traveler.

One's lifestyle while abroad may include other risks, such as work or study in a tropical area, living with indigenous populations, sleeping in tents or boarding houses, and spending prolonged periods in areas with poor sanitation. Pre-existing illness and medication use must also be considered as risk factors in areas of marginal medical facilities.

RISK FACTORS

- Chronic illness
- Lifestyle while abroad:
 - Living or having unprotected sex with anyone unknown or with an unknown sexual/medical history
 - Sleeping in tents or boarding houses
 - Prolonged stay in area with poor sanitation
- Visit to sub-Saharan Africa
- Travel to the tropics
- Driving a motorized vehicle in a less developed country
- Wading or swimming in fresh water
- Being immuno-compromised from diseases or treatment such as diabetes, HIV or chemotherapy

Pre-Travel Precautions

The four most important categories of pretravel precautions are:

- Vaccinations and immunizations; ■ Diarrhea management;
- Malaria prophylaxis; ■ Behavioral counseling.

Immunizations

As more than 90 percent of travelers are repeat travelers you might consider vaccinations as an investment for the future. Giving general recommendations on vaccinations and immunizations is difficult, and detailed recommendations are beyond the scope of this guide. However, you should carefully review your immunization status, especially the routine vaccinations such as **tetanus / diphtheria (DTaP), measles (MMR), polio, hepatitis B, Varicella and influenza**, with your physician well before starting your trip. A current test for **tuberculosis** exposure (PPD) is advised. **Yellow fever** vaccination is the only one currently required by the WHO, but some countries still require proof of **cholera** vaccination. Other vaccinations will depend on the itinerary, lifestyle and length of the trip. Check with DAN at +1-919-684-2948, the CDC website or your doctor for the latest recommendations.



Cholera is transmitted through food or drinking water contaminated with the bacteria *Vibrio cholerae*. Modern sanitation practices have drastically reduced its incidence. A cholera vaccination is still required by some countries, but it is not medically recommended, as travelers rarely develop cholera even in endemic areas (2 cases per 1 million travelers to endemic areas). The vaccine is no longer available in the USA. There are two current manufacturers of an oral vaccine in other countries.

Hepatitis A is a worldwide problem associated with food and water contamination. The most luxurious resort in a major nation or a humble dwelling in a poor nation can be the source of an infection. Indigenous populations acquire most cases of hepatitis A. These generally happen early in life and consequently are subclinical infections. However when an adult traveler from North America or Western Europe contracts hepatitis a serious illness can result. There are two inactivated virus vaccines licensed in the United States — HAVRIX® and VAQTA®. Immune globulin may be used in those allergic to the vaccine but will provide protection for only three months.

For travel longer than three months, the CDC has recommended extended dosage schedules. In persons previously vaccinated or exposed to the disease, screening for antibodies to hepatitis A virus (HAV) may be useful to prevent unnecessary immunization or prophylaxis. It takes approximately four weeks after vaccination before full protection can be assumed, so individuals traveling sooner should consider receiving a dose of immune globulin in addition to the initial vaccination, but at a different injection site.

Hepatitis B is transmitted through activities that involve contact with blood or blood-derived fluids. The vaccine is advised for anyone who will have close personal or sexual contact, blood transfusions, needle sharing, tattooing and use of unsterilized surgical or dental instruments within populations harboring asymptomatic carriers.

Hepatitis C is transmitted through blood exchanged with infected individuals, as with sharing of needles. Symptoms are usually mild or may be absent. No vaccine is available. The risk to travelers is low but they should consider the health risks of engaging in the activities mentioned above for Hepatitis B.

Hepatitis E is transmitted by the oral-fecal route, mainly through contaminated drinking water. It can be distinguished from other forms of hepatitis by serological (blood) testing. The best prevention is to avoid potentially contaminated water or food in endemic areas.

Japanese B encephalitis is mosquito-borne. A vaccine is available in the United States but should only be considered for individuals who will be visiting high-risk areas for 30 days or longer. This disease is relatively rare and generally confined to certain areas of Southeast Asia.

IMMUNIZATIONS

Depending on destination divers should consider immunization for:

Chickenpox (Varicella)	Influenza	Polio
Cholera	Japanese Encephalitis	Rabies
Diphtheria	MMR (Measles, Mumps, Rubella)	Tetanus
Hemophilus B	Meningococcal Meningitis	Typhoid
Hepatitis A & B	Pneumococcus	Yellow fever

(A tuberculin skin test — PPD — is not an immunization but should be done to document tuberculosis exposure status.)

Meningococcal meningitis is endemic in various areas, and the CDC should be consulted for weekly advisories. This bacterial infection can be fatal.

Rabies, transmitted via animal bites, is prevalent in developing countries and should be considered a risk for individuals spending time in villages in Africa, Asia or Central and South America.

Smallpox vaccination is no longer required or given.

Tuberculosis, with airborne transmission, is always a risk, especially in developing countries. The TB vaccine has variable efficacy and is not available for travelers. A tuberculin skin test (PPD) will tell if a person has been exposed; it may be required before a trip, with a repeat test about 12 weeks following the trip if the first test is negative. If a negative test turns positive after a trip, prophylactic treatment may be indicated. If the initial test is positive, reinfection is unlikely unless immunity is impaired (as with **human immunodeficiency virus** — HIV infection or the use of corticosteroids such as prednisone).

Typhoid fever is still endemic in many countries of the world, where it is predominantly a disease of school-age children and is a major public health problem. Contracting typhoid fever is unlikely, but divers who will be exposed to potentially contaminated food or water for long periods of time in rural or less traveled areas should be immunized. Current CDC advisories should be consulted with regard to specific areas. There are currently three types of vaccines available, one oral and two parenteral or given by injection. The CDC provides dosage schedules in its “Health Information” publication. Since these vaccines only provide protection in 50-80 percent of recipients, one should still be careful in selecting food and water for consumption.

Yellow fever is a mosquito-borne viral illness that is potentially fatal and for which there is no known treatment. The vaccine is advised for a visitor to any country in the yellow fever endemic zone, although some countries in this zone do not require a yellow fever certificate. A few countries outside the high-risk zone require vaccination of a traveler coming from that zone.



AVOID MOSQUITO BITES!

Stay in screened areas when indoors — especially from dusk to dawn.

Sleep under mosquito netting.

Wear adequate clothing when outdoors.

Use “DEET” (N,N-diethyl-meta-toluamide).

Malaria

Malaria has caused more deaths worldwide than any other infectious disease: it is the most serious infectious disease hazard to divers traveling to the tropics. The disease is found primarily in subtropical and tropical regions of the world, where environmental conditions favor stable, infected *Anopheles* mosquito populations. Malaria occurs in large areas of Central and South America, Hispaniola, sub-Saharan Africa, the Indian subcontinent, southern and Southeast Asia, the Middle East, Mexico, Haiti, the Dominican Republic and Oceania. Major cities in Asia and South America are nearly malaria-free, though cities in Africa, India, and Pakistan are not. There is less risk of malaria at altitudes above 4,900 ft / 1,500 m.

Malaria Prophylaxis

The serious health risk represented by malaria cannot be overemphasized. Prophylaxis is essential and includes both the prevention of mosquito bites and drug prophylaxis. The malaria parasite, a protozoan, is transmitted to humans by the bite of an infected female *Anopheles* mosquito, usually dusk to dawn.

Personal protection is the best way to prevent malaria and other insect-transmitted diseases. This means staying in well-screened areas while indoors, wearing clothes that cover most of the body when outdoors, and using mosquito nets when sleeping. Insect sprays and repellents for clothing, tents and nets should be used as well as personal repellents containing at least 30 percent DEET (Note: concentrations above 30 percent do not add significantly to the protective effect or duration). Standard preparations last about four hours; longer-acting preparations are available. Picaridin is an alternative and effective agent.

Travelers to malarious areas should also take prophylactic drugs, which must be obtained by prescription. Recommendations may vary depending upon drug susceptibilities of local malaria strains. Most of the drugs used for prophylaxis are safe and well tolerated. However, as with any drug, some serious side effects and toxic reactions may occur occasionally.

The severity of malaria, however, entails temporary mild side effects. Mefloquine (Lariam®) in particular rarely causes symptoms that can mimic DCI. Divers taking mefloquine are prohibited from diving in some countries, in which case another drug should be substituted.



If a diver traveling to an area with a high risk of malaria is unable to take preventive medications against malaria because of side effects, the trip should be canceled: the risk is too great that the diver may contract malaria and even die because he/she did not take appropriate prophylaxis.

Regardless of preventive measures, malaria may still be contracted. Malaria may not develop until long after the trip, and prophylaxis must be continued for an appropriate length of time. If flu-like symptoms (any illness with chills, fever and headache) develop during a trip in malarious areas or within several months after the last exposure, obtain medical attention immediately. It is important to mention your possible exposure to malaria when seeking further medical attention.

Amebiasis

This disease is caused by the protozoan *Entamoeba histolytica*. The most common symptom is diarrhea, which may become painful and bloody. The disease is transmitted by person-to-person contact through the fecal-oral route, by ingesting contaminated food or water. Eating or drinking in areas of poor sanitation will put one at increased risk. There is no vaccine, and treatment should be obtained through a specialist in infectious disease or tropical medicine specialist.

Dengue Fever

Dengue is a viral disease transmitted by the mosquito *Aedes aegypti*. It has a sudden onset, with fever, severe frontal headache, and joint and muscle pain. Nausea, vomiting and a rash may also occur. The disease is usually self-limited and benign, but it may require a long convalescence. Dengue fever can also occur as a severe fatal form, called dengue hemorrhagic fever. Dengue fever occurs worldwide, especially in tropical areas. There is no vaccine available and preventive measures should be targeted at avoiding mosquito bites, particularly between dusk and dawn. This can be done by remaining indoors, wearing clothing covering arms and legs and by using repellents such as DEET.

Giardiasis

A parasitic disease caused by *Giardia intestinalis*, symptoms occur one to two weeks after ingestion; they include diarrhea, abdominal cramps, bloating, fatigue, weight loss, flatulence, anorexia or nausea in various combinations, usually lasting more than five days. There is no vaccine or prophylaxis. Those who eat and drink in areas with poor sanitation are at increased risk. For treatment, consult a specialist in infectious disease or tropical medicine specialist.

When you travel, if you eat and drink in areas with poor sanitation, you increase your risk of diseases like giardiasis and travelers diarrhea.

Leishmaniasis

This is a parasitic disease transmitted by the bite of phlebotomine sand flies. The skin form of the disease is characterized by open or closed sores that can develop weeks to months after a bite. The visceral form (affecting internal organs) is manifested by fever, enlargement of the liver and spleen, and anemia, developing months to years after infection. There is no vaccine; the disease requires treatment from a specialist in tropical diseases.

Individuals at risk are those who engage in outdoor activities at night in endemic areas. High-risk areas are Bangladesh, Brazil, India and Nepal. Cases have also been reported from northern Argentina to southern Texas, northern Asia, Middle East, and eastern and northern Africa. Preventive measures include wearing long-sleeved clothing, using insect repellents (DEET on skin and permethrin-containing insecticides on clothing) and avoiding outdoor activities at night when sand flies are active.

Leptospirosis

Leptospirosis is found worldwide, with a higher incidence in tropical climates. It is a disease that affects humans, wild and domestic animals and is caused by bacteria of the genus *Leptospira*. The animals excrete the organism in their urine and feces, contaminating soil and water. Symptoms can mimic other tropical diseases and include fever, chills, myalgias (muscle spasms), nausea, diarrhea, cough and conjunctival suffusion (redness of the membrane covering the eye). Severe disease may result in renal failure.

Travelers participating in recreational water activities in local areas are at increased risk, especially during flooding. There is no vaccine. The CDC recommends that travelers who might be at increased risk consider prophylactic doxycycline (200 mg weekly) beginning one to two days before exposure.

Travelers Diarrhea

USE THE PEACE CORPS RULE — *Boil it, cook it, peel it or forget it*

- Hot and steaming is safe.
- Bread is safe.
- Rice and noodles are safe if cooked and steaming hot.
- Fruit is safe if freshly peeled by the consumer.
- Factory-sealed bottled water is safe.
- Factory-sealed carbonated drinks are safe.

AVOID these items ...

- Buffets
- Room-temperature foods
- Previously peeled fruit, raw produce and salads
- Raw or poorly cooked seafood
- Unboiled tap water, even for brushing teeth
- Beverages not in factory-sealed containers
- Ice cubes, unless made with safe water
- Milk products, unless boiled or pasteurized

Travelers diarrhea (TD) is the most common complaint of the tourist and can be encountered anywhere in the world. All travel involves a risk of acquiring diarrhea. The CDC estimates that 30-50 percent of travelers will develop TD in a one- to two-week stay in certain areas. The best defense is to develop safe eating and drinking habits when in high-risk areas.

Most cases of travelers diarrhea can be avoided by eating food that is steaming hot (not merely cooked), has a high acid content (like citrus: orange, grapefruit, etc.), a high sugar content (jellies and syrups), or one that is dry (bread).

Anything that is moist and warm or at room temperature is unsafe. This includes sauces, salads and anything on a buffet. Citrus fruits and all fruits that can be peeled by the consumer are safe (hands must be clean, however). Unpeelable fruits (e.g., grapes, berries) are not safe. An unpeeled tomato is not safe, but a tomato peeled by the consumer is safe. Watermelon is sometimes injected with water to make it heavier and therefore may be unsafe.

Untreated water is not safe, but bottled drinks, wine and beer can be considered safe. Bottled water must have an intact seal at the time of purchase to be considered safe. Children sometimes refill water bottles at a town well and resell them as safe water.

These simple precautions will give a better-than-even chance that the traveler will avoid diarrhea, even in the worst circumstances. Medications can slightly improve the chances, but are not without risk. Thirty to 50 percent of travelers who do not take preventive medications in high-risk areas get diarrhea. Not taking a medication has obvious advantages: it is more convenient, avoids drug side effects and costs nothing.

While travelers diarrhea may cause discomfort, it is not usually life-threatening, is easily treated by over-the-counter medications and will even go away (eventually) without treatment. Most travel physicians do not advise antibiotics to prevent diarrhea, because serious reactions to the antibiotic are about as common as serious diarrhea.



Life-threatening drug reactions occur in as many as one in 10,000 individuals. Most important, the widespread use of antibiotics has led to significant resistance on the part of the organisms, making treatment more difficult for individuals once they become ill.

The CDC advice is “prophylactic antimicrobial agents are **NOT** recommended for travelers” to prevent TD. However, once an individual has contracted TD, the CDC has recommended some specific medications.

Because bacterial causes of TD far outnumber other microbial causes, practical treatment with an antibiotic directed at intestinal bacterial pathogens remains the best therapy. The effectiveness of a particular antimicrobial depends on the etiologic agent (the microbe causing the ailment) and its antibiotic sensitivity. For treatment of a specific bacterial pathogen, first-line antibiotics include ciprofloxacin or levofloxacin. Increasing microbial resistance to the fluoroquinolones may limit their usefulness in some destinations such as Thailand and Nepal. (Note: The FDA recently issued a black-box warning about these drugs. There is a significant risk of tendon rupture. [Several Achilles ruptures have been reported to DAN.] With sudden exercise, please read the hazard warning supplied.) An alternative in this situation is azithromycin. Rifaximin has been approved for the treatment of TD caused by noninvasive strains of *E. coli*.

The standard treatment regimens consist of three days of antibiotic, although when treatment is initiated promptly shorter courses, including single-dose therapy, may reduce the duration of the illness to a few hours.

Bismuth subsalicylate (Pepto-Bismol®) has been shown to decrease the incidence of diarrhea significantly when taken prophylactically (2 ounces four times daily or two tablets four times daily; it should not be used for longer than three weeks). Pepto-Bismol is also useful in the treatment of diarrhea, but less so than antibiotics. The dosage for TD is 1 ounce every 30 minutes for eight doses, not to exceed 8 ounces in 24 hours or eight doses. Wait at least two hours after taking antibiotics before taking Pepto-Bismol since it will retard antibiotic absorption.

Avoid Pepto-Bismol if these conditions exist:

- If you're allergic to, or intolerant of, aspirin
- If you are taking an anticoagulant (blood thinner)
- If you have renal insufficiency, gout, or are taking probenecid or methotrexate
- If you have any type of bleeding disorder
- If you have a history of peptic ulcer

Do not use Pepto-Bismol for children under 12 years of age or under 19 with chicken pox or flu because of the possible risk of Reye's syndrome. Self-treatment of traveler diarrhea, if it occurs, is possible with a little preparation. The following items are required: a thermometer, an antidiarrheal medication (e.g., loperamide, diphenoxylate), Pepto-Bismol and an antibiotic prescribed by a physician.



Any sign of illness requires quick reaction. Immediately after a watery stool occurs, determine the body temperature. With fever (100°F / 38°C) or a bloody stool, take only the antibiotic. If there is no fever or bloody stool, take both Pepto-Bismol (1 oz. liquid or two chewable tablets every 30 minutes for eight doses) and/or an antidiarrheal. If nausea, vomiting and/or cramps are present, an antibiotic may be taken along with the Pepto-Bismol and an antidiarrheal. This will usually relieve symptoms in 12-15 hours. Avoid using antidiarrheals for children under 2 years of age.

Significant dehydration usually will not occur in adults, and safe fluids should be encouraged. If you are having fewer than eight episodes of watery stool per day, continue with your regular diet supplemented with clear broth, salted crackers and 2-3 liters of clean water daily. Avoid dairy products and beverages that contain high levels of sugar, as most nondiet soft drinks do.

Rehydration beverages containing electrolytes such as Gatorade® are appropriate in cases of TD. The best solution is to take liberal quantities of oral rehydration solutions (ORS), such as World Health Organization ORS solutions, which are widely available at stores and pharmacies in most developing countries, and may be purchased at outdoor stores.

If symptoms do not improve within 48 hours, medical attention is recommended because of the possibility of a parasitic infection. Note: Treatments for travelers diarrhea do not eradicate *Giardia intestinalis* (giardiasis); antimicrobial drugs are needed.

SELF-TREATMENT of TRAVELERS DIARRHEA

NEED

- Pepto-Bismol®
- Antidiarrheal [Lomotil® (diphenoxylate) or Imodium® (loperamide)]
- Antibiotic prescribed by physician
- Thermometer

IF you have diarrhea and fever or bloody stool:

- Take antibiotic only.

IF you have diarrhea without fever:

- Take Pepto-Bismol and/or antidiarrheal medicine.
- Get medical attention if symptoms persist 48 hours.

Schistosomiasis

The *Schistosoma* parasite has a life cycle involving a freshwater snail. The disease is found in rural tropical and subtropical areas, including the Middle East, Africa, eastern South America, especially Amazonia, and parts of the Caribbean, including Puerto Rico and St. Lucia. A person bathing in or drinking fresh water harboring the snail may encounter larvae that can penetrate skin. Schistosomiasis can have serious consequences. Chlorinated and salt water are usually safe for swimming, but swimming or bathing in



fresh water in endemic areas is not. Heat water for bathing to hotter than 122°F / 50°C for more than five minutes. You can also chemically treat water or allow it to stand for more than 48 hours. (Let cool before bathing; water hotter than 113°F / 45°C may cause burns.)

SEAFOOD and TRAVEL

Many marine creatures are always poisonous when ingested, and others are toxic only during certain seasons. Whenever a person develops an unexplained illness on an island trip, it is important to obtain an accurate dietary history. Problems involving diagnosis and treatment of a marine toxin may occur anywhere due to air travel and the universal distribution of seafood.

Ciguatera

The most serious of marine toxins and most commonly reported, ciguatera is mainly a tropical disorder, but does occur in semitropical and temperate areas when contaminated, imported fish are consumed. Occasionally a traveler will return home with an undiagnosed illness that turns out to be ciguatera. Distribution is widespread, and the ciguatera-toxic fish are found between latitudes 35 degrees north and 35 degrees south. The fish are usually large predatory reef fish, but are not identifiable as toxic by external appearance. The dinoflagellate *Gambierdiscus toxicus* — which forms part of plankton — is thought to be the originator of the toxin, which is harmless to fish and moves up through the food chain. The toxin is heat-stable, and neither cooking nor freezing will destroy it.

Clinical Features

Symptoms begin within two and 12 hours after ingestion, with generalized nonspecific symptoms and mild weakness. Symptoms increase in severity, with dull aches, cramps and numbness around the mouth, tongue and throat. Gastrointestinal symptoms include loss of appetite, nausea, vomiting and diarrhea. Neurological symptoms include delirium, lack of coordination, difficulty walking, reversal of temperature perception, convulsions, coma and, in rare instances, death.

The main symptoms clear up in one to two days, but residual weakness, alteration of temperature perception and other symptoms may persist for months. The symptoms might resemble those of neurological decompression illness, making the differential diagnosis difficult at times. Ingestion of alcohol can precipitate a recurrence of the symptoms even months after the illness. A reddened skin area, with burning sensation developing after alcohol consumption, is a characteristic of the disease. Symptoms can also recur after stress or eating certain fish. Immunity does not develop, and a subsequent poisoning may be more severe. Diagnosis depends on history of travel and exposure to fish, followed by developing symptoms, though there are other more complex — but not so readily available — diagnostic procedures which require examining the suspected food or stomach contents.

Prevention

Local knowledge is not always reliable in reference to toxic fish; follow it, however, if some species in the area are considered toxic. Here are some preventive measures.

AVOID EATING:

- Viscera (internal organs)
- Large reef predators and other species implicated in poisoning: barracuda, grouper, snapper, sea bass, surgeonfish, parrotfish, wrasses, jacks and others
- Moray eels



Treatment

There are limited first aid and definitive treatment measures. If the fish was ingested in the previous few hours, vomiting can be induced to remove any remaining fragments. The victim should be fully conscious if it is necessary to induce vomiting. The severely toxic victim may require respiratory support. Physician care is required as soon as possible.

Scombroid Poisoning

Mackerel-like fish of the family Scombridae and a few other species may be the source of scombroid poisoning. All forms of tuna, including albacore, as well as bonito and mackerel are examples of Scombridae fish. Occasionally, nonscombroid fish such as dolphin (mahi-mahi), bluefish, sardine and marlin may be the source of the toxin.

As a result of improper handling of these fish — such as allowing exposure to sun or room temperature for several hours — a toxic histamine-like substance develops. Bacterial action converts histidine (a normal constituent of dark-meat fishes) into a toxin. The reaction is not allergic, but a response to the toxic byproducts. The fish have been typically reported to have a peppery taste, but this may be a result of the chef's attempting to conceal the condition of the fish.

Clinical Features

About 30-60 minutes after ingestion, symptoms of nausea, vomiting, diarrhea and abdominal pain may appear. These symptoms may be followed by headache, palpitations and a generalized rash with itching and blister formation. The symptoms may become very severe, with cardiovascular shock. Infrequently, death has occurred.

Prevention

Fish should be properly refrigerated and not exposed to sunlight or warm temperatures for long periods. Suspect fish should be discarded.



Treatment

An antihistamine may be helpful for scombroid poisoning; plus you should get a consultation with a physician as quickly as possible. Since this is not due to an endogenous release of histamine, glucocorticoids will not change the natural course of the disease.

Parasitism

Raw or lightly pickled marine or freshwater fish of many species are consumed frequently as sushi, sashimi or similar dishes. Both marine and freshwater fish are hosts for several roundworms and tapeworms which may be transmitted to humans. Sushi may be the source of diphyllobothriasis (fish tapeworm infection) or *anisakiasis* (Anisakis roundworm).

Any of the lightly pickled fish of many species also may be the source of anisakiasis. The larvae may be present in many commonly marketed fish, including salmon, mackerel, cod, pollock, herring and sole. Prevent this form of parasitism by eating only fish that have been fully cooked to 140°F / 60°C. Avoid raw, lightly pickled or undercooked fish.

Pufferfish Poisoning

Tetrodotoxin is the culprit responsible for so-called pufferfish poisoning. This poison is not delivered via a sting, however; most cases of Pufferfish Poisoning are caused from intentional ingestion of fish dishes that include pufferfish, blowfish, balloon fish, sunfish, porcupine fish, toadfish, globefish and swellfish (Tetrodontidae).

Pufferfish are considered an Asian delicacy, served in some types of sushi and sashimi, as well as the popular dish known as fugu. This is the leading cause of death in Japan due to food poisoning. Unless the chef is specially trained and licensed to cut the meat in a particular fashion, the dish may contain a large amount of the neurotoxin, found in the organs of these fish or skin.

Clinical Features

Signs and symptoms generally occur from 10 to 45 minutes after ingestion. The illness begins with numbness and tingling around the mouth, salivation, nausea and vomiting. Symptoms may progress to paralysis, loss of consciousness, and respiratory failure, and if untreated, can lead to death. It is said that this toxin can cause a state of suspended animation acting in a uniquely manner at mitochondrial level, which some say might explain the myth of voodoo's zombies.

Treatment

Seek medical treatment as soon as possible. Induce vomiting if the poisoned person is awake and alert and has eaten the fish in less than three hours. Be sure to keep any recumbent vomiting persons on their sides to help keep the airway clear. If paralysis sets in, the injured person may require rescue breathing until you reach a hospital's emergency department.

SEXUALLY TRANSMITTED DISEASES

The traveler who practices high-risk behaviors may encounter a number of sexually transmitted diseases. Currently, 147 countries are reporting HIV/AIDS, and the World Health Organization reported that the number of people living with HIV globally rose to 33 million in 2007, with a drop in new cases to 2.7 million in that year.

Wide availability of antiretroviral therapy has helped keep AIDS deaths comparatively low, at about 40,000 in 2005 in Western Europe and North America. In sub-Saharan Africa, the prevalence varies from 1 to 28 percent. The global death rate is falling slowly (data from www.unaids.org).

Hepatitis B, syphilis, gonorrhea and other sexually transmitted diseases are widespread. Be aware of the risks of these diseases. Treatment is frequently complicated by drug resistance on the part of the organism or by the lack of any effective treatment at all. Prophylaxis is best. Other than abstinence, the most effective prophylactic measure is the use of condoms.

Be aware that equipment used for tattooing, body piercings, ear piercing and other such procedures may not be subject to the same health regulations enforced in the United States. Needles and other instruments should be in single use, disposable, sterile packaging. If there is any question of sterility, the traveler should avoid these activities.

TRAVEL GUIDELINES

Travel on Airlines

Long international trips can result in more-than-usual fatigue. The sudden shift in time zones results in the well-known jet lag. In addition, the noise, low humidity, irritants in the cabin air and physical inactivity all contribute to fatigue. Avoiding alcohol and caffeine and using a sedative for sleep will help to minimize the problem. Plan to rest on arrival day after a shift of multiple time zones.

There is a growing concern that sitting in a cramped airplane seat for long periods of time may result in deep vein thrombosis (DVT, or blood clots) in the legs. These clots could break off and travel to the lungs, resulting in a potentially fatal pulmonary embolism. Current preventive measures are to:

- Avoid sitting still for long periods. During the flight, it may help to move around the aircraft from time to time and do some inflight exercises;
- Keep hydrated by drinking sufficient water and fruit or vegetable juices;
- Individual's with certain pre-existing health issues may want to consider wearing graduated compression stockings for long-haul flights. These need to be fitted to the size of the calves, not the foot size, and they aren't suitable for people with arterial disease. Before travel, discuss this with your doctor.

- Discuss taking aspirin before and after a long-haul flight with your doctor. The effectiveness of aspirin in the prevention of this condition needs more study; more research is needed to confirm how effective it is.

Travel in Motor Vehicles

Infectious disease is not the major cause of disability or loss of life for the traveler — motor vehicle accidents are. A variety of factors contribute to the motor vehicle accident, most of which can be prevented or abated. These factors are well known and similar in all nations, the primary one being the use of seat belts. Familiarize yourself with local traffic laws and patterns before driving. Bear in mind that local observation of traffic laws may be limited.

The risks in a developing nation may be increased because of inaccessible medical care. Remote locations may not have an adequate level of care appropriate to the injuries. There is also the possibility of inadequate screening of blood supplies, inadequate sterilization of instruments and needles in medical facilities.

Prescription Drugs

A traveler going abroad with a pre-existing medical problem should carry a letter from the attending physician, describing the medical condition and any prescription medications, including the generic names of prescribed drugs.

Any medications being carried overseas should be left in their original containers and be clearly labeled. Travelers should check with the foreign embassy of the country they are visiting to make sure any required medications are not considered to be illegal narcotics. (A listing of foreign embassies and consulates in the United States is available on the Department of State's website at <http://www.state.gov/s/cpr/rls/dpl/32122.htm>. Foreign embassy and consulate contact information can also be found on the Country Specific Information for each country.)

If you wear eyeglasses or contacts take an extra pair with you. Pack medicines and extra eyeglasses in your hand luggage so they will be available in case your checked luggage is lost. To be extra secure, pack a backup supply of medicines and an additional pair of eyeglasses in your checked luggage.

If you have allergies to certain medications, foods, insect bites, or other unique medical problems, consider wearing a "medical alert" bracelet. You may also wish to carry a letter from your physician explaining required treatment. This would be useful, should you become ill.

Enjoy Yourself!

Travel with an open mind and leave your prejudices at home. Travel with curiosity and imagination. Travel relaxed, and — above all — travel patiently. It takes time to understand others, especially where there are barriers of language and customs. Stay flexible and adaptable to all situations, and you'll have a wonderful time!

TRAVEL CHECKLIST

GENERAL NEEDS

Malaria prophylaxis

TRAVELERS DIARRHEA KIT

Pepto-Bismol®
Antibiotic (prescribed)
Loperamide (non-prescription antidiarrheal)
Antidiarrheal (prescribed)
Oral rehydration solution (ORS)

Travel medical kit
General risk avoidance
Insect precautions
Medical assistance abroad
Safe eating and drinking habits
Safe sexual practices
Travel health insurance

VACCINATIONS, IMMUNIZATIONS

ROUTINE

Diphtheria-Tetanus
Measles — Mumps — Rubella Pertussis —
Poliomyelitis
Varicella (Chicken Pox)

TRAVEL-SPECIFIC

Cholera
Yellow Fever
Hepatitis A
Hepatitis B
Meningococcal Meningitis
Rabies
Typhoid Fever
Japanese Encephalitis

SURVEILLANCE AND OUTBREAK INFORMATION

Morbidity and Mortality Weekly Report www.cdc.gov/mmwr

Weekly Epidemiological Review www.who.int/wer

Canada Communicable Disease Report www.phac-aspc.gc.ca/publicat/ccdr-rmtc

MEDICAL ASSISTANCE FOR TRAVELERS

International Society of Travel Medicine www.istm.org

US Department of State www.travel.state.gov

INTERACTIVE WEB-BASED SOURCES

Centers for Disease Control and Prevention Travel Information

www.cdc.gov/travel

World Health Organization International Travel www.who.int/ith

Health Canada Travel www.TravelHealth.gc.ca

UK National Travel Health www.fitfortravel.scot.nhs.uk

MALARIA MAPS

For information, see the websites of the CDC or WHO.

BOOKS

Hunter, *Hunter's Tropical Medicine and Emerging Infectious Diseases*,
Saunders, 2000

Cook & Zumla, *Manson's Tropical Diseases*, Saunders, 2002

Steffen, *Manual of Travel Medicine & Health*, Decker, 2003

Eddleston, *Oxford Handbook of Tropical Medicine*, Oxford University Press, 2004

Red Book, *American Academy of Pediatrics Report of the Committee on Infectious Diseases*, Annual Updates

Thompson, *Travel & Routine Immunizations*, Shoreland, 2003

Keystone, *Travel Medicine*, Mosby, 2004

Guerrant, *Tropical Infectious Diseases: Principles, Pathogens & Practice*,
Churchill Livingstone, 2006

SECTION II: Diving Disorders That Do Not Require Recompression

DROWNING

A drowning incident involves a lack of oxygen, possible aspiration (water in the lungs) and possibly even full cardiac arrest resulting from immersion. It has been recommended that the term “near-drowning” no longer be used. Every drowning victim should be taken to a medical facility for thorough evaluation, no matter how trivial the episode may seem. In minor cases, medical treatment may be unnecessary.

Divers should be familiar with the problem of drowning and with the techniques of rescue and resuscitation. In-water rescue is a special subject requiring study and practice to gain the necessary expertise. Divers are urged to participate in one of the scuba lifesaving and accident management courses offered by virtually all diver certification agencies.

In potentially dangerous situations — such as in caves and currents — the safety of the rescuers or the group may take precedence over the ideal medical management of such an injury. The rescue effort may need to be abandoned if continuing would pose a significant risk to the safety of the rescuer.

While submerged, a drowning victim eventually dies from a hypoxic cardiac arrest. Drowning occurs in stages as outlined below:

- The victim next fights to stay afloat while hyperventilating, which may result in negative buoyancy.
- Submergence occurs, and reflex breath-holding begins. The urge to breathe becomes stronger and stronger as the victim consumes all the available oxygen from air remaining in the lungs.
- After two to three minutes, the combination of the lack of oxygen and carbon dioxide accumulation causes an uncontrollable urge to breathe; the victim eventually inhales water, though usually very little.
- The individual, although unconscious, begins to swallow water reflexively. Consequently, some victims will have a stomach full of water.
- As oxygen is consumed, carbon dioxide accumulates more; the urge to breathe becomes stronger. The reflex swallowing gives way to a strong, deep breath. When the lungs are then emptied of air, the individual becomes more negatively buoyant.

A complete recovery is possible if:

- the drowning victim is rescued before significant aspiration (inhaling water) occurs; and
- breathing is restored before circulatory arrest occurs, which otherwise results in permanent brain damage.



Treatment of drowning depends on the restoration of breathing, heartbeat and obtaining assistance from qualified medical personnel.

In the event of drowning, immediately assess the airway and breathing. Perform rescue breathing as soon as possible with the non-breathing person, but maybe wait until the unresponsive person has been moved to shallow water or indeed out of the water. It is very hard to carry out effective rescue breaths in deep water. Once the individual has been removed from the water, assess him/her, and if necessary begin CPR immediately. Look for foreign bodies in the airway; divers have been known to bite off the bite tabs on some regulators and aspirate them. The routine use of abdominal thrusts or the Heimlich maneuver for drowning victims is not recommended.

Successful resuscitation of drowning victims in cold water has occurred even after prolonged submersion. Immersion times of more than one hour will make successful resuscitation unlikely. Unless immersion time can be definitively determined, CPR should always be initiated; however, if there is obvious evidence of death such as decomposition, severe trauma (e.g., head or body crushed), or trained medical personnel are available to certify death, stop efforts to resuscitate.

Survival after a prolonged immersion is possible if the water is icy cold (especially for children), even though the diver initially appears to be dead. (For CPR guidelines, see the following section on hypothermia.) Since delayed pulmonary edema, or fluid in the lungs, frequently occurs, all cases of drowning should receive medical evaluation.

THERMAL STRESS

The diver is subject to the effects of temperature as well as to the effects of water pressure. Water has a very high heat capacity and is an excellent conductor of heat. Heat transfer occurs whenever a temperature gradient exists between two objects, and always moves from the object with the higher temperature to the object with the lower temperature. Control of heat production and flow maintains stable body temperature.

Normal body core temperature is generally accepted as 98.6°F / 37°C, but actual temperatures vary in accordance with daily cycles, monthly cycles (for women) and with the individual. Deviations that exceed normal ranges produce hyperthermia or hypothermia.



Hyperthermia

Hyperthermia is a condition of elevated body core temperature. The lower temperature limit of hyperthermia is poorly defined. The U.S. Occupational Safety and Health Administration (OSHA) requires a planned intervention when oral temperature exceeds 99.7°F / 37.6°C.

Research protocols often restrict the upper limit for core temperature to 102°F / 39°C or 104°F / 40°C. Heat stroke can occur when the core temperature exceeds 104°F / 40°C. However, extreme ultramarathon runners have been observed to sustain core temperatures of 108°F / 42°C.

The core temperature response to heat stress is strongly influenced by an individual's state of acclimatization (adaptation to repeated or sustained environmental exposure), the physical-work demands and the relative humidity of the environment.

The heat stress associated with rising relative humidity increases dramatically at higher air temperatures. Body cooling relies not on sweating but on the evaporation of sweat. Evaporation is inhibited by increasing relative humidity.

The U.S. National Weather Service developed a heat index (apparent temperature) scale in 1990 to account for the effect of relative humidity.

Water immersion represents the highest level of relative humidity. Between the loss of evaporative cooling and the huge heat capacity of water, water temperatures that exceed 97°F / 36°C are not well tolerated, particularly if exercise is required. However, since such high-water temperatures are not commonly experienced by recreational divers, most heat insult will occur during surface activities. Heat illness can be divided into five classic categories for purposes of description and management.

Signs & Symptoms

- **Heat edema:** peripheral edema
- **Heat cramps:** muscle cramps and spasm
- **Heat syncope:** temporary loss of consciousness
- **Heat exhaustion:** headache, nausea/vomiting, low blood pressure, dizziness, fatigue and temporary loss of consciousness; mental function is normal; rectal temperature remains below 104°F / 40°C
- **Heat stroke:** pronounced mental status change, severe headache, nausea/vomiting, loss of consciousness and possible cessation of sweating; rectal temperature exceeds 104°F / 40°C

Management of Heat Illness

Action should be taken to remove the heat stress or remove the individual from the stressful environment when signs or symptoms develop. The greater the magnitude of the insult, the more aggressive the efforts to cool.

- Heat edema is easily resolved with rest and elevation of extremities.
- Heat cramps are managed with ice massage, stretching and oral fluids.
- Heat syncope is managed with a resting, supine position, mild elevation of extremities and vital sign monitoring (blood pressure, heart rate, temperature and respiration).
- Heat exhaustion requires vital sign and core temperature monitoring, oral electrolyte-containing fluids (e.g., Gatorade®), rest and cooling. If the patient becomes dizzy or blood pressure drops with standing, intravenous fluids may be required.
- Heat stroke requires urgent cooling, vital signs and core temperature monitoring, intravenous fluids and rest.

Cooling measures may be as simple as a seat in the shade for minor heat insults through to immersion in ice water for victims of heat stroke. Immediate cooling is critical for serious cases. Even though it is uncomfortable, ice water baths for heat stroke victims are documented as safe and effective. If signs and symptoms do not begin to abate after treatment, or if the individual appears to be getting warmer despite management efforts, medical aid is required.

Prevention

Unacceptably high water temperatures are not a common problem for most divers. The more common stressors are exposure to hot surface conditions, particularly when wearing suits designed to protect the diver from cool or cold water (especially drysuits), and the physical work involved in carrying dive equipment on land. Adequate hydration, a source of shade, and the ability to rest and adjust or remove attire as required are the main preventive measures.

Adequate hydration requires continual attention in hot and, more so, in hot and humid environments. The need is increased for divers who experience the diuretic (urine-producing) effects of tight wetsuits and/or immersion. Urine concentration will be influenced by acute changes in dietary intake, activity and thermal status, but passing clear, colorless urine several times per day is at least consistent with adequate hydration. If urine volume is reduced or the color darkens, divers should drink more water and stimulant-free fluids.

Hypothermia

Hypothermia is a condition of reduced body core temperature, defined as a temperature below 95°F / 35°C. Exposure to cold results in heat loss at a rate dependent on protective clothing, the temperature gradient between skin and the environment, the heat capacity of the environment (much greater for water than air), body composition (lean-versus-fat ratio and body mass-to-surface area), and the presence of wind or water movement.



‘HELP’ position

Water conducts heat 20-27 times faster than air. The cold shock associated with sudden immersion in water colder than 59°F / 15°C (with no thermal protection) can result in an inspiratory gasp response. While primarily observed when the head is above water, this can increase the risk of water inhalation. The stress response will produce extremely rapid breathing and heart rates.

The cold shock response may be accompanied by pain and mental disorientation, possibly leading to fear and panic. Thermal protection by a wetsuit, drysuit or other survival-type suit will dramatically lessen the immediate effects, but heat loss will still occur over time.

Heat production is increased by exercise or shivering, but for individuals with little or no thermal protection, swimming increases the exposed surface area and rate of heat transfer to the water. On average, core temperature can be maintained by swimming activity in water warmer than 75°F / 24°C. The core temperature of unprotected swimmers will generally drop in colder water. An inability to continue swimming (swimming failure) will typically develop more rapidly than expected in cold water.

Persons who are immersed unprotected, but with buoyant support in cold water when there is a chance of rescue, should remain still, holding a position to minimize exposed surface area. Pulling the knees together and up to the chest into the heat-escape-lessening position (“HELP,” or rescue position) provides improved protection of the high heat loss areas of the armpits, groin, anterior chest and thighs.

Hypothermia can also occur in relatively warm or even tropical waters as a result of slow body cooling. This may happen in water as warm as 84°-91°F / 29°-33°C if no thermal protection is worn. The person may not be aware of the slow heat drain for some time. The following are the common signs (observable manifestations) and symptoms (subjective or nonobservable manifestations) of hypothermia.

Signs & Symptoms

MILD HYPOTHERMIA (core temperature 95°-90°F / 35°-32°C)

- Increased heart rate
- Impaired coordination
- Uncomfortably cold
- Impaired ability to concentrate
- Shivering
- Introversion/Inattentiveness
- Decreased motor activity
- Fatigue

MODERATE HYPOTHERMIA (core temperature 90°-82°F / 32°-28°C)

- Increasing muscular incoordination
- Stumbling gait
- Slurred speech
- Confusion
- Amnesia
- Shivering slows or stops
- Weakness
- Drowsiness
- Hallucinations

SEVERE HYPOTHERMIA (core temperature below 82°F / 28°C)

- Inability to follow commands
- Decreased heart rate
- Inability to walk
- Loss of consciousness
- Decreased respirations
- Absence of shivering
- Dilated pupils
- Decreased blood pressure
- Appearance of death
- Muscle rigidity

Management of Hypothermia

Hypothermia may be mild, with little risk to the individual, or it may be severe, with death a possibility. A variety of rewarming strategies can be used, depending on the degree of hypothermic injury, the level of consciousness of the victim, the nature of other injuries and the availability of resources and additional medical aid.

The mildly hypothermic individual will be awake, conversing lucidly, complaining of cold and probably shivering. Assuming no other injuries, a mildly hypothermic victim can be rewarmed with a variety of passive or active techniques with minimal risk of complications.



Recognizing that many options, particularly the more aggressive and invasive techniques, will likely not be available in remote settings, rescuers must do what they can to protect victims from further injury.

Remove wet clothing and replace with dry insulating inner and windproof outer layers, including the head, whenever possible. Shivering will provide effective rewarming. The individual who feels comfortable exercising at this point can increase the rewarming rate. Exercise will transiently increase the afterdrop — a continued decline in core temperature after removal of (or from) the cold stress — but this should not be problematic in most cases of mild hypothermia.

The fully alert and cooperative hypothermic individual can have warm liquids to drink. These deliver negligible amounts of heat, but will help to correct the inevitable dehydration and provide a sense of comfort. Most beverages can be used. Avoid alcohol, as it can compromise awareness and contribute to dehydration and inappropriate vasodilatation. Food will augment the individual's energy reserves, but is not a critical immediate need for the well-nourished victim.

The person with moderate hypothermia will be awake, but may be confused, apathetic or uncooperative and may have difficulty speaking. Moderate hypothermia demands more caution since cardiac dysrhythmias should be expected. Gentle handling and active techniques such as heated blankets, forced-air rewarming and heated and humidified breathing gas are all desirable, if available.

Due to compromised physical coordination and the potential to increase afterdrop, physical exercise is not recommended for persons with moderate hypothermia. Afterdrop can increase the risk of physiological collapse sometimes observed during or shortly after rescue from immersion. Gentle handling, including keeping the victim supine (on the back) with heart and head at similar levels and completely at rest will reduce the risk of collapse. Use the most effective alternatives at hand when rewarming. Take care to insulate the injured person from the ground or surroundings (consider using a wetsuit as an insulated mattress), even if the need is not communicated.

A bath in warm water is another good option for the moderately hypothermic individual. You will need to provide physical support, however, throughout the transfer and immersion. The initial immersion temperature should be lukewarm, definitely not more than 105°F / 41°C, to minimize the sensation of burning that the person will likely experience. After immersion, the water temperature can be progressively increased to no more than 113°F / 45°C.

If hot water is not available, augment insulated clothing with chemical packs or electric pads. To avoid burns, these should never be applied directly to the skin.

The severely hypothermic individual may be unconscious, with a slow heart rate and respiration, or may even appear dead, with no detectable heartbeat. Look very carefully for signs of life, such as breathing, movement, or a pulse in the neck (carotid artery). Assess breathing, and later assess the pulse for a period of at least one minute to confirm respiratory arrest or pulseless cardiac arrest requiring CPR.

Death from cold-water immersion usually results from loss of consciousness and subsequent drowning. If drowning preceded the hypothermia, then successful resuscitation is unlikely. If continued breathing or movement is present, then the heart is beating, even if at a slow rate. Spending sufficient time to check for spontaneous pulse is essential. If there is either breathing or heartbeat, external heart massage (chest compression) is not needed. For the unconscious hypothermic individual, the main goals are to maintain adequate blood pressure and respiration and to prevent further heat loss.

Severe hypothermia leaves the individual susceptible to cardiac arrest. Extremely gentle handling — supine position with head and heart at same level, fully supported, no physical activity — and aggressive and often invasive rewarming strategies are required to save victims. Cardiac arrhythmias may result from severe hypothermia or even from rewarming the severely hypothermic individual. Basic life support takes precedence over efforts to rewarm.

If there are no signs of life, begin CPR and make arrangements for emergency transport to the nearest medical facility.

Rewarming of the severely hypothermic victim is almost impossible to accomplish in the field. Protect against further heat loss. If CPR is required, it should be continued, if possible, until medical assistance is obtained. There have been successful resuscitations after prolonged CPR, in part, because of the protective effect of hypothermia. Although injured persons can appear to be clinically dead because of marked depression of the brain and cardiovascular function, full resuscitation with intact neurological recovery is possible, if unusual.

The outlook is poor in adults who have a core temperature below 82°F / 28°C, have been immersed more than 50 minutes, have life-threatening injuries or are more than four hours from definitive medical care.



In the hypothermic individual, discontinue CPR only if:

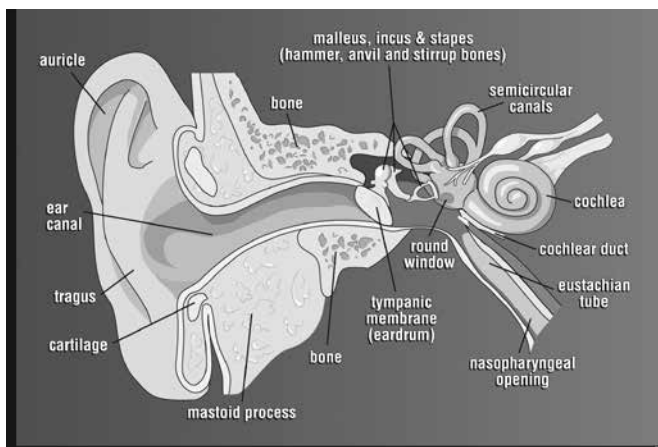
1. The person is successfully resuscitated.
2. Rescuers become too fatigued to continue.
3. The person has completely rewarmed and is still unresponsive to properly applied CPR.
4. A medically trained and qualified individual arrives at the scene, and, after examination, declares the person dead.

In a Cold-Water Immersion Incident

- Determine cause of immersion to reduce risk to the rescue team.
- Handle victim as gently as possible.
- Assess airway, breathing and circulation (be aware of an increased risk of cardiac arrest during handling and removal from the water).
- If CPR required, continue until EMS arrives.
- Give as much oxygen as possible.
- Determine cause for immersion.
- If injury is suspected, support and immobilize neck.
- Arrange transport to a medical facility.
- Prevent further heat loss.
- Rewarm as needed and capacity allows.

Prevention

The prevention of hypothermia requires preparation. The diver must understand the use of protective garments to conserve body heat and control heat loss. Most divers will benefit from wearing thermal protection in water cooler than 80°F / 27°C. Significant thermal stress can be expected in water colder than 75°F / 24°C. Divers should ensure that they have the proper protective equipment and experience to dive safely in cool or cold waters. Unprotected coldwater immersion will produce incapacitation much faster than expected. Readiness and rapid action are required to increase the likelihood for successful outcome for any rescue or self-rescue.



The middle ear is the space behind the eardrum. It is vented to the atmosphere by the auditory (Eustachian) tube, which connects it to the back of the throat. If this tube is blocked, the space behind the eardrum cannot equilibrate with ambient pressure.

If the pressure difference across the eardrum is small, only slight injury (called a squeeze) may result. Symptoms may include a sense of fullness and muffled sound in the affected ear, or there may be frank pain as the eardrum distends.

Large pressure differences can have very serious results — rupture of the eardrum, and/or damage and rupture of a similar smaller membrane covering the round or oval window inside the ear. If an eardrum ruptures, the pain of eardrum distension is typically suddenly relieved. However, if water suddenly enters the middle ear, dizziness and possibly vertigo and severe nausea may result. Fortunately, these symptoms will disappear when the water reaches body temperature, but this means there's a significant ear injury that needs evaluation and care before one can resume diving.

Ear-clearing injuries most commonly occur during descent and can result from going down as little as 6 ft (2 m) with a blocked Eustachian tube or from forceful clearing attempts once the ear is blocked. Injury can be prevented in most cases by applying proper ear-clearing techniques as described in the following pages.

Ear-clearing injuries are rare on ascent because the Eustachian tube normally allows gas to exit safely. Rarely, there is unequal release from the middle ear cavities during ascent, resulting in a relative pressure difference between the ears and unequal stimuli to the vestibular system in the inner ear. This results in a condition called alternobaric vertigo. The diver may experience temporary dizziness and disorientation that clear when the pressure is balanced.



If the diver reaches the surface with unequal pressure between the two middle ear cavities, dizziness and disorientation may persist. There have been instances of increasing pain during ascent, with the eventual perforation of the eardrum and subsequent inner ear damage. In a serious diving injury, dizziness on ascent or shortly after a dive can also be caused by decompression sickness (DCS).

Signs & Symptoms

- Nystagmus (*rapid back-and-forth eye movement*)
- Hearing loss
- Ear pain
- Loss of balance
- Dizziness
- Nausea
- Traumatic eardrum damage with bleeding
- Jaw or neck pain
- Hearing difficulty

Prevention

Cautious, nonforceful, clearing — begun on the surface prior to descending — can help divers avoid injuries. Divers should not use excessive force in attempting to clear the ears. If unable to clear, ascend a few feet until clearing is possible and then resume, making a slower descent, clearing continuously. It is helpful to descend feet-first down a weighted line when possible.

Equalization Techniques

The novice diver should learn equalization techniques from an experienced instructor. There are several recommended techniques, and it is advisable to practice them on land before attempting them in the water. The most common technique is called the Valsalva maneuver and is performed by blocking the nostrils, closing the mouth and bearing down as though attempting to exhale. The pressure in the nose and throat then increases, forcing air up the Eustachian tube into the middle ear. This also equalizes the sinuses.

Use the Frenzel technique by closing the mouth and nose and contracting the muscles of the floor of the mouth. The tongue is elevated and compresses the trapped air, forcing it up the Eustachian tube.

The Edmonds technique is often successful for divers having difficulty with either the Valsalva or Frenzel. Perform this technique by jutting the lower jaw forward so that the lower teeth project well in front of the upper teeth, then completing either the Frenzel or Valsalva maneuver.

Treatment

Serious ear damage should be treated by an ear, nose and throat specialist (ENT specialist or otolaryngologist) in consultation with an experienced diving physician. If serious signs are present, contact a dive medicine

physician or DAN immediately. Place the diver on bed rest, with head elevated and advise against coughing, sneezing, attempting forceful bowel movements or using forceful breath-hold maneuvers.

Otitis Externa

Prolonged or frequent immersion may result in an external ear infection, otitis externa (OE), commonly called swimmer's ear. The disease does not necessarily result from bacterial contamination in the water, but is due to the breakdown of the epithelial cells lining the ear canal as a result of frequent exposure to water. The bacteria normally present in the ear canal gain access to the spaces under the epithelium and multiply.

The first symptom is usually itching or a wet feeling in the affected ear which, if not treated, can progress to painful lymph node inflammation. Once OE develops, the only treatment is to stop diving and use antibiotic eardrops and, in severe cases, oral antibiotics.

Prevention is key. Acetic Acid Otic Solution, USP 2 percent, is effective in providing prophylaxis against OE. These solutions are currently prescription medications. Other preparations are available over the counter (OTC). Ask your doctor about similar products.

These OTC solutions usually consist of 95 percent isopropyl alcohol, with anhydrous glycerine. They have generally not been tested in the diving environment, so how well they work is still under scrutiny.

A bottle of ear-drying solution should be a part of your dive bag. Whatever preparation you choose to use, the trick is in the application. Before your first dive in the morning and after your last dive each night, the *U.S. Navy Diving Manual* recommends this procedure:

1. Tilt the head to one side and fill the external ear canal gently.
2. Leave the solution in the ear canal for a full five minutes.
3. Then tilt the head to the other side, allowing the solution to run out.
4. Repeat this procedure in the other ear.

For the best possible results, time the five-minute treatment. If the solution does not remain in the ear a full five minutes, the effectiveness of the procedure is greatly reduced. Remember, this is a prophylactic procedure that should be started before the ear becomes infected; beginning the treatment after an infection occurs is not effective.

One word of warning: Do not put drops in your ear if you have reason to suspect you have a ruptured eardrum. If you do, it may wash bacteria into the middle ear, where an infection requires antibiotics.

CONDITIONS RELATED TO BREATHING GAS UNDERWATER

Nitrogen Narcosis

The acute effects of nitrogen on the diver have been compared to those of alcohol intoxication. Just as alcohol impairs judgment and coordination, breathing nitrogen in air affects the diver with significant impairment at depths of 100 fsw/30 msw. Everyone is affected whether or not they recognize it, although there is some individual variation.

More important than individual variation is the fact that familiarity with the sensation can be confused with a false sense of not being impaired. The effects often go unrecognized as the diver becomes overconfident. This will be true even of the “experienced” diver who may dive beyond 100 fsw/30 msw seemingly without effect.

While experiencing narcosis, most divers are able to perform routine tasks, but they may not be able to handle an emergency. Nitrogen narcosis may play a major role in many diving accidents. All divers are susceptible to nitrogen narcosis.

Signs & Symptoms

- Inappropriate behavior
- Inattentiveness
- Repeating but not obeying hand signals
- Rigid and inflexible thinking
- Stupor
- Impaired consciousness at depth
- Lack of concern for task and own safety
- Tendency to panic rather than to cope constructively

Prevention

Recreational divers breathing air should avoid depths greater than 130 fsw/40 msw. Air dives deeper than this involve unacceptable risks promoted by nitrogen narcosis.

Treatment

Ascend until symptoms clear (using a controlled ascent). Resolution of symptoms should be immediate.

Oxygen Toxicity

Although oxygen is required for human life, it can have toxic effects when breathed at above-normal pressures. The organs affected are the lung and the central nervous system (CNS). Oxygen toxicity involving the lungs (pulmonary oxygen toxicity) results from long (many hours) exposures usually encountered only during recompression treatments or during long decompression using enriched oxygen breathing mixtures and will not be covered in this book.

Recreational divers can encounter oxygen toxicity involving the brain (CNS oxygen toxicity). The diver using regular scuba equipment at reasonable depths will not encounter this problem, but gas density and heavy exertion can cause carbon dioxide retention that makes divers more sensitive to oxygen. The current maximum oxygen partial pressure recommended for diving is 1.4 ATA or, under more restricted circumstances, to 1.6 ATA.

Air will have an oxygen partial pressure of 1.4 and 1.6 ATA at 188 and 220 fsw (61 and 72 msw), respectively. Divers using modified gas mixtures with concentrations of oxygen higher than air are at risk at much shallower depths.

A 32 percent enriched-air nitrox (EAN, or nitrox) mix will have an oxygen partial pressure of 1.4 and 1.6 ATA at 111 and 132 fsw (36 and 43 msw), respectively. A 36 percent nitrox mix will have an oxygen partial pressure of 1.4 and 1.6 ATA at 95 and 114 fsw (31 and 37 msw), respectively. A diver breathing pure oxygen can have convulsions at depths as shallow as 20 fsw/6 msw.

Signs & Symptoms

- Nausea
- Abnormal vision
- Ringing ears
- Confusion
- Dizziness
- Convulsion
- Facial twitching

Convulsions (or seizures) due to oxygen are not harmful per se, if the diver can be prevented from injury while thrashing about or from drowning if underwater. Minimizing the risk is critical since oxygen convulsion may occur without warning.

Prevention

Avoid deep diving, and do not use breathing gases with oxygen concentrations inappropriately high for the depth. Oxygen partial pressures high enough to cause symptoms are unlikely when diving on air within recommended recreational depth/time limits. Problems are more likely to be encountered when breathing elevated oxygen mixtures (EAN) or when using rebreathers.

A maximum oxygen partial pressure of 1.4 ATA has been recommended for open-circuit scuba using nitrogen-oxygen breathing gas mixtures. For scuba divers who adhere to the 1.4 ATA oxygen limit, an oxygen convulsion is unlikely.



Opening the airway: If the diver is not breathing, begin rescue breathing.

Oxygen partial pressures as high as 1.6 ATA following National Oceanic and Atmospheric Administration (NOAA) depth/time limits have been used by some, but it is usually recommended that these higher partial pressures be reserved for situations in which the diver is largely at rest, such as during decompression stops.

For extended diving exposures using rebreathers, the U.S. Navy has a 1.3 ATA limit oxygen partial pressure. Special training is required before diving nitrox or using rebreathers. This must include methods of minimizing the possibility of oxygen toxicity.

If symptoms occur, reduce the oxygen partial pressure immediately by ascending or switching to a breathing gas with a lower oxygen partial pressure. Do not assume that an oxygen convulsion will not occur until the diver has been on a reduced oxygen level for at least five minutes.

Treatment

Early symptoms should be treated by surfacing if possible. Management of an underwater seizure is difficult, and the victim's life is clearly at risk. Like learning cardiopulmonary resuscitation (CPR), practicing the proper handling of an oxygen convulsion helps you maintain this vital skill.

Once the convulsion subsides, if the mouthpiece is secure (or if the diver is wearing a full-face mask) and the diver is still in the water and breathing, then leave everything in place until you can get the diver out of the water. Once on the surface, if the diver is not breathing, remove the mouthpiece and begin rescue breathing, clearing the airway as required.

While the injured diver is in the water, the main goal is to prevent drowning. After the seizure ends, ensure that the diver's airway is open. Once out of the water, be on the lookout for foreign bodies in the airway. During a convulsion, it is possible to bite off parts of the mouthpiece, which can find their way into the trachea. In these cases the diver will begin coughing upon returning to consciousness, or the diver may try to breathe but not get any air into the lungs. Here you need to institute the standard procedures taught in CPR classes to remove a foreign body.

Carbon Dioxide Toxicity

Carbon dioxide (CO₂) buildup in the diver using conventional scuba gear is caused by increased breathing resistance in the circuit, intentional skip-breathing (consciously decreasing breathing rate in an attempt to conserve gas), overexertion or equipment malfunction (especially the nonreturn valve).

Equipment malfunction is more common in divers using rebreathing equipment employing CO₂ scrubbers. The high gas density of compressed air at depths over 100 ft / 30 m can cause normally adequate regulators to perform poorly, leading to CO₂ buildup. Divers working strenuously at depth are at greater risk for CO₂ buildup.

Signs & Symptoms

- Labored or rapid breathing
- Muscle twitching
- Shortness of breath
- Dizziness, nausea
- Slowed responses
- Headache
- Confusion
- Unconsciousness

Prevention

Avoid the causes of CO₂ buildup and do not skip-breathe. If breathlessness occurs, a diver should stop and rest until breathing is normal. If breathing troubles persist, the diver should surface and rest.

Treatment

Symptoms usually clear quickly after the cause is removed, although a headache may persist for hours. The diver who does not stop and rest during the early symptoms risks unconsciousness at depth. This has no satisfactory management and can lead to embolism or drowning.

Hypoxia

The term hypoxia is used to denote low tissue oxygen levels. Manifestations of hypoxia include rapid heartbeat and breathing, dizziness, euphoria, lightheadedness, confusion, vision impairment, lack of coordination, turning blue (cyanosis), drowsiness, unconsciousness and death.

Reasons for hypoxia include impaired circulation, lung injury (e.g., pneumothorax, water aspiration, cardiorespiratory decompression sickness) or a breathing gas in which the oxygen partial pressure is low.

Symptoms of hypoxia are not usually apparent until the oxygen partial pressure drops to less than 0.15 ATA, or at the surface, 15 percent oxygen. Altitude hypoxia is caused when the oxygen partial pressure is reduced due to low ambient pressure. Hypoxia is the most common cause of rebreather fatalities, due to equipment malfunction or operator error. Hypoxia is treated by administering a breathing gas containing a high percentage of oxygen.



Contaminated Gas Supply

Contaminants can be introduced to a compressed gas supply by inadequate filtration or faulty operation of compressor systems. Breathing gas must meet exceptionally high quality standards for use underwater. The concentration of gas breathed under pressure means that any contaminants are also concentrated. Carbon monoxide (CO), for example, can pose a serious risk to divers. Both odorless and tasteless, CO cannot be immediately perceived. It binds to hemoglobin that would normally carry oxygen, but with a much greater affinity (200 to 250 times greater than oxygen). Once CO is bound, the ability to transport oxygen is restricted for long periods of time. Since the effect is persistent, a small amount in a breathing gas has great impact when it is concentrated under pressure.

Additional contaminants, including carbon dioxide, oil and other volatiles can also pose significant risk. Only some may be perceived during pre-dive checks.

Signs & Symptoms

- Taste or odor to breathing gas
- Headache
- Dizziness
- Nausea
- Hyperventilation or air hunger
- Impaired concentration

Prevention

Breathing gas supplies should be secured from reputable sources. Unusual odor or taste noted during pre-dive checks should prompt replacement of the supply.

Treatment

Discontinue use of problem gas immediately, surface and take fresh air and oxygen, if available. If any symptoms or discomfort persist, medical evaluation is required. CO poisoning is most effectively treated by hyperbaric oxygen therapy. Surface oxygen also clears CO from hemoglobin, but at a much slower rate.

LUNG OVERPRESSURE PROBLEMS

Overinflation of the lungs is a common cause of a number of disorders. A local pressure buildup in part of the lung may damage it and allow air to escape into the circulatory system, leading to air embolism.

Air can also escape from the lung into nearby tissues and cause three other disorders:

- Pneumothorax
- Mediastinal emphysema
- Subcutaneous emphysema

These disorders can occur separately or with an air embolism, depending upon the exact nature of the lung injury. The occurrence of any of these disorders means that the lung has been injured, and an air embolism should be suspected.



After a lung overpressure incident divers should not resume diving without consulting a physician knowledgeable in dive medicine.

Pneumothorax

The lungs are not attached directly to the chest wall, but are kept expanded in the chest cavity by negative pressure between the lung and the chest wall. If lung damage allows air to enter the chest cavity and alters the negative pressure that normally keeps the lung expanded, lung collapse can occur.

Signs & Symptoms

- Rapid shallow breathing
- Shortness of breath
- Blue skin, lips, fingernails (cyanosis)
- Pain in chest

Prevention

Breathe normally and ascend slowly.

Treatment

A person with a pneumothorax does not need recompression but does require medical treatment. A physician may need to insert a chest tube, withdraw air from the chest cavity and allow the lung to reinflate. If the pneumothorax is small, breathing 100 percent oxygen may hasten resorption of gas, without the need for a chest tube. A chest tube may be required regardless of the size of the pneumothorax if recompression therapy is required for other reasons — such as decompression illness. Not usually life-threatening (unless it is a tension pneumothorax), this condition does require immediate care at a hospital. The injured person should make no further dives until an evaluation has been conducted by a physician familiar with diving medicine.



Pneumothorax, mediastinal emphysema and subcutaneous emphysema can occur separately or with an air embolism.

Mediastinal Emphysema

Air may escape from a damaged lung into the space between the lungs (mediastinum) which contains the heart and various large blood vessels. This space extends from the diaphragm to the neck.

Signs & Symptoms

- Pain in chest, usually under the breastbone (sternum)
- Shortness of breath
- Faintness
- Difficulty in breathing
- Change in voice

Prevention

Breathe normally and ascend slowly.

Treatment

A physician should examine the diver for other signs of a lung over-pressure accident and observe for 24 hours. Mediastinal emphysema can be hard to see on a plain X-ray. A CT scan may be helpful if available. Unless air embolism or decompression sickness is also present, recompression of the diver is usually not required. Breathing 100 percent oxygen at the surface will hasten resorption of the trapped gas.

Subcutaneous Emphysema

Air escaping from a lung may also be trapped under the skin, usually around the neck.

Signs & Symptoms

- Swelling at base of neck/feeling of fullness
- Change in voice
- Difficulty swallowing
- Crackling sensation when skin is pressed

Prevention

Breathe normally and ascend slowly.

Treatment

This is usually not an emergency. The diver should be examined by a physician and observed for other problems, especially for air embolism. Breathing 100 percent oxygen at the surface will hasten resorption of the trapped gas.

The injured person should make no further dives until an evaluation has been conducted by a physician familiar with diving medicine.

MOTION SICKNESS



A common complaint of divers who spend time on a dive boat traveling to dive sites, motion sickness has affected nearly everyone at least once. The most distressing symptom of nausea is caused by overstimulation of the vestibular balance organs and/or a mismatch between the sensory input of the eyes and the vestibular or inner ear. Closing the eyes or sitting where the rocking motion of the boat is clearly visible helps to prevent the problem. Gazing at the horizon, rather than concentrating on the immediate vicinity, is also useful. Staying away from areas with strong fumes, particularly fuel, is a good idea, too.

Motion sickness itself is not a serious medical problem, but it may set the scene for more serious incidents. Affected individuals can develop an almost desperate inattentiveness. The desire to get into the water quickly to reduce motion sickness can affect the care taken in setting up equipment or attending to a buddy.

Once underwater, vomiting can be a real problem if a diver fouls his or her second stage and/or inhales water. It is not true that vomiting underwater is obligatorily followed by an uncontrollable reflex inhalation, but coughing or choking can occur. Removing a regulator to vomit underwater keeps the regulator from being fouled but must be done carefully. Divers should think carefully before deciding to start a dive when seriously affected.

Mild nausea from motion sickness must also be differentiated from the symptoms, dizziness and nausea; they may signal a more serious injury. This can be difficult at times, as motion sickness can often recur and persist after the diver returns to land.

Signs & Symptoms

- Sweating
- Pallor (paleness)
- Vomiting
- Nausea
- General ill feeling
- Mild headache

Treatment

Persistent or unusually severe nausea needs to be evaluated by a physician, especially if other symptoms are also present. Drugs to treat motion sickness are available, but should be used with caution during diving as most of these drugs cause mild drowsiness and a decrease in mucous secretions. Since both effectiveness and the level of side effects vary between individuals, no single drug is specifically recommended.

Transderm Scopamine® has been evaluated by the U.S. Navy and has shown to have minimal adverse effects in divers. The Transderm Scop® patch is a prescription medication that contains 1.5 mg of scopolamine.



When it is placed on the skin, the patch will deliver the drug at a constant rate for three days. After that period, the patch should be removed. If you are still in an environment where motion sickness will be a problem, you can use another. Never wear more than one patch at a time, even if you think one is exhausted. There is a risk of too much of the medication entering the bloodstream, causing undesirable side effects.

While on a dive trip, place the patch at least an hour before boarding the boat. Scrub the area behind the ear with an alcohol swab and dry well. Once the patch is placed, it can be left there continuously for three days, even when diving. If the patch falls off or is removed, discard it. If motion sickness is still likely to be a problem, place a new patch immediately. Before placing a new patch, remove the old one. When the patch foil wrapper is opened, do not touch the patch under the peel skin. If some of the medication gets on your finger and you touch your eye, the drug will be then absorbed rapidly.

Motion Sickness

Side effects may occur, including dry mouth, drowsiness and blurred vision. Less frequently, disorientation, memory disturbances, dizziness and restlessness may occur. Scopolamine should be used with caution in patients with narrow-angle glaucoma, with pyloric obstruction or urinary bladder neck obstruction (e.g., due to prostate enlargement).

Rare side effects include hallucinations, confusion, difficulty urinating, skin rashes and eye pain. These side effects depend on each individual; there is no way to know in advance who will be affected. Thus, before using it to prevent motion sickness, wear the patch on dry land for at least 24 hours to test its effects. Do not consume alcohol while wearing the patch.

If side effects occur, remove the patch. If the patch is worn for more than three days, withdrawal symptoms can occur when it is removed; these symptoms, which generally do not occur until 24 hours after removal, include dizziness, nausea, vomiting, headache and disturbances of equilibrium. These symptoms are also associated with decompression sickness, and they can complicate diagnosis if the patch is removed right after making a deep dive. If you have these symptoms and you wore the patch at any time, tell the examining physician.

Note: Mild motion sickness is often relieved once underwater, but one experiencing severe nausea should exercise caution. In that situation, canceling the dive would be a wise decision.

DIABETES AND RECREATIONAL DIVING



Insulin-requiring diabetes mellitus (IRDM) has traditionally been considered an absolute contraindication to diving. Persons with IRDM who chose to dive despite medical recommendations to the contrary generally did so by hiding their condition. However, in recent years, there has been a growing shift away from the blanket prohibition position due to antidiscrimination laws and the growing record of diving safely by individuals with diabetes. Those with IRDM can now receive training and dive in several countries.

An international workshop in 2005, jointly sponsored by the Undersea and Hyperbaric Medical Society (UHMS) and DAN, reached agreement that dive candidates who use either dietary control or medication (oral hypoglycemic agents [OHA] and / or insulin) to treat diabetes but who are otherwise qualified to dive may undertake recreational scuba diving, provided they meet certain criteria. This has been ratified by the Recreational Scuba Training Council (RSTC) in the United States.

The criteria are detailed in the full-consensus guidelines. These guidelines consist of 19 points that are divided into three sections:

- selection and surveillance
- scope of diving
- glucose management on the day of diving

Read a single-page summary of the guidelines on the DAN website. The workshop discussions and complete text of the guidelines appear in the published proceedings.*

The guidelines contain practical recommendations for rescue medications and procedures in case a diver develops hypoglycemic problems underwater. Individuals with diabetes, their buddies and dive leaders should all be aware of the status of the diver or divers, signs and symptoms of hypoglycemia and procedures required in case of a problem.

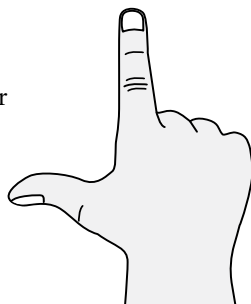
The diver with diabetes is generally very sensitive to manifestations of hypoglycemia. There are typically early warning signs and symptoms (headache, altered mood and fatigue) and mild to moderate reactions (tremors, accelerating heart rate, neck pain, irritability and extreme fatigue) that will prompt the individual to take corrective action or request assistance. In the remote chance that the problem is not addressed in a timely manner, severe signs that could be observed underwater include decreased awareness or unresponsiveness, unconsciousness or convulsions.

* Pollock NW, Ugucioni DM, Dear GdeL, eds. Diabetes and recreational diving: guidelines for the future. Proceedings of the UHMS/DAN 2005 June 19 Workshop. Durham, NC: Divers Alert Network; 2005.



The suspicion of hypoglycemia can be easily communicated underwater with an “L” signal (for “low”) formed with the extended upright index finger and extended thumb of either hand.

The diver can signal with either hand as a question or as a statement. Before the dive, discuss the signal, its significance and action plans.



Rescue medications include oral glucose carried by the diver and buddy during all dives and parenteral glucagon available at the surface. Parenteral glucagon is an injectable agent that stimulates the liver to release glucose into the bloodstream to counter severe hypoglycemia reactions. If hypoglycemia is noticed underwater, the diver should surface with his or her buddy, establish positive buoyancy, ingest glucose and leave the water.

INJURY & OTHER MEDICAL EMERGENCIES

Emergencies

Dive trips are no different from other travel, and not all emergencies will be dive-related. Trauma, injuries, heart attacks and strokes can and do occur, and their treatments generally do not differ from what would normally be applied.

Knowledge of first aid and being able to rapidly contact trained medical personnel are the mainstays of treatment. Evaluation of the airway and initiating CPR, where required, are almost always the first steps in treating emergencies.

Oxygen is usually a part of the first aid for most of these types of conditions; plus, oxygen delivery is covered in Section IV.

Some diving injuries will, however, require a treatment not usually found at most medical facilities, namely recompression.

For this reason, it is crucial that the need for recompression be assessed in all emergencies involving divers; this is covered fully in Section III. Prompt recompression is likely to be most effective.

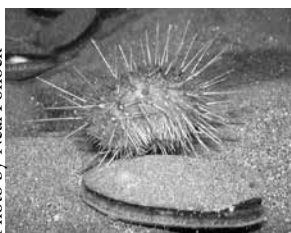


MARINE ANIMAL INJURY

Introduction



Photo by Neal Pollock



This section describes the initial first aid measures for the management of injury due to an encounter with a marine animal. These measures use ordinary first aid supplies and mostly do not involve the use of prescription drugs or procedures best left to medical professionals.

The sea is filled with creatures that may appear harmless, although some are capable of wounding, poisoning or even killing an unlucky diver. Despite the extreme rarity of serious incidents, the shark is the most well known of marine perils. Far more common are the animals with both defensive and offensive weapons potent enough to cause human injury. The best protection against most injuries is a healthy respect for these animals. When in doubt, keep your distance.

Most marine animal injuries are the result of a chance encounter (such as swimming into a jellyfish) or a defensive maneuver by the animal (a stingray wound, for example). Injury is rarely due to an aggressive action on the animal's part. Marine animals are generally harmless unless deliberately or accidentally threatened or disturbed. The wounds that result, however, share many common characteristics, although they differ in type and severity. These wounds are nearly always contaminated with bacteria, frequently with foreign bodies and occasionally with venom.

Many publications are available to divers to help in identification of marine life. A diver's ability to recognize and identify the commonly encountered animals at a dive site adds to the pleasure of the dive and helps to avoid those animals capable of harm. There are several excellent publications that cover in detail the identification of marine life hazardous to the diver and the management of injury that may follow an encounter.

Following are useful references:

- Auerbach, P.S., *A Medical Guide to Hazardous Marine Life*. 4th edition, Best Publishing Co., 2006.
- Auerbach, P.S. *Medicine for the Outdoors*. 3rd edition, Lyons Press, 1999.
- Auerbach, P.S., editor. *Wilderness Medicine: Management of Wilderness and Environmental Emergencies*. St. Louis, 4th edition, Mosby, 2001.
- Edmonds, C. *Dangerous Marine Creatures*. Best Publishing Co., 1995.
- Bove and Davis. *Diving Medicine*. 4th edition, W.B. Saunders Co., 2004. (Chapter 22; "Marine Animal Injuries," pp. 293-315, Edmonds, Carl, M.D.).
- Cunningham, Patricia, and Goetz, P.E. *Guide to Venomous and Toxic Marine Life of the World*. Pisces Books, 1996.



Divers concerned about injury may lessen the opportunity for an adverse encounter by showing respect for the undersea environment and knowing the damage that humans can do — and have done — to living marine organisms. Most divers are now aware of these problems and are careful in their personal diving techniques to respect the sea and its living creatures. “Look, but don’t touch,” is the most conservative approach.

In the event of injury, identification of the animal responsible for the injury is helpful. However, symptoms may not appear for hours after the contact, or the animal may not have been seen or recognized at the time of injury. Treatment, then, is frequently based on the presentation of the injury with limited information as to the cause. Careful examination of the characteristics of the wound may indicate the most likely source.

Wounds

Wounds or soft-tissue injuries may be classified as closed or open. A closed wound (contusion) results from blunt trauma to the skin, which produces injuries to the soft tissues beneath the skin surface. Such wounds can be caused by mask squeeze, falls, pinching injuries or the bites of marine animals without well-developed teeth. Stingrays, when hand-fed, frequently produce contusions (which look like world-class “hickies”) when they inadvertently sample the diver’s arms or legs. However, they are also capable of biting with sufficient force to amputate a fingertip.

Another closed wound is the contact injury resulting from touching an animal capable of releasing a venom, but not capable of deeply penetrating the skin surface (e.g., beyond the epidermis) with its delivery apparatus. Examples are sponges, coelenterates and certain segmented worms.

An open wound is the result of an injury that penetrates the skin surface. It may or may not be accompanied by injury to tissues beneath the skin. Open wounds can be subdivided by the characteristics of the injury.

Lacerations, avulsions and amputations are produced by a sharp instrument such as a fish bite, coral edge or shell. Avulsion occurs when a flap of skin or body part is torn loose partially or is completely amputated.

Abrasions are superficial wounds that occur when the skin is rubbed or scraped over a rough surface so that part of the outer skin layer (the epidermis) is lost. Deeper abrasions may involve the dermis. Abrasions may ooze blood and tissue fluid, and are often covered with debris.

Puncture wounds are stabs from a sharp object such as a tooth, fang, a fish or sea urchin’s spine, or a cone shell’s radicular tooth (“dart”).

Envenomation

Many marine animal injuries are complicated by a venom delivered by the animal either by injection via a spine or fang or contact with some part of the animal. The coelenterates, for example, possess stinging cells (nematocysts) capable of penetrating the human skin for a short distance

and delivering venom. Each nematocyst contains a tiny amount of venom, but following an encounter with a large animal, the total number of nematocysts delivered may be several million. Other examples of venomous marine animals are discussed in these pages.

FIRST AID TREATMENT — GENERAL

For any marine animal injury, there are general principles of treatment, determined by the type of injury and the responsible animal. You will find important first aid information here for managing the injury until medical assistance is available.

NOTE: Infection, which can be severe, can occur from any marine injury in which the skin is punctured. If the area becomes painful, red or swollen in the days after the injury, seek medical attention.

Contusions

A small contusion does not require treatment, although the temporary application of an ice pack and gentle compression may minimize swelling and bleeding. A large contusion may result in extensive bleeding beneath the skin, with significant swelling. Apply pressure and ice packs to a large contusion and, if possible, elevate the injured part above heart level. Apply a splint to an injured extremity to prevent motion to decrease bleeding, swelling, and pain. Any time that a compression wrap or splint is applied, be certain that the circulation to the body part beyond the wrap or splint remains intact, as determined by the presence of normal sensation and tissue color.

Abrasions

Abrasions must be cleaned of debris that may be embedded. This is optimally accomplished with adequate supplies of a germicidal soap and clean, preferably disinfected, water. This procedure should be done as soon as possible, after which you should cover the wound lightly with antiseptic ointment underneath a sterile, and preferably nonadherent, dressing.

Puncture Wounds

Puncture wounds may not produce significant external bleeding. However, there can be internal bleeding not visible from outside the body. Occasionally an impaled object remains in a puncture wound. Large impaled objects should not be removed but left in place, stabilized by a bulky dressing. Smaller objects such as sea urchin spines should also be left alone until adequate equipment and facilities are available for removal. If a spine is small and easily extracted from a hand, arm, foot, or leg, this may be done so long as the rescuer is confident that it has not penetrated a blood vessel. Be prepared to apply pressure directly to the wound if there is more than very minor bleeding.

II Lacerations, Avulsions, Amputations

These wounds require immediate control of bleeding prior to any other measure. Bleeding is best controlled by direct pressure upon the injury and elevation of the injured part above heart level, if possible.



Steady, direct pressure at the site and elevation are the most effective means to control bleeding.

Although it happens rarely, direct pressure can at times be insufficient, and pressure must be applied to an artery at an accessible point (closer to the heart) on the arm or leg. Tourniquets are not recommended. There are several potential hazards with a tourniquet. It is a last resort when using it is the only way to save the injured person's life at the risk of sacrificing a limb. If a tourniquet must be applied, tighten it until bleeding stops, and do not release it until proper medical care is available. If transport will be prolonged, it is acceptable to loosen the tourniquet briefly for a moment after it has been in place for 20 to 30 minutes, to see if pressure alone — without the tourniquet — will control the bleeding. If brisk, uncontrolled bleeding occurs, be prepared to rapidly apply the tourniquet again.

After the bleeding is controlled, irrigate the wound with sterile water or clean (preferably, disinfected) tap water to remove loose debris.

Follow these guidelines in wound care:

- **Do not** attempt to pick out embedded foreign matter. Cover the wound with a dry, sterile dressing.
- If there are amputated parts, these should be preserved loosely wrapped in a saline-moistened gauze and kept in a cool container.
 - **Do not** warm an amputated part.
 - **Do not** place it in water or directly on ice; **do not** cool it with dry ice or do not allow the part to freeze. Simply wrap it in a moist dressing until it can be delivered to the medical treatment facility.

Envenomation

Most of the symptoms following envenomation are due to the poisonous nature of the venom itself. However, an allergic reaction to a venom may occur, particularly if the individual has had a previous exposure to the same or a similar venom. Occasionally, an allergic reaction occurs in an individual not known to be allergic to the specific venom. Rarely, a very severe, true allergic reaction, termed anaphylaxis, occurs. This is a life-threatening situation — the victim is very short of breath due to swelling in the mouth and throat, and constriction of the lung airways, and has a rapid pulse and low blood pressure. This type of episode usually develops within minutes after the injury, but — rarely — can be delayed for several hours.

Anaphylaxis is an emergency

that requires immediate medical care. Individuals who know themselves to be at risk for this type of reaction frequently carry epinephrine (e.g., EpiPen® or other auto injectors) in a prepared kit for self-injection. If epinephrine is available, rescuers should help in administering it to the injured person, following the package directions.



The pressure bandage helps prevent or delay venom absorption and reduce its clinical effect.

Minimize the toxic effects of the venom by prompt treatment. This requires rapid removal of any remaining venom, neutralizing the effect of the venom that cannot be removed, and relieving pain and other symptoms produced by the venom.

Pressure Bandages

Australian authorities advise the application of a pressure (or “pressure-immobilization”) bandage applied to extremities that have sustained by stings from sea snakes, the blue-ringed octopus and cone shells. The pressure bandage appears to prevent or delay venom absorption and reduce its clinical effect. For maximum effectiveness, the pressure bandage must be combined with immobilization of the extremity.

In the event of envenomation, place a gauze pad over the wound and wrap the extremity from the tips of the fingers or toes. Use a broad bandage applied tightly as if treating a sprained ankle, but not tight enough to stop circulation. The bandage should cover the entire extremity and be followed by application of a splint for immobilization. The bandage should remain in place until medical care is available. Leave finger or toe tips exposed so that you can see skin and nail color. If the skin or nail beds turn blue or numbness and tingling or loss of feeling occur, the bandage is too tight.

Application of Heat

Because many venoms appear to be sensitive to heat, you may help alleviate pain by applying a hot pack (approximately 113°F / 45°C) or take a hot shower for 30-90 minutes or until pain is relieved. Avoid excessive heat, because it can burn the skin. Always test the heat on an uninjured body part to be certain that it is not scalding. Heat is effective in treating injuries from most spiny creatures, such as echinoderms (e.g., starfish, sea urchins), as well as stings from spined fish (e.g., lionfish, scorpionfish, stonefish), and stingrays.

Application of seawater to a jellyfish sting to rinse away tentacles and nematocysts usually does not worsen it, because application of seawater does not per se stimulate the discharge of nematocysts, which may be released by the application of freshwater, because of its lower salt content.

It has recently been suggested that heat is useful to ease the pain for the stings of certain jellyfish, namely, the Australian man of war jellyfish sting,



by mechanism(s) unknown. Hot fresh water is still lower in salt content, so one should be extremely cautious in following this recommendation. It should not be assumed that it is appropriate to generalize this observation to other jellyfish, because it has not been observed or proven, and application of hot (hypotonic, fresh) water might make things worse.

Some lifeguards claim that putting a person under a fresh water shower is helpful for a jellyfish sting. Since hypotonic water usually worsens a sting, the only reason that this might work is because the force of the spray from the shower might supercede the deleterious effect of the hypotonic water. Again, one must be very cautious in using this method.

The application of cold packs (presumably dry, not moist) to jellyfish stings has been recommended as a therapy. Cold hypotonic water is hypotonic first and cold second, so application of ice water or crushed ice directly to the skin could worsen the situation, perhaps dramatically.

Application of a pressure immobilization dressing is not indicated, and may be harmful, for a jellyfish sting.

Contact Wounds

Contact injury most commonly results from an encounter with sponges, coelenterates or a segmented worm, although there are other animals that can produce contact injury.

Sponges

There are about 12 toxic species of sponges that are the source of a poorly understood toxin that may cause a contact dermatitis. Frequently, the diver is unaware of the contact until symptoms develop later, with the appearance of an itching rash. This type of injury is uncomfortable, but not life-threatening. Within the first few hours, the application of vinegar for 30 to 45 minutes to the area of contact may be helpful.

Coelenterates / Cnidaria

This phylum includes thousands of species of aquatic invertebrates and is responsible for more envenomations than any other marine phyla. Close to 9,000 species of coelenterates are known, of which at least 100 are capable of injury to humans. A common factor among animals in this phylum, which include Portuguese man-of-war, fire coral, box jellyfish, true jellyfish and sea anemones, is the presence of nematocysts (stinging capsules).

Of several types of nematocysts, those of the penetrating type usually cause injury. They are needlelike, up to 0.02 inches / 0.5 mm long and discharge venom. The triggering mechanism is initiated by many factors, including physical contact, stimulation by fresh water, or by a chemically mediated mechanism. The identity of the animal frequently can be determined by examination of the nematocysts under a microscope.

The pattern of the coelenterate sting is characteristic for each animal and depends on the morphology of the tentacle and the aggregation of nematocysts.

The sting of the Portuguese man-of-war (*Physalia physalis*) demonstrates single long stripes with blisters. The box jellyfish (*Chironex fleckeri*) pattern consists of multiple long and relatively broad red lines with adherent tentacles in a cross-hatched pattern. The nonmobile species (fire coral, sea anemones and hydroids) produce a pattern related to how they were touched.

Sometimes the injured diver develops symptoms immediately after contact and can even identify the responsible animal. Jellyfish and the Portuguese man-of-war are not always easy to locate in the water, but the pattern of the injury and tentacles remaining on the skin can lead to identification. The Portuguese man-of-war is the most common coelenterate causing serious injury in swimmers and divers.



Portuguese man-of-war

The Portuguese man-of-war is distributed by tides and currents over the surface of the oceans. The specialized fishing tentacles may stretch out 50 feet / 15 meters from the floating sail and are dangerous. They are difficult to see, even in clear water, and may become detached from the main body of the animal in rough seas. Contact with a single tentacle may cause the release of hundreds of thousands of nematocysts, each bearing venom. Frequently, many tentacles and millions of nematocysts are involved in producing injury.

The jellyfish of the Cubozoa class, including the box jellyfish (also known as the sea wasp), contain several individual species that are the most venomous marine animals known and capable of causing major human injury. The most venomous species of the Cubozoa class are restricted to the warm waters of the Indo-Pacific region. The animals are pale in color, transparent and almost invisible. They are able to swim at speeds of 1 knot with — or even against — currents.

Fatalities have occurred in the waters of northern Australia and the Philippines. The Gulf Coast sea wasp (*Chiropsalmus quadrumanus*, a different species than the one found in the Pacific) of the United States is not as toxic, but is dangerous and is known to have caused a fatality. This creature has a body which is boxlike and about 8 inches / 20 cm long. There are 15 tentacles per pedalia (corner appendage attached to the body), and each tentacle is about 10 ft / 3 m in length.

Bristle Worms

Bristle worms are segmented worms found at depths accessible to divers as well as elsewhere in the oceans. The appendages on each segment of the worm are tipped with bristles, which are a form of armament. These detach easily on contact with the skin, producing pain for several hours. The larger worms can also cause injury by biting.

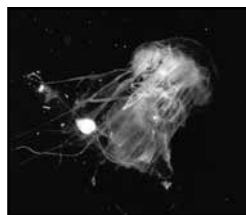
General Effects

Sponges

An itching rash may develop within a few hours after contact with a sponge and is similar to the rash of contact with other mildly toxic marine animals. It is safe to assume that a diver who has handled a sponge and develops a rash on the hands has been exposed to a toxic species. The reactions are usually mild and subside in a few days with little or no treatment, but they can become quite severe, with pain and blistering.

Coelenterates

The reaction to coelenterate envenomation may range from mild stinging from fire coral, lasting only minutes, all the way to death, which can occur within six to seven minutes of contact with a box jellyfish. If the animal was not identified at the time of contact, the geographic location of the dive, the character of the wound and the systemic reaction may identify the culprit. Coelenterate venoms are complex mixtures of proteins and carbohydrates and share common characteristics as well as species-specific effects. Allergic reactions are possible, and may be severe or life threatening.



Box jellyfish *

Reactions to the venoms from hydroids, sea anemones and coral are usually mild, self-limited and require little, if any, treatment. But a few sea anemones are capable of producing a severe, even fatal, injury.

The larvae of the thimble jellyfish (e.g., *Linuche unguiculata*), among others, produce an itchy, red rash with blisters or bumps generally on skin areas covered by bathing suits. Erroneously believed caused by “sea lice,” this is known as “sea bather’s eruption.”

The severe reactions to marine animal injuries, some possibly life-threatening, are usually the result of envenomation by Portuguese man-of-war or a member of the Cubozoa class. If the injured diver is in Indo-Pacific waters, it is important to identify the animal, if possible, because of the availability of an antivenom to the Australian box jellyfish (*Chironex fleckeri*). The local effects of *C. fleckeri* envenomation are multiple, interlacing whiplash lines with a “frosted,” “beaded” or “ladder” pattern and transverse wheals (welts). After seven to 10 days there is necrosis (local tissue death) and ulceration. The skin lesions require months to heal. The clinical

* Photo courtesy OAR/National Undersea Research Program (NURP); University of Connecticut

features are excruciating pain, followed by confusion, unconsciousness and, rarely, death due to respiratory failure. If death occurs, it is usually in the first 10 minutes, and survival is likely if death does not occur during the first hour after injury. The cardiovascular effects include an initial rise in blood pressure followed by hypotensive / hypertensive oscillations, shock, muscle spasm, and muscular and breathing paralysis.

Clinical features of the other Cubozoa and the Physalia injuries are similar and range from mild itching to a severe systemic reaction, where intensity increases with time. The skin shows an injury pattern consistent with the tentacle contact, with an immediate stinging sensation with a rapid increase in pain and accompanied by numbness and tingling.

The major risk after contact is drowning if the individual, due to the pain and confusion, is unable to maintain buoyancy in the water. Within a few hours, contact points show blistering, swelling and discoloration, followed during the next days by skin ulcers and possible secondary infection.

Bristle Worms

The bristle worm contact produces an immediate reaction: a sensation of burning, followed by a red rash that itches intensely and has local swelling.

Prevention

Over-the-counter preparations such as Safe Sea® jellyfish-safe protective lotion, may help in preventing stings from sea life. Available from local scuba retailers, the lotion, in a preparation with or without sunscreen, prevents stings from jellyfish, sea nettles, stinging coral and sea anemones, according to its manufacturer. It is applied before entering the water. The length of time an application lasts in the water may vary depending upon water conditions.

FIRST AID TREATMENT — CONTACT INJURY

Sponges

Following known contact with a sponge that has produced symptoms, the skin should be gently dried and foreign material such as spicules (minute, spiky bodies that support sponge tissue) removed with adhesive tape. Follow that with a vinegar soak that can be repeated several times a day. After initial treatment, a moisturizing lotion or mild over-the-counter steroid cream can help in relieving symptoms during the period required for healing. If the reaction is severe, potent topical or systemic steroids may be prescribed by a physician.

Coelenterates

The first step in managing a severe coelenterate injury is to prevent drowning and use resuscitative measures if needed. Anticipate an allergic reaction and treat appropriately.

After the diver has been rescued, the tentacles must be removed from the skin without triggering the release of more nematocysts. Use gloves (“double glove” if possible if wearing thin surgical gloves) to handle the tentacles, and irrigate the area with large amounts of sea water. Freshwater irrigation may cause the nematocysts to discharge, causing more pain to the injured diver. Researchers in Australia have suggested that applying topical isopropyl (“rubbing”) alcohol may cause nematocysts to discharge, but many observers note that it is an effective field treatment that improves, rather than worsens, the situation.

For stings from box jellyfish, apply a dilute vinegar solution (3 to 5 percent acetic acid) to disable the stinging capsules. Do not rub the area or apply the pressure-immobilization technique. Prompt medical attention is needed, so that antivenom can be administered if it is necessary and available.

If the injury occurs in the Indo-Pacific area, identification of the animal is important. As noted on the previous page, there is an antivenom available for the box jellyfish (Commonwealth Serum Laboratory, Australia — CSL Limited: www.CSL.com.au). Trained lifesavers have administered this product successfully nearly a hundred times in the field.

Bristle Worms

Remove visible bristles with tweezers or forceps, followed by an application of adhesive tape to the dry skin to remove the remaining bristles. Flushing the area afterwards with dilute vinegar, ammonia or isopropyl alcohol may be beneficial.

Puncture Wounds

Spines

Puncture wounds are frequently due to an encounter with an animal equipped with a spine. Adapted by animals for various purposes, spines are generally used for protection, although animals frequently use specialized spines for tasks like locomotion and gathering prey. Spines may be concealed or highlighted, slashing or penetrating and venomous or non-venomous. Some are fragile and needlelike, while others are large and strong, with recurved teeth.

Animals in several phyla possess spines that are alike in the principle of operation, but that differ in location, size, potency of venom and degree of hazard to the diver. Both invertebrate and vertebrate animals have spines, and an examination of the characteristics and functions of spines found in each group is useful.

Echinoderms

Sea urchins and sea stars are members of the 6,000 species of echinoderms, approximately 80 of which are venomous to man. They are worldwide in distribution. Sea urchins are nocturnal animals that seek shelter during daylight in coral reefs and niches. Starfish are active during daylight hours, although they are commonly seen during night dives.

Echinoderms, which are radially symmetrical animals, usually have five arms or radii and a more or less rigid skeleton embedded in the body wall.

There are two known venomous starfish: the *Acanthaster planci* (crown of thorns), found in the Indo-Pacific and Red Sea, and *Acanthaster elissi*, found in the eastern Pacific. The outer surface of the body of both is covered by large, sharp spines, calcareous structures that may break off upon penetration and are then difficult to remove from the wound. Glands in the animal's skin produce a venom which causes a severe inflammatory response consisting of redness and swelling; it is associated with severe pain, vomiting, numbness and, rarely, paralysis.

There are many hazardous sea urchin species; all produce similar symptoms. Sea urchins are equipped with spines that vary greatly among species: In some, they are long, hollow, slender and needle sharp. The sharpness permits them to penetrate easily and then break because of their brittleness. Many spines contain a calcium carbonate core and cause injury by mechanical skin penetration. The embedded spine is frequently visible, or in some cases it may have withdrawn and left behind pigment, producing a characteristic "tattooing" at the site.

Penetration by the spine can result in an immediate burning sensation, followed quickly by redness, swelling and aching. The wound is complicated by deposition of calcareous foreign bodies and a reaction to toxic venom. More serious symptoms of numbness and paralysis have been reported, and infection is common.

The spines are of three types: straight hollow, straight solid and pedicellariae used for grasping. The pedicellariae have a three-pronged "fang" at the end that surrounds a venom gland. The pedicellariae seize any organic material they encounter and inject the venom.

The sea urchins with pedicellariae capable of delivering the most potent stings belong to the Toxopneustidae family. Found in the Indo-Pacific region, they possess short, thick spines and deliver a venom.

II First Aid Treatment — Echinoderms

Spine fragments must be removed to prevent a granulomatous (infected, chronically inflamed) reaction from occurring many months later. Remove long spines along their vertical axis, using care not to break them. Do not break up the spines under the skin to leave them in place; they may not be absorbed. A local anesthetic can be infiltrated by qualified medical people to relieve pain. A bath of hot water for 30 to 60 minutes or more sometimes relieves pain. No other field remedy has a verifiable benefit.

Stingrays (Order Rajiformes)

Stingray injuries are fairly common in most warm and tropical U.S. waters. These injuries can be serious. There are estimates of more than 1,500 injuries per year in the United States from these animals. With one exception, stingrays are marine.

Their favorite habitats are sandy areas, shoals or river mouths in shallow water. They lie on top of the sand or partially burrowed with only the eyes, gill slits and caudal appendage (“tail”) visible. The stinging spine is part of the tail and situated near the base. The spine is made of a hard cartilaginous material and has sharp, recurved teeth along either side. There are deep grooves on the underside of the spine, where the venom glands are located. The spine is covered by an integumentary sheath, which protects the stinging organ.

Most injuries occur when a person steps on an unsuspecting stingray lying in the sand; this can result in a defensive response by the animal.

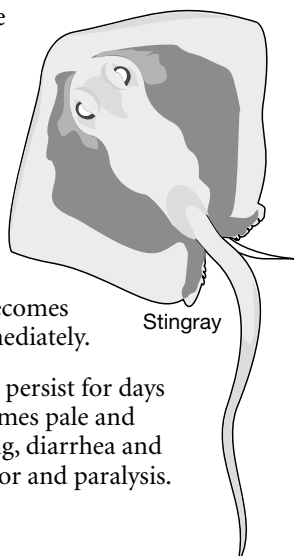
The injury begins as a puncture wound when the spine penetrates the skin. It then becomes a jagged laceration as the spine is withdrawn, and the recurved teeth inflict further injury while venom is injected into the wound.

The sheath remains behind in fragments so that the wound contains:

- a foreign body (the sheath)
- venom
- some seriously damaged tissue
- inevitably, bacterial contamination.

The result is a complicated injury that may require extensive treatment and prolonged healing time. Infection is a high probability in any marine puncture wound. If the affected area becomes painful, swollen or red, seek medical attention immediately.

Clinical features of the injury include pain that can persist for days and a bleeding laceration in an area that soon becomes pale and swollen. The venom may cause nausea and vomiting, diarrhea and appetite loss. There may be muscular cramps, tremor and paralysis.



The heart and blood vessels are affected, depending on the amount of venom injected. A small dose may cause a slowing of heart rate and a fall in blood pressure. A large dose can cause a disturbance in heartbeat and coronary circulation and can even produce respiratory depression. Fatalities have occurred when the stingray spine perforated the heart, chest cavity or abdominal cavity.

The venomous stingray species are numerous. Members of the Dasyatidae are probably the most common, with representatives around the world. Other species capable of harm include the spotted eagle ray, *Aetobatis narinari*; the California bat ray, *Myliobatis californicus*; the cow-nosed ray, *Rhinoptera bonasus*; and the Urolophidae, or round stingrays.

First Aid Treatment — Stingrays

Irrigate the wound to remove venom, and attempt to extract the spine and integument, a membrane or sheath covering the spine. If possible, remove all traces of the sheath. However, if the spine has penetrated in a location where it may be occluding severe bleeding, such as deeply into the abdomen, chest or neck, leave it in place until you reach a medical facility. If an arm or leg is injured, immerse the area in hot water at 113°F / 45°C for 30 to 90 minutes or until the pain is relieved. This maneuver may be insufficient to relieve pain, so that pain medications and/or local anesthetic injection by a medical professional is necessary. Monitor the pulse and respirations, and provide resuscitation as needed.

Fish Stings

There are many fish species with spines capable of injecting a venom. The spines may be concealed, as in stonefish, or highlighted, as in lionfish as a warning to predators.

This ability is nearly always a protective mechanism, and not as likely to affect divers as fishermen, who handle the fish by net or line.



Lionfish

Ratfish

The ratfish (*Hydrolagus colliei*) are cartilaginous fish that prefer cold water; they are found from the surface down to 9,843 ft / 3,000 m. They have two dorsal fins, the second of which has a venomous, sharp spine at the anterior edge that curves rearward; it is raised only when the animal is threatened. Although it is difficult for a diver to touch a ratfish underwater, they move away before the opportunity arises. These animals can inflict a painful wound if the spine penetrates tissue. There is immediate pain increasing in intensity, then gradually decreasing; the pain can persist for days. The area around the wound becomes numb and cyanotic, with the appearance of a severe inflammation.

Catfish

Catfish are a large group of species — most of which are freshwater — with a few marine species. There is a single, strong, needle-sharp spine located in front of the dorsal and pectoral fins. The spine is covered by an integumentary sheath that contains the venom glands. A few species have recurved teeth along the spine. These teeth can lacerate a wound, enhancing venom absorption and increasing the likelihood of infection. Two common species in the United States are the “sea catfish” (*Galeichthys felis*) and the freshwater Carolina madtom (*Noturus furiosus*). The gafftopsail catfish (*Bagre marinus*) inhabits the east coast of the Americas from New England to Brazil.

Weeverfish

The weeverfish are small, attractive but aggressive marine fish with a well-developed venom apparatus. They may be a real danger to a diver. The weevers bury themselves in soft sand until they dart out rapidly to strike. They have a series of dorsal spines with venom glands, producing a venom that affects the nervous system and the blood cells.

The pain from a sting is instant and rapidly worsens to excruciating levels. If not treated, the pain will subside in about 24 hours, although full recovery may take several days to months. There have been very severe reactions reported, including death. Two European species include the greater weeverfish (*Trachinus draco*) and the lesser weeverfish (*T. vipera*).

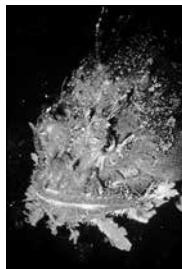
Scorpionfish/Stonefish

Scorpionfish (family Scorpaenidae) and stonefish (family Synancejidae) are found worldwide in tropical and temperate areas. The family Scorpaenidae can be divided into scorpionfish (*Scorpaena*) and lionfish, also known as zebra or turkeyfish (*Pterois*).

The most deadly punctures comes from the stonefish, or devilfish (*Synanceia horrida*), of the Indo-Pacific. Both scorpionfish and stonefish are shallow-water dwellers and may be found on sandy bottoms, rocks or coral reefs. Their protective camouflage coloring makes them extremely difficult to see. Accidental encounters are common with scorpionfish.

The zebrafish are beautiful, ornate coral reef fish usually found in shallow water hovering over a crevice or resting on a fixed object. They are fearless, and handling one of these fish can result in an extremely painful experience. Marine aquarium hobbyists are occasionally stung by such animals kept in home aquariums.

The spines of these groups differ somewhat, but all deliver venom. The stonefish is perhaps the most dangerous, as its spines are very strong. The symptoms of a sting are quite similar for all species. Identification of the responsible fish may not be possible, but there is no great variety in symptomatology regardless of the species responsible. There is immediate



Scorpionfish

pain, with increasing intensity and a dusky, blue-colored wound that remains the same for several hours and then begins to improve if the sting is minor. If the sting is severe, the situation can continue to worsen up to a severity necessitating amputation of a portion of a foot.

There is an antivenom available for stonefish stings from Commonwealth Serum Laboratories (CSL Limited) in Australia (www.csl.com.au).

Toadfish

The numerous species of toadfish (family Batrachoididae) are small bottom fish that inhabit most of the warm-water coastal areas of the world. The fish from the genus *Thalassophryne* are the venomous ones, while the rest are generally harmless.

Toadfish have broad, depressed heads and large mouths. They have two dorsal fin spines with venom glands and another spine located in the gill cover. Anglers are the frequent victims of a sting when they attempt to remove a hooked fish from their line. The pain is similar to that of the scorpionfish and develops rapidly, with intense pain followed by swelling, redness and heat. There are no recorded fatalities, and the symptoms subside within a few days.

Surgeonfish

Family Acanthuridae contains both surgeonfish and tangs and have spines that resemble scalpels near the tail. If the fish is threatened, it extends the spine and lashes out with its tail. Contact with the spine can produce a deep, painful laceration. There may be a venom associated with this spine.

Other Species

There are other fish with venomous spines capable of producing wounds in divers. These include the gurnards (family Dactylopteridae); sea robins (family Triglidae); dragonets (family Callionymidae); rabbitfish (family Siganidae); scats (family Scatophagidae); stargazers (family Uranoscopidae); and leatherbacks (family Carangidae).

FIRST AID TREATMENT — FISH LACERATIONS, STINGS

The wounds produced by the various species of animals with venomous spines have common features. The wounds are frequently lacerations and puncture wounds, containing venom, foreign material (e.g., dirt or sand), and contaminated with bacteria. The basic principles of wound care apply to these injuries after the injured diver has been initially evaluated and stabilized. It is important to relieve pain as promptly as possible and to cleanse the wound of all foreign material using sterile technique if available.

Irrigation of the wound may remove venom as well as portions of the integumentary sheath (layer of skin or membrane covering or enclosing the spine), slime, sand, etc. If any foreign material remains, healing will be delayed or may not occur. Many of these venoms respond to heat therapy, and a hot soak at a temperature not to exceed 113°F / 45°C should be



initiated for 30 to 90 minutes.

The care of these wounds can be summarized as follows:

- Resuscitate as needed.
- Rest affected area in a position of comfort.
- Immerse the wound in hot water to tolerance (115°F / 45°C) for 30 to 90 minutes or until pain is relieved and does not recur.
- Use local anesthetic, if needed for pain relief.
- Remove foreign body.
- Apply general wound care, including antibiotics if needed.
- Systemic analgesics or narcotics are rarely needed.
- Do not use ligatures, tourniquets or pressure bandages.
- Seek medical attention

Some of these wounds will be severe either due to the size of the animal (stingray) or the potency of the venom (stonefish). The stingray wound may require surgical exploration and surgical removal of foreign material and damaged tissue. The stonefish injury may require an antivenom, which itself may be hazardous.

To avoid infection, keep the wound clean. Victims of these injuries should be treated at a local medical facility, the sophistication of which will depend on the location of the diving area. Divers Alert Network can frequently advise concerning immediate care of these injuries and refer to appropriate medical centers. DAN Members, of course, can be evacuated at no cost.

Blue-Ringed Octopus

The blue-ringed octopus (*Hapalochaena maculosa* and *Hapalochlaena lunulata*) is found around countries and islands of the Indo-Pacific area. These animals are small (0.4-3.5 oz / 10-100 gm weight; 0.8-8 in / 2-20 cm length) and attractively colored with yellowish-brown rings on the tentacles and striations on the body. When alarmed, the rings turn a striking iridescent blue. They are frequently found in tidal pools and shallows around reefs.

Clinical Features

Most bites from the blue-ringed octopus have minor effects. The bite may be painless and unnoticed at first. However, in some cases a 0.4 inch / 1.0 cm blanched area may develop with swelling, with an occasional blood blister. There may be a clear, yellowish or bloody discharge from the wound.

There have been cases in which, within minutes, a rapid, painless paralysis progresses, beginning with numbness and tingling sensations around the mouth, neck and head. Other symptoms include nausea, vomiting and shortness of breath, with rapid, shallow respirations. The injured person may also experience disturbances in vision, with paralysis of eye movement and fixed, dilated pupils.

As paralysis progresses, speech and swallowing may become difficult, with generalized weakness and incoordination, and, finally, complete paralysis lasting four to 12 hours. The victim may be conscious, but unable to respond.

First Aid Treatment — Blue-Ringed Octopus

If the bite is on an extremity, immobilize the limb and apply a pressure bandage.

Prompt medical attention is required, but cardiopulmonary resuscitation is rarely required. Be prepared to support the victim's breathing. The venom of the blue-ringed octopus is tetrodotoxin, the same paralytic toxin found in pufferfish. Seek medical treatment as soon as possible.

Cone Shells

Cone shells (family Conidae) are collectors' favorites. These univalve mollusks are up to 4 inches / 10 cm in length and have a proboscis extendable from the narrow end, which can reach around to the rear of the animal's shell. The proboscis carries one to 20 venomous radular teeth, which can be extended to pierce the skin or a thin diveskin.

The animals inhabit shallows, reefs, ponds and rubble, burying themselves in sand with siphon exposed. The fish-eating cones are the dangerous ones; their venom consists of two or more substances that produce neuromuscular interference with sustained contraction. These substances also can have major effects on skeletal muscular activity.



Cone shell

Clinical Features

The venom produces inflammation, swelling and, often, severe pain. If present, pain is aggravated by salt water; the area becomes pale, bluish in color and numb. The general symptoms are numbness and tingling that can ascend from the bite to the entire body in about 10 minutes, especially in the areas around the mouth and lips.

Skeletal muscle involvement spreads from the site. It usually starts as a mild weakness and may progress to a point where the injured diver's limb is completely limp and no voluntary movement is possible; this is known as flaccid paralysis. Swallowing and speech become difficult. There is visual impairment: double vision, blurred vision, paralyzed voluntary muscles and paralyzed pupillary reactions developing within 10-30 minutes. Respiratory paralysis may dominate, with shallow, rapid breathing, cyanosis, apnea and coma, followed by death.

First Aid Treatment — Cone Shells

If paralysis is not present, keep the patient at rest and reassure him. If the bite is on an extremity, it should be immobilized and a pressure bandage applied. Seek immediate medical assistance.

If the injured person experiences paralysis, provide cardiopulmonary resuscitation as needed. The individual may be conscious, but unable to communicate. Breathing support — mouth-to-mouth or other artificial ventilation — may be required until medical help is available.

Sea Snakes

Sea snakes (family Hydrophiidae) are reptiles found only in the

tropical and temperate waters of the Indo-Pacific,

usually in coastal waters, but sometimes far at sea. Sea snakes

do not occur in the North or South Atlantic or in the Caribbean. There are approximately 50 species and all are venomous, although only a few species have been implicated in serious human envenomations or fatalities. Sea snakes may be aggressive at times, especially if handled or threatened. They are characterized by a flat paddle-shaped tail not seen on any land snake.



Sea snake

The venom is more toxic than cobra venom, but less is delivered; only about a quarter of the bites become symptomatic. The snakes have a delivery apparatus developed for small prey and not very hazardous to humans. In most species, the fangs are short, easily dislodged from their sockets, and not able to penetrate a wetsuit. The venom is a heat-stable, non-enzymatic protein that blocks neuromuscular transmission.

Clinical Features

The puncture wound will usually show from one to four marks, although as many as 20 are possible. There may be fangs embedded in the wound or wetsuit. For the individual who is bitten, there may be a symptom-free interval of 10 minutes to several hours. If generalized symptoms do not appear in six to eight hours, significant poisoning has likely not occurred.

The initial symptoms may be euphoria and anxiety, with restlessness, thirst, nausea and vomiting. More severe symptoms may develop and extend centrally from the bit. These may include painful muscle spasms and ascending paralysis, leading to respiratory failure and death.

First Aid Treatment — Sea Snake

Australian authorities recommend pressure bandages around the bite, but do not recommend application of a tourniquet. Immobilize the bitten body part and do not allow exertion. Do not attempt incision and drainage of the area to remove venom.

Be prepared to begin cardiopulmonary resuscitation. A nonspecific antivenom is available (Commonwealth Serum Laboratory, Australia — website: www.csl.com.au), but should be restricted for use by physicians.

LACERATIONS, AVULSIONS, AMPUTATIONS

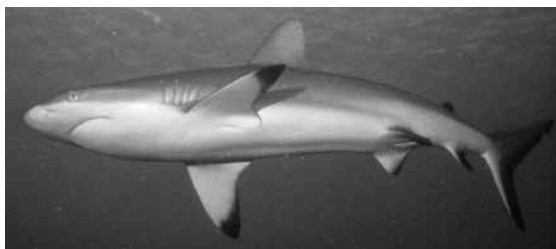


Some puncture wounds described may also have the characteristics of a laceration. There are a few marine animals capable of causing a major laceration, including sharp coral edges and predatory reef fish.

Coral lacerations may appear to be clean, but may become inflamed, swollen and tender within a few hours. The coral can discharge nematocysts directly into the wound, allowing venom to be injected, accompanied by bacterial and coral fragment contamination; a foreign-body reaction to the nematocysts and coral fragments occurs. Bacterial contamination may lead to abscess formation.

The shark is probably the most impressive of marine animals capable of harm to humans. Shark attack is a genuine but very unlikely danger — most divers consider themselves fortunate to even see a shark.

The very few encounters that result in injury usually occur after a shark perceives a threat, is molested in some way, or is enticed by some object on the diver (fish on a stringer, for example).



One typical attack pattern begins with a bump or brush contact with the prey by the shark; this produces an abrasion that can be extensive. If the shark continues with the attack, it will bite from a horizontal or slightly

UNPROVEN — AND POSSIBLY HARMFUL — FOLK REMEDIES

Marine biotoxicology is in its infancy, and there is little funding for research. The treatments for marine animal injury, therefore, are largely based on experience and anecdotal reference. Most of the treatments in use have supporters and detractors who engage in heated debate concerning efficacy. Much remains to be done to discover reliable treatments based on sound research.

There are many therapies, unproven, possibly harmful, or even dangerous, and not recommended, advocated from time to time.

Some examples of these unproved, possibly harmful actions include:

- Urinating on the injury site
- Incision of fish sting and snake bite wounds
- Applying oil or gasoline to an injury
- Applications of oxidizing agents, strong alkalis or acidic substances

upward position, with the head back and the upper teeth projecting forward. This can produce a major injury. The wound is characterized by a crescent-shaped rim with separate incisions from each tooth on the rim. There are usually tooth fragments in the wound and a crushing injury with tissues torn from the body and severe hemorrhage.

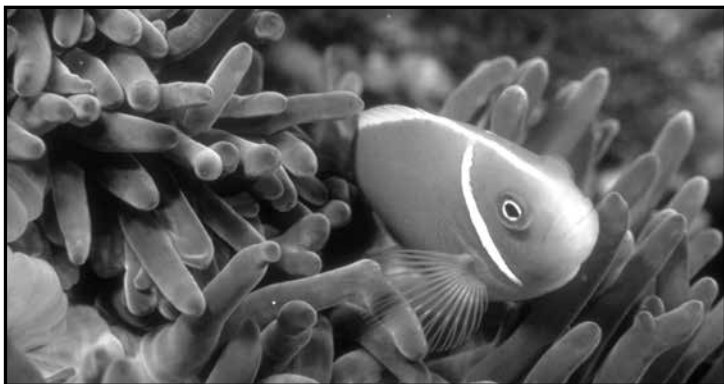
If the shark did not complete the bite, there may be only bruising and abrasive injury with teeth marks. Usually there is a single bite. Amputations and extensive body wounds are common; massive bleeding and shock are major immediate complications.

First Aid Treatment: Shark Attack and Major Lacerations

Remove the injured person from the water and immediately begin measures to control bleeding. This is best accomplished by direct pressure over the bleeding vessels; firm pressure on an artery generally will quickly stop bleeding.

When direct pressure is not successful in controlling the bleeding, apply a tourniquet between the wound and the heart; it must be tight enough to stop arterial blood flow. Use a tourniquet on extremities only. Once a tourniquet applied, do not release it until definitive therapy is available or bleeding is felt to be controlled by pressure techniques alone.

The injured person should be placed in a head-down/legs elevated position to combat shock and kept warm, even in a warm climate. Medical assistance must be obtained for intravenous fluid resuscitation as quickly as possible. The requirements may be massive, and fluid administration should begin before hospital transfer if possible. Do not give anything by mouth.



The clownfish, or anemone fish (family Pomacentridae; subfamily Amphiprionae), inhabits the anemone surrounded by its stinging cells.

PREVENTION OF MARINE ANIMAL INJURIES



- Avoid contact with the animal: this sounds simple, but it may not be if you have poor buoyancy control and/or are experiencing conditions of poor visibility, currents, confined areas or other environmental limitations.
- Do not attempt to handle, tease, feed or annoy any marine animal. Do not explore a crevice with your hand; that can promote a reaction by a concealed animal defending itself.
- Strive to develop excellent buoyancy control and remain aware of what surrounds you.
- Do not allow a current to force you against a fixed object; it may be covered with marine animals.
- Wear protective clothing.
- Make an effort to find out which animals you may encounter in your dive and learn about their characteristics and habitats before you begin the dive. This will help you enjoy your dive more and prevent possible injury from the animals you encounter.



SECTION III: DISORDERS THAT REQUIRE RECOMPRESSION

Careful observation and common sense are both needed to respond appropriately to a suspected case of decompression illness (DCI).

If you suspect DCI, steps to follow include answering these questions:

- Is something seriously wrong with the individual?
- How rapidly is the condition changing?
- How should the injured person be stabilized on site?
- What help is needed, and where it should be obtained?

An individual with shoulder pain that is unchanged over several hours is obviously in a less critical condition than someone who surfaces unconscious.

RECOGNIZING DECOMPRESSION ILLNESS

Decompression illness (DCI) is a term that includes **arterial gas embolism (AGE)** and **decompression sickness (DCS)**. These two diseases are described separately below because their presumed causes are different. From a practical standpoint, however, distinguishing them from one another based on the diver's signs and symptoms may be impossible. The initial treatment and stabilization are the same for both conditions.

Arterial Gas Embolism (AGE)

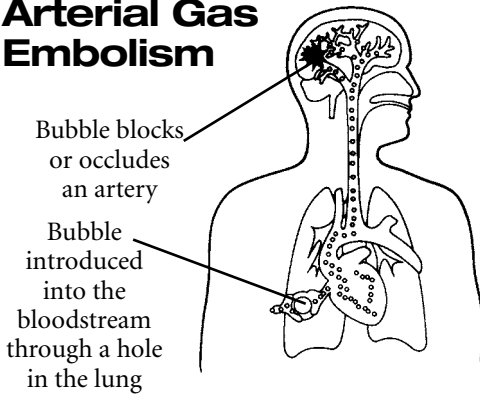
If a diver ascends without exhaling, air trapped in the lungs expands and may rupture lung tissue, releasing gas bubbles into the arterial circulation. Bubbles are then carried to body tissues, including vital organs such as the heart and brain. When lodged in small arteries, bubbles may interrupt circulation; they may damage the lining of vessels and impair flow even if they pass through without being trapped. This is air embolism, or arterial gas embolism. When AGE affects the brain, it is called a cerebral arterial gas embolism (CAGE).

This condition can occur when, in some cases, divers may have made a panic ascent, or held their breath during ascent. However, air embolism can occur even if ascent appeared normal. Some lung conditions (such as asthma) can cause gas-trapping during ascent, and subsequent AGE.

The effects of reduced circulation to the brain are critical, often leading to unconsciousness and paralysis; they require immediate treatment.

The most dramatic sign of air embolism is the diver who loses consciousness within 10 minutes of surfacing. In these cases, a true medical emergency exists, and rapid evacuation to a treatment facility is paramount.

Arterial Gas Embolism



Some cases of AGE occur in divers who surface awake and have minimal symptoms of neurological dysfunction.

If the diver experiences only symptoms such as tingling, numbness, weakness, difficulty in thinking, then there is time for a more thorough evaluation to rule out other causes.

Signs & Symptoms of AGE

- Paralysis or weakness
- Convulsions
- Dizziness
- Visual blurring
- Personality change
- Bloody froth from mouth or nose (sign of possible pulmonary barotrauma)
- Unconsciousness
- Cessation of breathing
- Chest pain
- Disorientation
- Death

Note: Symptoms and signs usually appear during or immediately after surfacing and may resemble a stroke.

Prevention

Relax and breathe normally during ascent. Lung conditions such as asthma, infections, cysts, tumors, scar tissue from surgery or obstructive lung disease may predispose to air embolism. If you have any of these conditions, then you should be evaluated by a dive physician.

Treatment — Call DAN!

The early management of air embolism and decompression sickness is the same and is covered in the Immediate Care section that follows. Although a diver with an air embolism requires urgent recompression for definitive treatment, patient stabilization and early medical management at the nearest medical facility may be appropriate before transportation to a more distant chamber.

Oxygen first aid may be highly effective and is strongly recommended for AGE. Signs of air embolism and serious DCS often disappear after initial oxygen breathing, but they may reappear later. Because of the possibility of delayed recurrence, always contact DAN or a dive physician, even if the symptoms and signs seem to have resolved. Recompression therapy for an air embolism can be effective even if delayed, although a cure may be more likely with early treatment.



Decompression Sickness (DCS)

Decompression sickness (also called the bends, or caisson disease) is the result of decompression following exposure to increased pressure. During a dive, the body tissues absorb nitrogen from the breathing gas in proportion to the surrounding pressure. As long as the diver remains at pressure, the gas presents no problem. When pressure is decreased (such as on ascent), the nitrogen can come out of solution and form bubbles in the tissues and bloodstream. In order to minimize the likelihood of DCS, it is always wise to stay away from the very edge of dive computer / table limits and to use those devices conservatively.

Bubbles forming in or near joints are the presumed cause of the joint pain of a classical “bend.” More serious manifestations such as paralysis can be caused by bubbles in the spinal cord or brain.

Who gets decompression sickness? There is great individual variation. Some divers can develop decompression sickness even when other divers making the same dive remain symptom-free. These variations are caused by myriad factors, most unknown. Evaluation of a diver for symptoms of DCS, therefore, must be made on an individual basis. The fact that other divers making the same dive are unaffected is no reason to discount the possibility of decompression sickness (or other injury).

Signs & Symptoms of DCS

- Pain in joints and/or muscles, arms, legs or torso
- Numbness, tingling
- Dizziness, inability to maintain balance while walking or standing
- Coughing spasms
- Unusual fatigue
- Paralysis, weakness
- Collapse or unconsciousness
- Shortness of breath
- Skin itch or rash

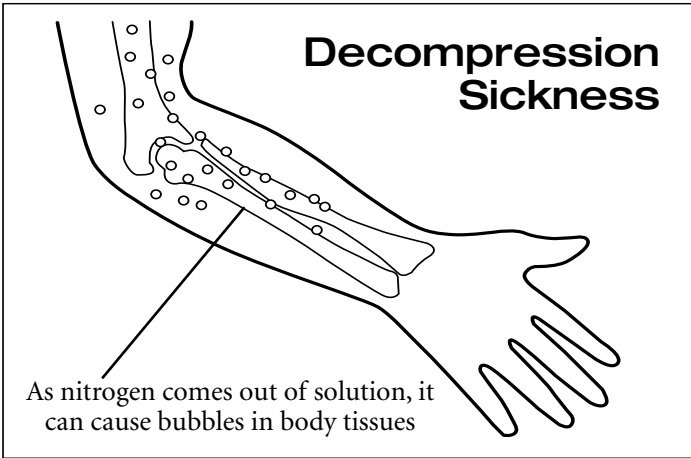
Note: Signs and symptoms usually appear within 24 hours after surfacing; but in severe cases, symptoms may appear before surfacing or immediately afterwards. Delayed occurrence of symptoms is rare, but it does occur, especially if diving is followed by altitude exposure.

Prevention

Recreational divers should dive conservatively, whether they are using dive tables or computers. When using tables, one conservative principle is to select the table depth equal to or greater than the actual depth in order to confer a greater degree of safety. This practice is highly recommended for all divers, especially when diving in cold water or under strenuous conditions such as swimming against a current.

Divers should preferably avoid approaching maximum allowable bottom time, especially when diving deeper than 100 ft / 30 m.

Employing conservative diving practices such as leaving at least 10 minutes of no-stop time on the computer or table will help reduce risk. Using



enriched-air nitrox (EAN) as the breathing mix with an air protocol on the computer or dive tables is also a good way to reduce risk.

For those using tables or computers, the most important risk factors for DCS are dive depth and bottom time. However, other factors include exertion during the dive, rapid ascent, repetitive diving, cold water and diving deeper than 80 ft / 24 m.

Hard exercise immediately after a dive or exposure to altitude or flying after a dive may also increase the risk of DCS. There are also undoubtedly diver-related risk factors. Although it is recognized that some divers seem to be more likely than others to develop DCS, the exact reasons are not yet understood.

Breathing Surface Oxygen

Immediate breathing of high concentrations of oxygen is a highly effective measure in relieving the signs and symptoms of decompression sickness. Use it whenever it is available. The injured person should breathe 100 percent oxygen as long as supplies last or up to a maximum of 12 hours or until medical evaluation. It may be continued for a longer period at the discretion of a physician.

Although oxygen first aid may reduce symptoms

substantially, the treatment plan should not be changed even if improvement occurs. In cases with complete relief, consult DAN or a dive physician to determine whether recompression or other follow-up is appropriate.

Recompression treatment for all forms of DCS can be effective, particularly when performed early. Although successful treatment has occurred many days after symptom onset, early therapy is more effective.



FLYING AFTER DIVING

2002 Consensus Guidelines for Flying After Recreational Diving

The following guidelines are the consensus of attendees at the 2002 Flying After Diving Workshop. They apply to air dives followed by flights at cabin altitudes of 2,000 to 8,000 ft (610 to 2,438 m) for divers who do not have symptoms of decompression sickness (DCS).

The suggested preflight surface intervals do not guarantee avoidance of DCS. Longer surface intervals will reduce DCS risk further.

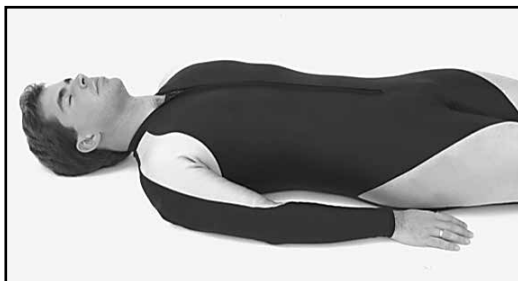
- For a single no-decompression stop dive, a minimum preflight surface interval of 12 hours is suggested.
- For multiple dives per day or multiple days of diving, a minimum preflight surface interval of 18 hours is suggested.
- For dives requiring decompression stops, there is little evidence on which to base a recommendation; therefore, a preflight surface interval longer than 18 hours appears prudent.*

Treatment — Call DAN!

Decompression sickness or air embolism generally requires recompression treatment.

However, the injured diver should usually be stabilized and receive prompt medical treatment at the nearest medical facility before transport to a recompression chamber. If there is no nearby medical or recompression facility, consult with a diving physician or call DAN.

* Sheffield PJ, Vann RD (eds). *DAN Flying After Diving Workshop Proceedings*. Durham, NC: Divers Alert Network, 2004.



If cardiorespiratory resuscitation is required, put the injured diver in the supine position. If vomiting occurs in this position, quickly turn the diver on his side to help clear the airway before resuming resuscitation.

CARE OF THE DIVER WITH DECOMPRESSION ILLNESS

Initial Evaluation at the Dive Site

Suspect decompression illness if any of the signs or symptoms previously described occur within 24 hours of surfacing from a dive. The initial state of the affected diver determines the order and urgency of the actions.

Severe

Symptoms are severe and appear rapidly and within an hour of surfacing. Unconsciousness may occur. Symptoms may be progressing, and the diver is obviously ill. The diver may be profoundly dizzy, have trouble breathing or have a significant change in level of consciousness. Obvious neurological injury is present if the injured person shows signs of altered consciousness, abnormal gait or weakness.

These divers are notably very sick, and a true medical emergency exists. Monitor airway and breathing and, if necessary (e.g., if the diver is unconscious), consider CPR and take immediate action to have the diver evacuated. Check for foreign bodies in the airway. If ventilatory or cardiac resuscitation is required, put the injured diver in the supine position (lying on the back). If vomiting occurs in this position, quickly turn the diver on his side in order to facilitate clearing the airway before resuming resuscitation.

Even if CPR is successful and the diver regains consciousness, 100 percent oxygen should be provided and continued until the diver arrives at a medical facility.



The lateral recumbent, or recovery, position places the person on the side with head supported at a low angle and the upper leg bent at the knee to prevent the body from moving forward. If vomiting occurs in this position, gravity assists in keeping the airway clear.

If trained healthcare personnel are available,

and appropriate intravenous administration equipment are available, then an intravenous (IV) infusion using isotonic fluids (crystalloid: normal saline, Lactated Ringers solution, Normosol-R® or a colloid, e.g., a starch solution) without dextrose should be administered. If dehydration is suspected and there is no contraindication to rapid fluid administration (such as heart failure, pulmonary edema or cardiorespiratory DCS, or the “chokes”), an initial rapid infusion of 1 liter of a saline solution as described above should be administered as quickly as possible to begin correction of dehydration and hemoconcentration. Once this is accomplished, the rate of administration should be reduced to a rate appropriate to maintain adequate cardiac output as judged by heart rate, blood pressure and urine output.

Additional fluid boluses may be required, but should only be given by trained healthcare personnel capable of weighing the need for further fluid against possible complications such as pulmonary edema. Divers with spinal cord decompression sickness may be unable to urinate and require bladder catheterization. Large fluid boluses are not recommended for divers with AGE alone (without DCS) or patients with cardiorespiratory DCS or pulmonary edema of any cause.

If trained personnel are available, a urinary catheter should be placed in all unconscious divers and in those who cannot urinate.

After stabilization and arrangements for evacuation are made, contact DAN for the nearest available chamber. DAN medical experts can get in touch with the receiving facility to assist in diagnosis and, if necessary, treatment. Do this even if the diver appears to be improving while using oxygen.



Milder cases, in which manifestations are stable and not life-threatening should be treated with oxygen: Continue with oxygen until the injured person is evaluated medically. Individuals who are alert and not nauseated or vomiting can receive fluids by mouth.

Unless the pain is severe, do not attempt to treat the pain with analgesics until advised to do so by medical personnel. If the diver is not allergic or intolerant to it, acetaminophen or a simple nonsteroidal anti-inflammatory analgesic (e.g., ibuprofen — Advil®, Motrin®) may be used if the pain is severe. Contact DAN or the nearest medical facility for advice on transport, even if symptoms improve or are relieved with oxygen. Emergency air transport may not be necessary in such cases.

While awaiting evacuation, take as detailed a history as possible and try to evaluate and record the diver's neurological status. This information will be useful to those at the receiving medical facility. If air evacuation is used, cabin pressure should be maintained at the highest level (i.e., lowest altitude equivalent) consistent with aircraft safety.

Dive History

If possible, obtain and document the following information:

- For 48 hours preceding the injury, a description of all dives: depths/times, ascent rates, intervals between dives, breathing gases, problems or symptoms
- Symptom onset times and progression, relative to surfacing from last dive
- Description of all first aid measures (including times and method of oxygen delivery) and effect on symptoms since accident
- The results of the on-site neurological examination (described below)
- Description of all joint or other musculoskeletal pain including: location, intensity, changes with movement or weight-bearing
- Description and distribution of any rashes
- Description of any traumatic injuries before, during or after the dive

ON-SITE NEUROLOGICAL EXAMINATION

Information regarding the injured diver's neurological status will be useful to medical personnel in not only deciding the initial course of treatment but also in the effectiveness of treatment. Examination of an injured diver's central nervous system soon after an accident may provide valuable information to the physician responsible for treatment.

The On-Site Neuro Exam is easy to learn and can be done by individuals with no medical experience. Perform as much of the examination as possible, but do not let it interfere with evacuation to a medical treatment facility.



Examination of an injured diver's central nervous system soon after an accident may provide valuable information to the physician responsible for treatment.

The On-Site Neuro Exam is easy to learn and can be performed by individuals with no medical experience.

While it is best to participate in a training course specific to performing neurological assessments, the examination can be done while reading from this manual. **Perform the following steps in order; record the time and results.**

SYMPTOMS

For each symptom, record the locations and time of onset. Symptoms may come and go. Therefore, ask the diver to report periodically.

- Does the diver have any pain anywhere?
- How severe is it? Rate it 0-10: "0" = no pain; "10" = worst pain ever.
- Does it change with movement at the nearest joint?
- Is there any numbness or tingling?
- Is there any vertigo (spinning), dizziness, nausea or vomiting?
- Are there any changes in vision?
- Does the diver have nausea and/or vomiting?
- Is the diver able to urinate?

MENTAL FUNCTION

Consciousness

- Is the diver alert?
- Does the diver respond to commands, only to pain or is he/she unresponsive?

Orientation

- Is the diver oriented to person, place and time?
- Ask: What is your name? Where are you? What time is it?

CRANIAL NERVES

Eyes

- Can the diver move eyes in all directions?
- Any eye twitching (nystagmus)

Face

- Have diver close eyes and smile: Is the face symmetrical?

Hearing

- Is the diver's hearing approximately equal in both ears?
- Can the diver hear your finger and thumb rubbing together at a distance greater than 1 foot while in a quiet place?

Sensation on the face

- Is there any area where light touch or pin prick cannot be felt? Record the location.

MOTOR FUNCTION

- Get the diver to push against you to assess strength in as many muscle groups as you can.
- Check shoulders, biceps and triceps, grip strength.
- Are these all normal, weak or no movement?
- Check flexion and extension of the hips, knees and ankle.
- Are these all normal, weak or no movement?

SENSORY FUNCTION

- Are there any areas where light touch cannot be felt on the body? Record the location.
- Any areas where pin prick cannot be felt? Record the location.

COORDINATION AND BALANCE

- Can the diver walk normally; walks but wobbly; falls over? Check this only on a stable platform.
- Can the diver follow, using one index finger, from his/her nose to your index finger held out in midair? What happens if you move your finger and repeat?

OTHER INFORMATION

- Record time test performed a.m./p.m.

The diver's condition may prevent the performance of one or more of these tests. Record any omitted test and the reason.

If any of the tests are not normal, suspect injury to the central nervous system.

The tests should be repeated at 60-minute intervals while awaiting assistance to determine whether any change occurs. Report the results to the emergency medical personnel responding to the call. Good diving safety habits would include practicing this examination on normal divers to become proficient in the test.



At the Medical Treatment Facility

(Information for Medical Personnel)

The following section is aimed at medical personnel: *If, in the course of your rescue or that of a friend, you find yourself at a facility that has not had much experience with divers — do ask — then they may find this part of the guide helpful.*

If an individual has made a dive within the past 24 hours and has joint or muscle pain, skin rashes, hearing or vestibular problems, abnormalities of consciousness or higher mental function, personality changes, cerebellar abnormalities, disorders of sensation or muscle strength or problems emptying the bladder, consider decompression illness in your differential diagnosis.

The definitive treatment for decompression illness is recompression. Initial stabilization should first be accomplished for the Emergency and Urgent patient (see previous section), and 100 percent oxygen should be delivered until definitive recompression can be accomplished.

The injured diver should be kept hydrated using an isotonic solution not containing dextrose. If the diver is unconscious or unable to void, then a urinary catheter should be inserted.

If you suspect a diving accident and are unfamiliar with dive medicine, obtain help from a local medical expert or call DAN at +1-919-684-9111 for assistance in deciding whether recompression is needed, where the closest recompression facility is, and in arranging to transport the patient to the treatment facility.

Before consulting with dive medical experts, obtain the following useful information.

- For 48 hours preceding the injury, gather a description of all dives: depths/times, ascent rates, intervals between dives, breathing gases, problems or symptoms. List symptom onset times and progression occurring after surfacing from last dive.
- Describe all first aid measures (including times and method of 100 percent oxygen delivery) and effect on symptoms since the accident.
- A complete neurological exam should include: higher mental function; cerebellar function (finger-nose, gait and tandem gait or ability to walk barefoot heel-toe on a hard floor); strength of all major muscle groups; sensation (e.g., pin prick, light touch, and temperature), proprioception (reception of a stimulus) and coordination.
- Examining of auditory and vestibular function should include presence of hearing or balance deficits, tinnitus, nystagmus and appearance of tympanic membranes.

- Description of all joint or other musculoskeletal pain should include: location, intensity, changes with movement or weight-bearing.
- Note the description and distribution of any rashes. Describe any traumatic injuries before, during or after the dive.



Sara Shoemaker Lind Photos

The arm strength test (at left) and checking the diver's balance are two important steps in the On-Site Neuro Exam.

In-Water Recompression Treatment

What is it? In-water recompression is defined as re-entering the water to a depth of 15 ft / 4.5 m while breathing a high concentration of oxygen (usually 100 percent).

Do it only if you have training. This treatment should never be attempted unless it can be performed by trained, experienced individuals who have all of the proper equipment available.

The Australian system for oxygen treatment in the water may be appropriate for very remote calm-water locations until evacuation can be accomplished.* The system requires advanced planning, immediate access to extensive, essential equipment, a large oxygen supply, and individuals trained in the technique for support of the diver's needs during treatment.

Before embarking on any dive trip, inquire about the emergency support facilities that are available and whether in-water recompression would be used. If so, find out the levels of training of the individuals who would perform this technique.

In-water recompression treatment performed improperly or without extensive training and experience can end with the diver being forced to the surface in cold water, or with an inadequate air supply.

Other problems can include panic, seasickness, difficulty in communications, hypothermia from prolonged exposure to water, hyperoxic convulsions and drowning. In addition, incomplete treatment and further nitrogen uptake by the diver often occurs. Because of all these risks, in-water recompression is an option that is used only when diving in remote areas.

* Edmonds C., Lowry C., Pennefather J. & Walker, R., *Diving and Subaquatic Medicine: 4th Ed. Appendix C2*, Arnold, London UK; 2002.

SECTION IV: Principles of First Aid

CPR/Basic Life Support

Students receiving instruction in oxygen use will have completed training in CPR by a national agency and follow emergency cardiac care guidelines such as those published by the American Heart Association (www.americanheart.org).

Learning CPR procedures is not difficult, but does require training and practice with qualified instructors. This manual is not



intended as a resource for learning basic life support, but it is important to review the steps of CPR. Recheck your CPR basic manual for further details.

In the unconscious victim it is common to find obstruction of the upper airway by a foreign body or the tongue. The drowning victim may have a damaged oxygen delivery system and requires massive oxygen supplementation. This section emphasizes the use of oxygen in the event of diving injury and drowning, but it does not approach the many other indications for oxygen treatment.

Oxygen First Aid

Oxygen first aid is one of the most important measures taken at the scene of the accident for the victim of an underwater diving injury before definitive medical care becomes available.

Supplemental oxygen is a valuable adjunct in CPR, in drowning, and in serious accident or injury that impairs the body's ability to transport oxygen to the tissues. The presence of gas bubbles can produce obstruction in blood vessels, thus an interruption of blood supply and cause a cascade of cellular effects.

Decompression illness (DCI) — pulmonary overpressure injury that results in arterial gas embolism (AGE) and decompression sickness (DCS) — are the most important indications for the use of oxygen. Breathing 100 percent oxygen will create a significant gradient from normal tissue to the tissues where the blood flow has been blocked. This may be just enough to prevent or delay permanent injury.

High concentrations of inhaled oxygen are helpful in several ways. DCI is due to the formation of bubbles composed of nitrogen or air. By breathing 100 percent oxygen, a pressure gradient is created between the bubble and the tissues; the bubble becomes smaller and is eventually reabsorbed at a faster rate than if breathing air. The goal is to provide 100 percent oxygen in order to speed nitrogen elimination and get good oxygen supply to hypoxic areas.



The goal of oxygen first aid in pressure-related diving injuries is to provide 100 percent oxygen in order to speed nitrogen elimination and get good oxygen supply to hypoxic areas.

The injured diver should be transported to the nearest medical facility, and a physician knowledgeable in dive medicine should be consulted. Oxygen first aid must **NOT** be considered a substitute for recompression treatment, if this type of treatment is indicated. (See the following pages for guidelines in providing surface oxygen).

DAN has developed a special course in the use of oxygen in diving injuries. This course is taught by DAN-certified instructors throughout the world. See the DAN website for a listing of current DAN instructors or contact DAN.

DAN advises that oxygen and people trained to use oxygen should be available on all dive boats and at all dive sites. The diver should be a prepared diver with CPR, rescue, and oxygen skills and insist that oxygen be available at the dive site or on a boat that will be used for diving.

DCI may involve the central nervous system and can cause cessation of breathing due to damage to the control centers. In this situation, rescue breathing and oxygen administration are essential to prevent death.

The use of oxygen in the early stages following a diving injury may reduce or totally relieve the symptoms within a short time. If this happens, however, the emergency is not over. Oxygen first aid should be continued; if stopped, symptoms may return.

Responding to the Injured Diver

This section does not replace formal training in Diver Rescue, CPR or Oxygen First Aid. Before attempting any of the following skills, you should complete a formal course of instruction to gain the knowledge and skills necessary to assist an injured diver.

Managing an Injured Diver on the Surface

- Ensure safety of yourself and the injured diver.
- Establish positive buoyancy for yourself and the injured diver.
 - Remove weight belts.
 - Inflate buoyancy control devices as appropriate.
- Assess diver's responsiveness. Ask: "Are you all right?"
- If the diver is responsive, assist the diver with the problem and bring him/her to the shore or the boat.
- If the diver is unresponsive, alert someone on shore or the boat.
- Contact the local emergency medical services (EMS).
- If close to shore or boat, tow the unresponsive diver to the closest stable site for out-of-water management and begin basic life support. Provide one breath every five seconds.
- Otherwise, open the injured diver's airway.
 - Remove the injured diver's regulator or snorkel and mask, if necessary.
 - Support the diver's head, and avoid submerging the diver's face.
- Assess breathing by looking, listening and feeling for 5 to 10 seconds.
 - Look for movement of the chest.
 - Listen for breathing.
 - Feel breathing against your cheek.
- If the injured diver is not breathing, provide two rescue breaths, and
 - Maintain an open airway, using the head-tilt, chin-lift method.
 - Use an oronasal resuscitation mask or pinch the injured diver's nose to make a seal.
 - Give two normal breaths (one second in duration) enough to make the chest rise.
 - Watch the chest rise and fall.
 - Prevent water and other debris from entering the airway.
 - If the first breath is ineffective, check and reposition the airway, and reattempt ventilations.
- Remove the diver's equipment.
- Remove the diver from the water.
- Reassess the diver's condition. If still not breathing, deliver two rescue breaths and begin CPR.

IV**Performing cardiopulmonary resuscitation (CPR) in the water is not recommended because:**

1. It is not feasible to perform adequately.
2. It delays the start of more definitive treatment on land.

Managing the Injured Diver on the Shore or Boat

- Ensure safety of yourself and the injured diver.
 - Use medical gloves and other personal protection equipment.
 - Use an oronasal or other resuscitation mask.
- Assess diver's responsiveness.
 - Grasp the diver's shoulder.
 - Ask: "Are you all right?"
- If the diver is responsive:
 - Continue to monitor and evaluate the diver's airway and breathing.
 - Provide high concentrations of oxygen.
 - Seek further medical assistance and advice.
- If the diver is unresponsive, send someone for help and activate local EMS.
- Open the diver's airway with the head-tilt, chin-lift maneuver.
 - Place one hand on the diver's forehead, and gently tilt the head back.
 - With the other hand, lift the chin with two or three fingers.
- Assess breathing by looking, listening and feeling for 5 to 10 seconds.
 - Look for movement of the chest.
 - Listen for breathing.
 - Feel breathing against your cheek.
- If the diver is breathing:
 - Place the diver in the recovery position to help protect the airway.
 - Continue to monitor and evaluate the diver's airway and breathing.
 - Provide high concentrations of oxygen.
 - Seek further medical assistance and advice.
- If the diver is not breathing, provide two rescue breaths.
 - Maintain an open airway with the head-tilt, chin-lift method.
 - Use an oronasal resuscitation mask or pinch the injured diver's nose to make a seal.
 - Give two normal breaths (one second in duration), enough to make the chest rise.
 - Watch the chest rise and fall.
 - If the first breath is ineffective, check and reposition the airway and reattempt ventilations.
 - Allow the diver's chest to fall before providing a second breath.
 - If available, provide supplemental oxygen.

- If the diver is not breathing, begin CPR.
 - Locate the lower sternum (breastbone).
 - Place the heel of one hand with the other hand on top of the first.
 - Perform 30 compressions at a rate of 100 per minute.
 - Combine compressions and rescue breathing at a ratio of 30:2.
 - If available, provide supplemental oxygen.
- Continue CPR until circulation and breathing resume or help arrives.

Additional details regarding CPR protocols for one or two rescuers and other first aid procedures are available through hands-on training courses. Contact your local dive center for information on training opportunities.

Providing Emergency Oxygen First Aid

Providing emergency oxygen first aid for an injured diver is one of the most important measures that can be taken prior to professional medical care and hyperbaric treatment.

Because respiratory arrest, cardiac arrest, drowning and scuba diving injuries interrupt or impair the body's ability to supply oxygen to the body's tissue, it's important to provide the highest concentration of oxygen possible. The injured diver's medical status helps determine which delivery method will provide the highest concentration of oxygen.



Note: DAN recommends that you seek formal training in the use of oxygen prior to use. Oxygen is a prescription drug in many countries, and improper handling and maintenance of oxygen equipment can cause serious injury, including death, to both the injured diver and rescuer.

To determine the oxygen delivery device that will provide the highest concentrations of oxygen, determine whether the diver is breathing or not, and select the delivery device with the highest concentration of oxygen available.

IV

Breathing Injured Diver

- Demand inhalator valve with oronasal mask;



- Nonrebreather mask with a minimum 15 liter per minute (Lpm) oxygen flow rate; or

- Other oxygen delivery devices capable of providing high concentrations of oxygen, such as closed-circuit oxygen rebreathers.



The demand inhalator valve is far more effective than the nonrebreather mask in both conserving oxygen supplies and delivering a high inspired fraction to the patient. Closed-circuit oxygen rebreathers are even more effective at conserving oxygen supplies. These devices can be of great value to support remote diving activity when long delays to reach definitive medical aid are expected.

Nonbreathing Injured Diver

- Oronasal resuscitation mask (DAN mask) with a minimum 15 Lpm oxygen flow rate.

Trained medical professionals may consider:

- Flow-restricted oxygen-powered ventilator (FROPV).
- Bag-valve mask.

Once the oxygen delivery device is chosen, follow this quick review of the steps to using one of the following oxygen delivery devices.

[**Note:** The use of supplemental oxygen should always take place within the context of Basic Life Support (BLS) and techniques such as rescue breathing and CPR. This section is not a substitute for formal training in oxygen first aid.]

Demand Inhalator Valve Procedures

1. Deploy the oxygen unit and open the cylinder valve.
2. Ask the diver to breathe normally from the demand inhalator valve and mask.
3. Check for leaks around the face.
4. Monitor the injured diver and oxygen pressure gauge.

Nonrebreather Mask Procedures

1. Deploy the oxygen unit and nonrebreather mask.
2. Set constant-flow control to 15 Lpm.

3. Inflate the mask's reservoir bag.
4. Ask the diver to breathe normally from mask.
5. Check for leaks around the face.
6. Monitor the injured diver and oxygen pressure gauge.

Oronasal (DAN) Mask Procedures

1. Deploy the oxygen unit and the oronasal mask.
2. Attach oxygen tubing to mask and oxygen regulator.
3. Set constant-flow control to 15 Lpm.
4. Provide CPR as indicated.

Notes on the Use of Oxygen

- Have enough oxygen supply for transport from the farthest dive site to the nearest EMS contact.
- Oxygen first aid should not be considered a substitute for definitive care by a trained healthcare provider.
- Do not overlook the priority of airway and breathing monitoring when providing emergency oxygen.

Oxygen Equipment Warnings

- Extinguish all open flame and smoking materials.
- Turn oxygen cylinder valves slowly.
- Do not allow the use of any oil or grease to come in contact with oxygen or oxygen equipment.
- Do not expose oxygen cylinder to high temperatures.

Positioning of the Injured Diver

Positioning of the diver is also important to facilitate CPR and the provision of oxygen first aid. Depending on the condition of the injured diver, place the diver in the appropriate position.

- Injured divers who are responsive (who are communicating) may be placed in either of these positions:
 - Recovery position (on side, usually the left, with head supported)
 - Semirecumbent position (comfortably reclining)
- Unresponsive breathing injured divers should be placed in the recovery position (on either side with the head supported) to help maintain an open airway and reduce the likelihood of the aspiration of vomitus in the lungs.
- Unresponsive nonbreathing injured divers should be placed in the supine position (on the back) in order for the rescuer to be able to perform CPR/rescue breathing.

IV

Notes on Positioning

- The diver should be in a stable, comfortable position, without pressure on the chest that could impair breathing.
- Avoid crossing the arms or legs in a manner that might restrict circulation.
- Avoid movement of the diver without stabilization if a head, neck or spinal injury is suspected.
- A head-down position is not recommended unless it is required to treat low blood pressure.

SUMMARY

General Principles of Accident Management are:

Airway and Breathing

- First priority always goes to the airway.
- Every diver with suspected DCS or AGE should receive oxygen.
- Every unresponsive person should be assumed to have respiratory insufficiency and needs:
 - (a) Protection of airway.
 - (b) Careful monitoring to determine whether assisted ventilation is required.

ACRONYMS

IV

ACLS – advanced cardiac life support
AED – automated external defibrillator
AGE – arterial gas embolism
AIDS – acquired immune deficiency syndrome
ATA – atmospheres absolute
BCD – buoyancy compensation device
BLS – basic life support
CAGE – cerebral arterial gas embolism (also called air embolism)
CDC – Centers for Disease Control and Prevention (U.S.)
CNS – central nervous system
CPR – cardiopulmonary resuscitation
DAN – Divers Alert Network
DCI – decompression illness
DCS – decompression sickness
DEET – N,N-diethyl-meta-toluamide
DVT – deep vein thrombosis
EAN – enriched-air nitrox
EMS – emergency medical services
ENT – ear, nose and throat
FROPV – flow-restricted oxygen-powered ventilator
fsw – feet of sea water
GMT – Greenwich Mean Time
HAV – hepatitis A virus
HELP – heat escape lessening position
HIV – human immunodeficiency virus
IRDM – insulin-requiring diabetes mellitus
Lpm – liters per minute
msw – meters of sea water
NOAA – National Oceanic and Atmospheric Administration (U.S.)
OE – otitis externa
OHA – oral hypoglycemic agents
ORS – oral rehydrating solution
OSHA – Occupational Safety and Health Administration
OTC – over-the-counter
PFSI – preflight surface interval
PPD – (purified protein derivative) tuberculin skin test
TB – tuberculosis
TD – travelers diarrhea
UBA – underwater breathing apparatus
UHMS – Undersea and Hyperbaric Medical Society
WHO – World Health Organization

Afterdrop

A transient decline in core temperature, often occurring after removal from cold stress.

Alternobaric Vertigo

An extreme dizziness and disorientation resulting from unequal pressure in the two middle ears, typically during ascent.

Antihistamine

Drugs that may be part of some “over-the-counter” medicines for allergies and colds. Some antihistamines cause drowsiness.

Arterial Gas Embolism

Air in the arterial circulation. In divers this may be caused by a sudden reduction in ambient pressure, such as a rapid ascent without exhalation, causing over-pressurization of the lung and pulmonary barotrauma. The most common target organ is the brain, and the usual signs and symptoms include the rapid (<15 minutes) onset of weakness, numbness, confusion or alteration in consciousness after reaching the surface.

Barotrauma

A condition caused by a change in ambient pressure in a gas-filled space. When gas is trapped in a closed space within the body, the gas will be compressed if the depth increases and will expand if the depth decreases. Barotrauma injuries of descent include ear squeeze, tympanic membrane rupture or sinus squeeze. Injuries of ascent include pulmonary barotrauma, which can result in air embolism, pneumothorax or pneumomediastinum.

Carbon Dioxide

A waste gas produced by the metabolism of oxygen in the body.

Carbon Monoxide

A highly poisonous, odorless, tasteless and colorless 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 hemoglobin, thereby resulting in diminished availability of oxygen in tissues.

Cardiac Arrest

The inability of the heart to generate effective circulation. It is confirmed by the absence of the carotid pulse in an unconscious nonbreathing person.

Conjunctival Suffusion

Redness of the membrane covering the eye.

Cyanosis

A bluish discoloration of the skin and mucous membranes due to deficient oxygenation of the blood.

Decompression Illness (DCI)

The broad term that encompasses both DCS and AGE. DCI is commonly used to describe any systemic disease caused by a reduction in ambient pressure. It is used because the signs and symptoms of DCS and AGE can be similar.

Decompression Sickness (DCS)

A syndrome caused by bubbles of inert gas forming in the tissues and

bloodstream during or after an ascent from a compressed-gas dive. The symptoms may include itching, rash, joint pain, muscle aches or sensory changes such as numbness and tingling. More serious symptoms include muscle weakness, paralysis or disorders of higher cerebral function, including memory and personality changes.

Dehydration

Depletion of body water. Mild dehydration may go unnoticed. More severe dehydration can cause dizziness, rapid heartbeat and low blood pressure (hypotension).

Enriched-Air Nitrox (EAN)

A nitrogen / oxygen breathing gas mixture containing more than 21 percent oxygen, usually made by mixing air and oxygen. Also known as oxygen-enriched air.

Hyperthermia

A condition of elevated body core temperature.

Hypoglycemia

A condition of low blood sugar.

Hypothermia

A condition of reduced body core temperature (below 95°F / 35°C).

Hypoxia

Inadequate oxygen supply to the body tissues.

Initial Assessment

Assessment of the airway and breathing in an ill or injured person.

Lpm

Liters per minute. A measurement of a flow rate of gas or liquid.

Mediastinum

The space within the chest located between the lungs; it contains the heart, major blood vessels, trachea and esophagus.

Mediastinal Emphysema (Pneumomediastinum)

Air within the tissues between the two lungs, e.g. surrounding the heart (not within the heart or blood vessels). This is usually the result of pulmonary barotrauma, but can occur as a result of perforation of the esophagus, stomach or intestine.

Myalgia

Muscle pain.

No-Decompression Dive or No-Stop Dive

A dive where direct ascent to the surface at 30-60 fsw (9-18 meters of sea water) per minute is allowed at any time during the dive without a decompression stop.

Nystagmus

Spontaneous, rapid, rhythmic movement of the eyes occurring on fixation or on ocular movement.

Oxygen

A colorless, odorless, tasteless gas essential to life making up approximately 21 percent of air.

IV Oxygen Toxicity

The term describing the syndrome caused by breathing of oxygen at greater-than-normal atmospheric pressure. Oxygen toxicity primarily affects the central nervous system (CNS) and the lungs. Pulmonary oxygen toxicity is caused by inflammation of the lung tissue itself, resulting in shortness of breath, cough and a reduced ability to perform exercise.

Parenteral

Introduced in a manner other than through the digestive tract, as with parenteral glucagon, an injectable agent which stimulates the liver to release glucose into the bloodstream to counter severe hypoglycemia reactions.

Pulmonary Edema

An accumulation of fluid in the lungs.

Pulmonary Overexpansion

Abnormal distension of the lungs. In divers, pulmonary overexpansion can cause rupture of alveoli and penetration of gas into various surrounding spaces, causing mediastinal emphysema, pneumothorax or arterial gas embolism.

Rapid Ascent

An ascent rate fast enough to put a diver at increased risk of decompression illness, usually at rates in excess of 60 fsw / 18 msw per minute.

Recovery Position

First aid technique for a patient who is unconscious or injured but breathing. The person is placed lying on the side; this helps keep the airway clear if the injured person begins to vomit.

Respiratory Arrest

Cessation of breathing.

Sign

Any medical or trauma condition that can be observed and described.

Supine

Lying flat on back, with face upward.

Symptom

Any nonobservable condition described by the patient.

CARDIOPULMONARY RESUSCITATION (One-Rescuer Adult CPR)

Remember S-A-F-E

Stop;

Assess scene;

Find and secure oxygen, first aid kit and automated external defibrillator (AED) unit; and use

Exposure protection (gloves and mask).

Assess Responsiveness

If no response, call for help — call local emergency medical services (EMS) number, get AED or send second rescuer to do this.

Open AIRWAY

Use the head-tilt, chin-lift method for all.

Assess BREATHING

Look, listen and feel for normal breathing for 10 seconds. If not breathing, give two breaths that make chest rise*.

* In its 2008 statement regarding CPR guidelines, the American Heart Association (AHA) encourages lay providers to administer chest compressions without ventilations. If a bystander was previously trained in CPR and is confident in his or her ability to provide rescue breaths with a minimal interruption in chest compressions, then the bystander should provide conventional CPR using a 30:2 compression-to-ventilation ratio.

Respiratory arrest may result from diving incidents involving loss of consciousness. Such cases demand effective artificial resuscitation. While hands-only CPR is deemed to be effective for general use, DAN Education does not plan to change any DAN courses to remove compression/ventilation protocols.

Do Not Assess Circulation

Do not check for signs of circulation. After delivering two rescue breaths, immediately begin chest compressions. If the subject moves, then stop.

Assume that a person who has stopped breathing is also in full cardiac arrest. The only exceptions to this are when caring for children or if you are a professional rescuer.

Chest Compressions

- Give cycles of 30 COMPRESSIONS and *TWO BREATHS until AED arrives, professional rescuers take over or victim starts to move.
- Push hard and fast (100/min) and release completely.
- Depress sternum 1.5 to 2 inches (4 to 5 cm).
- Minimize interruptions in compressions.

AED/Defibrillator ARRIVES

- Turn on AED and apply pads according to directions.
- Deliver shock if directed, resume CPR for 5 cycles.
- Continue CPR until circulation and breathing resume or help arrives.

YOUR BEACON OF SAFETY FOR OVER 30 YEARS.

DAN is a nonprofit organization that receives most of its funding from memberships and tax-deductible donations. DAN provides expert information and advice to the diving public, promotes and supports diving research and maintains a 24-hour emergency telephone line for dive injuries.

All DAN Members receive *Alert Diver*, DAN's member magazine, as well as coverage under the DAN *TravelAssist* plan, which provides free emergency evacuation assistance and a number of important hospital preadmission and legal services. Emergency evacuation assistance is a benefit for all DAN Members and their dependents during any travel at least 50 miles / 80 km from home.

The *TravelAssist* center numbers are listed inside and on your DAN Member card and must be called first in order to activate the services.

Dive accident insurance packages are available to DAN Members. For complete coverage and pricing information, explore DAN.org.



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