

I03: Dive / Scuba Injuries

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Introduction

Although scuba divers can experience a myriad of injuries from wildlife and trauma, the two most serious forms of diving injuries are decompression sickness (DCS) and arterial gas embolism (AGE), both of which are directly related to the behavior of pressurized gases. In many cases, the signs and symptoms of decompression sickness and gas emboli overlap significantly; it is not important to differentiate between the two in the prehospital environment, and the treatment for both is essentially identical.

Decompression Sickness ("the bends")

Scuba divers breathe compressed air. At depth, the nitrogen in this air dissolves into the bloodstream, and diffuses into body tissues at variable rates. The water pressure around the diver keeps this gas dissolved in the blood and tissues, but as a diver ascends, water pressure decreases, which allows the dissolved gases to come out of solution. (This is similar to opening a pop can – the carbon dioxide remains in the liquid because of the pressure inside the can – and the behavior of gases under pressure is described by Henry's Law.) Normally, during an ascent, divers change depths slowly and breathe constantly ensuring that the nitrogen is released from their lungs, but under some circumstances – a rapid ascent from too deep a dive, for instance – the dissolved gas may not diffuse into the lungs and may instead accumulate in the blood, musculoskeletal system, or other body tissues as bubbles.

Type 1 DCS is limited to the capillaries of the skin, lymphatic vessels, and the musculoskeletal system. It generally includes skin rashes or urticarial and joint pain. In its milder form, the symptoms can be fleeting and last only a few minutes as the bubbles break down and the diver off-gases; these do not generally require treatment. Pain at or around joints is rarely symmetrical. In more severe cases, the pain can increase over 12 to 24 hours after surfacing, and if untreated, will resolve slowly over the next three to seven days to a dull ache.

Type 2 DCS is more serious. It involves the central nervous, cardiovascular, and respiratory systems; common symptoms include headache, blurred vision, nausea, dizziness, and ataxia. Shortness of breath, hypotension, and weakness can occur. In many cases, Type 1 symptoms are also present.

Arterial Gas Embolism

The pressurized gas breathed by a diver at depth expands as she ascends, following the relationship described by Boyle's Law. If the expansion is not accommodated or controlled, the expansion can be fatal. In the lungs, gas can expand and rupture alveoli, introducing air into the bloodstream. Once in the blood, the bolus of air is carried into the heart, and then into the arterial circulation. Air can also be forced into the pleural space between the lungs and chest wall; in some cases, this is the result of a congenital weakness. Pleural air expansion can lead to either mediastinal emphysema (a collection of air in the mediastinum) or subcutaneous emphysema in the neck or upper chest.

Arterial gas embolisms are the most common cause of death in scuba diving.

Essentials

- Decompression sickness should be considered in any diver who, within 24 hours of completing a dive, complains of a persistent headache, dizziness, joint pain, or difficulty balancing. Most DCS cases are mild and treatment is often successful, but recognition can be difficult and expert consultation is required.
- Arterial gas embolisms are sudden, catastrophic events that become obvious upon surfacing. A diver who surfaces in distress should be assumed to have an arterial gas embolism or other barotrauma until proven otherwise.

Additional Treatment Information

- The immediate history of the dive can provide clues to the probability of decompression sickness. Some of the risk factors include:

- Strenuous work at depth
- Deep dives on air only (i.e., no mixed gas)
- Long bottom times
- Cold water dives
- Repetitive dives
- Missed or shortened safety stops
- Dehydration and/or recent alcohol consumption
- Individual susceptibility to DCS is not well understood, and the phenomenon is not predictable. Divers can strictly follow tables and use computers to monitor their dives, and still develop DCS. Every dive carries some risk of DCS, and the absence of risk factors on any given dive does not preclude the possibility of the disorder. A diver demonstrating symptoms consistent with DCS, and who lacks any of the risk factors listed above, should still be considered a potential diving injury until appropriately assessed.
- Individuals who have experienced DCS are at significant risk of subsequent episodes. A prior history of a patent foramen ovale or other structural heart disease resulting in a right-to-left intracardiac shunt is also at high risk of developing DCS.
- Although joint pain within 30 minutes of surfacing is considered a classic symptom of DCS, headaches and flu-like symptoms are also common. Joints commonly involved include the shoulders and elbows and the pain is not significantly worse with movement. These symptoms may take up to 24 hours to develop. Joint pain often resolves in several days.
- Arterial gas embolisms are often associated with rapid, buoyant ascents as might occur when a diver panics; breath holding during an ascent is a common cause. An AGE is an abrupt onset event: divers may be in obvious difficulty on the surface. The development of symptoms beyond 10 minutes post-dive is unlikely to be due to an AGE (consider DCS in this case).
 - Signs and symptoms of arterial gas embolism include:
 - Collapse and unconsciousness
 - Seizures
 - Visual field disturbances or blindness
 - Weakness or paralysis
 - Disorientation
 - Bloody, frothy sputum
 - Chest pain
 - Shortness of breath
 - Barotrauma can occur when compressed gas becomes trapped in a space in the body such as a dental filling, sinus, or the middle or inner ear. Pain and bleeding are common; dizziness, vertigo, and loss of hearing in the affected ear may be present as well.
 - Carbon monoxide toxicity can develop from breathing contaminated air, either in the scuba tank itself, or in the air on a boat. Treat in accordance with CPG J04.
 - Every breathing gas mixture has a critical limit, below which the oxygen becomes toxic. For air, that limit is roughly 200 feet; as the concentration of oxygen in the breathing mixture increases, the limit becomes shallower. Oxygen toxicity develops only in the context of increased partial gas pressures (i.e., it does not happen at atmospheric pressure), and can cause dizziness, nausea, facial tics, visual field disturbances, or seizures. These often develop at depth and remain present upon surfacing. Distinguishing between oxygen toxicity and DCS can be difficult, though a history of the dive (depth, breathing gas mixture) will help.
 - Marine life can cause a variety of injuries ranging from punctures and lacerations to venomous stings. Follow standard wound care procedures in managing these types of injuries.
 - In jellyfish stings, flush the affected area using seawater, as fresh water can cause the nematocysts to fire. Do not use vinegar or other fluids for stings occurring in Canadian coastal waters. After flushing, paramedics should attempt to cautiously, and gently, remove any remaining tentacles by scraping with the dull edge of a knife or plastic card.

Referral Information

Signs of decompression sickness can be subtle, and may take time to develop. An emergency physician should always see patients suspected of having suffered a dive injury. Consultation with a specialist in hyperbaric

medicine is highly recommended.

General Information

- Deliver oxygen at the highest possible percentage and flow rates to symptomatic patients. Continue providing oxygen even if symptoms appear to resolve. Use a non-rebreathing face mask, or bag-valve mask with reservoir. CPAP and PEEP are contraindicated due to the risk of exacerbating an underlying barotrauma.
- To the maximum extent possible patients should be kept supine. If required to protect the airway, an injured diver may be positioned laterally, left side down.
- Dive injuries can be multifaceted. Hypothermia can complicate management, and physical trauma sustained during the dive must be addressed. Do not focus on dive-related injuries to the exclusion of other clinical problems.
- The sole hyperbaric chamber accessible to civilians in the province of British Columbia is at Vancouver General Hospital. Follow destination guidelines – recompression therapy must be coordinated with the hyperbaric unit at VGH prior to patient arrival at the facility; in the absence of traumatic injuries requiring a trauma centre, patients should be transported to their nearest facility for assessment and referral. If the patient is to be flown to VGH, cabin altitude should be kept below 1,000' where possible.
- When communicating with other health care providers, paramedics must be clear about terminology: these patients have experienced a *dive injury* or a *scuba injury*, not a *diving injury*.
- Paramedics should make a concerted effort at gathering information relating to the dive, interviewing the injured diver's buddy, and securing the diver's gear (particularly any computer or monitoring equipment that recorded the depth profile).

Interventions

First Responder

- Provide high flow oxygen
 - → [A07: Oxygen and Drug Administration](#)
 - → [B01: Airway Management](#)

Emergency Medical Responder – All FR interventions, plus:

- Obtain thorough dive history
- Position patient supine where possible

Evidence Based Practice

[Diving Injury \(Decompression Sickness or Bends\)](#)

References

1. British Columbia Drug and Poison Information Centre. Jellyfish. 2010. [\[Link\]](#)
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3. Divers Alert Network. Health & Diving. [\[Link\]](#)
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5. Grover I et al. The SANDHOG criteria and its validation for the diagnosis of DCS arising from bounce diving. 2007. [\[Link\]](#)
6. Nitrox. Nitrox Basics: Oxygen Management (Part 1). [\[Link\]](#)

