Guideline 9.3.5 – First Aid and Resuscitation for Divers who have Breathed Compressed Gas

Summary

Who does this guideline apply to?

This guideline applies to adults and children over 8 years old who have dived while breathing compressed gas during the previous 24 hours or have travelled to altitude (e.g. by aircraft) within 24 hours of diving and have developed symptoms and signs which could be related to the diving.

Who is the audience for this guideline?

This guideline is for use by divers, dive professionals, bystanders, first aiders and first aid training providers.

Recommendations

The Australian and New Zealand Committee on Resuscitation (ANZCOR) makes the following recommendations:

1. Send for an ambulance early in the treatment of suspected decompression illness or pulmonary barotrauma and promptly contact the nearest public hospital Diving and Hyperbaric Medicine Unit (in Australia) or Diving Emergency Service Hotline (New Zealand) for specialist diving medical advice. [Good Practice Statement]
2. Provide near-100% oxygen to the person as soon as possible and continue oxygen administration until relieved by medical personnel. (Near-100% oxygen should be administered even if pulse oximetry indicates a high oxygen saturation). [Good Practice Statement]
3. Manage the person in a horizontal position if early onset decompression illness is suspected. Otherwise, and in the event of breathing difficulty, the person can be managed in a position of comfort. [Good Practice Statement]
4. Record details of the dive(s), the symptoms and signs, first aid provided and response. [Good

Practice Statement]

5. An alert and stable person suspected of having decompression illness may drink non-alcoholic fluids as advised by the diving doctor. [Good Practice Statement]
6. Keep the person thermally comfortable. [Good Practice Statement]

Abbreviations

Abbreviation	Meaning/Phrase
ANZCOR	Australian and New Zealand Committee on Resuscitation
SSBA	Surface Supplied Breathing Apparatus
DCI	Decompression Illness
PBT	Pulmonary Barotrauma
DCS	Decompression Sickness
CPR	Cardiopulmonary Resuscitation
CAGE	Cerebral Arterial Gas Embolism
CoSTR	Consensus on Science with Treatment Recommendations (from International Liaison Committee on Resuscitation - ILCOR)

1.0 | Introduction

'Compressed gas' divers breathe gas (usually air) while underwater. Most commonly, divers use self-contained underwater breathing apparatus (scuba) and breathe from cylinders carried underwater. However, the breathing gas can also be supplied from the surface via a surface supplied breathing apparatus (SSBA). Divers are vulnerable to a variety of potential injuries and illnesses which include ear injuries, drowning, carbon monoxide poisoning, and heart attack, among others. These can be managed by the usual first aid and resuscitation protocols outlined in various ANZCOR Guidelines. However, breathing compressed gas underwater can lead to several unique medical problems, the most significant being decompression illness (DCI) and pressure damage of the lungs called pulmonary barotrauma (PBT). Australian hyperbaric units treat an average of 125 cases of DCI a year.[1] Twenty-nine percent of calls to an Australian based diving emergency hotline were due to suspected DCI, compared to 1% from PBT.[2]

Decompression illness and pulmonary barotrauma require special first aid considerations,

including the prompt and continued administration of near-100% oxygen. This is different from most other first aid uses of oxygen as detailed in ANZCOR Guideline 9.2.10, which should be read in conjunction with this guideline.

2.0 | Background

2.1 | Decompression Sickness

During an air dive, oxygen and nitrogen from the inhaled gas is dissolved in the diver's blood and body tissues. The oxygen is used by the body but the nitrogen remains dissolved in the diver's blood and tissues. Unless the diver ascends slowly enough to allow excess nitrogen to leave the body gradually through the lungs, nitrogen comes out of solution and may form bubbles in the diver's blood and body tissues. The physical effects of these bubbles, and biochemical changes incited by them, can cause lack of blood supply (ischaemic) and inflammatory tissue damage. This is known as decompression sickness (DCS). Some deep divers breathe mixtures of gas containing helium and may face the same problems due to helium bubbles.

2.2 | Pulmonary Barotrauma

As a diver ascends, the gas in the lungs expands with reducing ambient pressure and, unless expanding gas is adequately exhaled, the diver's lungs can distend and tear. This can result in a collapsed lung (pneumothorax) and/or trapping of gas in the mediastinum (mediastinal emphysema), or under the skin (subcutaneous emphysema). Escaped gas may also enter the arterial circulation and distribute to the cerebral circulation causing cerebral arterial gas embolism (CAGE), causing stroke-like symptoms and signs.

2.3 | Decompression Illness

The term decompression illness (DCI) is used to collectively describe both DCS and CAGE. In the emergency setting it is unnecessary to differentiate between these as the first aid and more advanced treatment is the same for both conditions.

3.0 | Recognition

3.1 | Decompression Illness

DCI is associated with a wide range of potential symptoms and signs, from minor to rapidly fatal. Common symptoms and signs include:

- pain (often at or near joints)
- numbness/tingling
- extreme fatigue/feeling unwell
- dizziness/vertigo
- muscle weakness in one or both arms and/or legs
- mottled skin rash
- poor co-ordination
- altered consciousness

3.2 | Pulmonary barotrauma

- chest pain
- difficulty breathing
- coughing
- blueness of lips and tongue (cyanosis)
- voice changes
- difficulty swallowing
- 'crackly' skin around neck (crepitus)
- symptoms and signs of decompression illness may also be present.

4.0 | Management

- If the person is not responding and is not breathing normally, commence resuscitation following the ANZCOR Basic Life Support flowchart [Refer to ANZCOR Guideline 8]. [Good Practice Statement] A person with DCI may regain consciousness and appear to have recovered but still needs to be managed for suspected DCI due to the possibility of relapse.
- Promptly provide as close to 100% oxygen as possible if available and trained to do so and continue to do so until the ambulance/evacuation personnel arrives and takes over management.[3, 4, 5] Near-100% oxygen should be administered even if pulse oximetry indicates a high oxygen saturation. [Good Practice Statement]
- If early-onset DCI is suspected (within 30 minutes of surfacing), lay the person flat if [3, 6–8] [Good Practice Statement]
- Seek immediate diving medical advice by calling the nearest public hospital diving and hyperbaric medicine unit (in Australia), or the Diver Emergency Service (0800 4 DES 111 in New Zealand).[3] [Good Practice Statement]

- Assist with any transfer to a recompression chamber if requested to do so.
- The consulting diving doctor may advise that an alert and stable person thought to be suffering from DCI may freely drink non-alcoholic fluids, such as water or isotonic/electrolyte fluids (as long as they have no stomach cramps, nausea, urinary retention or paralysis).[3, 9, 10] [Good Practice Statement]
- The person should be kept thermally comfortable (warm but not hyperthermic).[3, 6, 11] [Good Practice Statement]
- Record details of the dive(s), the symptoms and signs (and their timing) the first aid given and the response to the first aid. [Good Practice Statement]

Rationale

A flat (horizontal) posture without leg elevation is recommended in persons suspected of DCI as it has been shown to increase the rate of inert gas elimination.[6] It may also reduce the likelihood of arterial bubbles distributing to the brain.[8] An unconscious diver should be managed in the 'recovery position'. However, a conscious person having increased difficulty breathing when supine can be placed in a position of comfort.

Administration of 100% oxygen reduces the size and number of gas bubbles in the blood and tissues by helping to eliminate the inert gas.[5, 12]

References

1. Historical decompression illness data – Australia. Available from: https://www.adsf.org.au/r/general-reports. [cited 2020 October 18].
2. Wilkinson D, Goble S. A review of 17 years of telephone calls to the Australian Diver Emergency Service (DES). Diving Hyperb Med. 2012; 42(3):137-145.
3. Mitchell SJ, Bennett MH, Bryson P, Butler FK, Doolette DJ, Holm JR, Kot J, Lafère P. Pre-hospital management of decompression illness: expert review of key principles and controversies. Diving Hyperb Med. 2018 Mar 31;48(1):45-55.
4. Longphre JM, Denoble PJ, Moon RE, Vann RD, Freiberger JJ. First aid normobaric oxygen for the treatment of recreational diving injuries. Undersea Hyperb Med. 2007 Jan-Feb;34(1):43-9.
5. Hyldegaard O, Møller M, Madsen J. Effect of He-O2, O2, and N2O-O2 breathing on injected bubbles in spinal white matter. Undersea Biomed Res. 1991 Sep-Nov;18(5-6):361-71.
6. Balldin UI. Effects of ambient temperature and body position on tissue nitrogen elimination in man. Aerosp Med. 1973 Apr;44(4):365-70.
7. *Dutka, AJ; Polychronidis, J*; Mink, RB; Hallenbeck, JM. Head-down position after air embolism impairs recovery of brain function as measured by the somatosensory evoked response in canines. Undersea Biomed res. 1990; 17(Suppl):64.
8. Van Allen CM, Hrdina LS, Clark J. Air embolism from the pulmonary vein. Arch Surg 1929;19:567-99.

9. Williams ST, Prior FG, Bryson P. Hematocrit change in tropical scuba divers. Wilderness Environ Med. 2007 Spring;18(1):48-53.
10. Gempp E, Blatteau JE, Pontier JM, Balestra C, Louge P. Preventive effect of pre-dive hydration on bubble formation in divers. Br J Sports Med. 2009 Mar;43(3):224-8.
11. Pendergast DR, Senf CJ, Fletcher MC, Lundgren CE. Effects of ambient temperature on nitrogen uptake and elimination in humans. Undersea Hyperb Med. 2015 Jan-Feb;42(1):85-94.
12. Hyldegaard O, Møller M, Madsen J. Protective effect of oxygen and heliox breathing during development of spinal decompression sickness. Undersea Hyperb Med. 1994 Jun;21(2):115-28.

Further Reading

- Mitchell SJ, Bennett MH, Bryson P, Butler FK, Doolette DJ, Holm JR, Kot J, Lafère P. Pre-hospital management of decompression illness: expert review of key principles and controversies. Diving Hyperb Med. 2018 Mar 31;48(1):45-55.
- Edmonds C, Bennett M, Lippmann J, Mitchell S, editors. Diving & Subaquatic Medicine. 5th Boca Raton, FL: Taylor & Francis; 2016.
- Blake DF, Crowe M, Lindsay D, Brouff A, Mitchell SJ, Leggat PA, Pollock NW. Comparison of tissue oxygenation achieved breathing oxygen using different delivery devices and flow rates. Diving Hyperb Med. 2020 Mar 31;50(1):34-42.
- Lippmann J. Oxygen First Aid for Divers. Melbourne: Submariner Publications; 2016.
- Lippmann J, Bugg S. The Diving Emergency Handbook. 8th Melbourne: Submariner Publications; 2020.

About this Guideline

Search date/s	18 September 2020
Question/PICO:	P: Divers using compressed gas requiring (resuscitation OR first aid) I: Any first aid or first responder intervention (out of hospital) other than standard CPR C: Standard CPR O: (Survival to discharge neurologically intact) OR (survival to admission to hospital) OR (return of spontaneous circulation) S: Any study T: 2000-present
Method:	Evidence update following systematic review Mitchell et al 2018
Primary reviewers:	John Lippmann, Simon Mitchell, Michael Bennett
Secondary review	Finlay Macneil

Worksheet	Hereco spreadsheet
Approved:	April 2021
Guidelines superseded:	ARC Guideline 9.3.5 - November 2011

Referencing this guideline

When citing the ANZCOR Guidelines we recommend:

ANZCOR, 2026, Guideline 9.3.5 – First Aid and Resuscitation for Divers who have Breathed Compressed Gas, accessed 29 September 2026, https://www.anzcor.org/home/first-aid/guideline-9-3-5-first-aid-and-resuscitation-for-divers-who-have-breathed-compressed-gas