**Title CSOP Diving Emergencies**

Version No: 3.4 Effective date: 11/04/2022

## APPROVALS

| | Name | Date | Signature |
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| CGG Approval: | Justin Squires – Deputy Clinical Lead | | |
| Next Review Date: | April 2025 | | |



## HISTORY

| Effective Date | Version No. | Summary of Amendment |
|---|---|---|
| Jan 2013 | 2.0 | Updated into new format, and amended section 2.2.7 to state <1000 feet from <300 m. |
| Nov 2015 | 3 | Moved pathophysiology to an appendix. Condensed management to discuss only specifics related to diving. Removed appendix with details of local centres and directed instead to British Hyperbaric Association website. |
| Aug 2017 | 3.1 | Review |
| Feb 2020 | 3.2 | Symptoms/Signs table moved back into main document<br>Emergency chamber numbers tested and updated<br>Chamber advice updated to reflect network changes |
| Feb 2023 | 3.4 | 24 hour contact number updated as well as process update, spelling and phrasing changes (Avoid – Never reference Entonox, where concern for nitrogen load, always 100% O2 where possible). Highlighted O2 as intervention. |

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## APPENDICES

| Document Reference Number | Document Title |
|---|---|
| Annex 1 | Local Decompression Chambers |

### 1. BACKGROUND

The majority of dives in the UK are in cold water for leisure purposes at a depth of <40 metres. Technical diving to greater depths, and commercial diving involve very different techniques, but from a HEMS perspective the physiology and pathophysiology are similar.

The main factors contributing to diving accidents are;

- Procedural error and dive technique
- Equipment problems
- Diver health
- Environmental issues

The potential sequelae of these factors include;

- Dysbarism (disease arising from changes in ambient pressure, especially during rapid ascent)
  - Barotrauma
  - Decompression illness due to formation of gas bubbles as ambient pressure reduces with ascent. These are almost always nitrogen, but under very rare circumstances helium may also contribute

- Toxicity from inhaled gases (related to depth and duration of dive) or contaminants
  - Nitrogen narcosis
  - Oxygen toxicity
  - Hypercapnoea
  - Contaminated compressed gas - e.g. with carbon monoxide
- Drowning.
- Acute medical events
- Hypothermia
- Dehydration

Appendix 1 outlines the pathophysiology and clinical features of dysbarism and toxicity from inhaled gases.

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## 2. GUIDANCE ON THE APPROACH TO THE DIVING CASUALTY

### 2.1.Safety

- Be vigilant of the dangers of working near water - at Stoney Cove dive centre, for example, the casualty is often treated on a pontoon at the bottom of a steep set of stairs
- If the casualty is still in the water they should be removed, where practical, in the horizontal position to reduce the risk of cardiovascular collapse, but speed of evacuation takes precedence.
- Keep the patient still and avoid rubbing the skin as this may increase the rate of nitrogen bubble formation.

### 2.2.History

- Divers usually work in pairs or teams- the 'dive buddy/buddies' often have valuable information about the event including speed of ascent, duration of dive, recent dive history and which breathing gases were used.
- The diver may not give an accurate history due to the effects of dysbarism or toxicity
- Many divers wear a 'dive computer' which can be interrogated for information. This can help inform management, (and may need to be forensically examined in the event of death.)
- An increasing number of divers are using rebreather diving systems. These are akin to an anaesthetic circle system i.e. exhaled gas is passed through a soda lime $CO_2$ absorber, oxygen added and the gas returned to the diver. It is useful to highlight this to hyperbaric services, as the pathophysiology varies from open circuit diving.

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2.3 Pathophsiology

| | Pathophysiology | Clinical Features / Sequelae |
|---|---|---|
| Barotrauma | Damage can occur as a direct result of changes in pressure affecting gas-filled spaces during descent and ascent.<br><br>Of particular concern is pulmonary barotrauma during rapid ascent without exhalation: as ambient pressure falls the gas at high pressure within the lungs can rapidly expand and cause pulmonary rupture. | • Lung rupture<br>• Pneumothorax<br>• Gas embolism<br>• Pneuomediastinum<br>• Pneumoperitoneum<br>• Ear barotrauma<br>• Dental pain<br>• Sinus pain<br>• Mask squeeze<br>• Petechial haemorrhage<br>• Subconjunctival haemorrhage |
| Decompression sickness | At depth the ambient pressure and pressure of inhaled gases is increased. This leads to a significant increase in the amount of nitrogen dissolved within the blood and saturation of body tissues.<br><br>Rapid decompression leads to nitrogen coming out of solution as bubbles within the tissues. These bubbles can impede circulation and promote ischaemia and inflammation. | Constitutional signs: nausea, weakness, fatigue, aches and pains<br>Skin: Itching, rash, lumps<br>Musculoskeletal: joint or muscle pain with reduced range of movement ('the bends'), spinal pain<br>Gastrointestinal: vomiting, abdominal cramps, diarrhoea<br>Cardiorespiratory: cough, pleuritic chest pain, tachypnoea<br>Neurological: headache, confusion, amnesia, tremors, scotoma, nystagmus, ataxia, reduced sensation and paresthesia, tinnitus, vertigo, hearing loss, paraplegia, reduced conscious level. |

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| | Pathophysiology | Clinical Features / Sequelae |
|---|---|---|
| Oxygen, nitrogen and $CO_2$ toxicity | Exposure to high partial pressures of oxygen or nitrogen cause physiological disturbance The effects are greater as length of dive and depth of dive increase. Divers may use a range of different breathing gasses which affect the degree of exposure. Under some circumstances, usually when using rebreather systems, divers may suffer a $CO_2$ "hit": what medical staff would call hypercapnoea. | *Oxygen toxicity*<br>• Visual changes<br>• Tinnitus<br>• Nausea<br>• Agitation<br>• Dizziness<br>• Seizures<br><br>*Nitrogen narcosis*<br>• Mimics effect of alcohol / benzodiazepines<br>• Impaired judgement and concentration<br>• Vertigo<br>• Auditory and visual effects<br><br>*CO2*<br>• Reduced GCS/Coma<br>• Flushing/vasodilation<br>• Increased respiratory drive (although the response to CO2 varies greatly between individuals) |

2.4 Management - specific points

- Administer as close to 100% inspired oxygen as possible for the duration of treatment to help wash out nitrogen – this can have a rapid, dramatic effect on decompression illness. This should be applied to all patients during initial assessment / treatment
- Maintain a high index of suspicion for pneumothorax (due to barotrauma) - perform bilateral thoracostomies for patients in cardiac arrest
- Never use entonox due to risk of worsening pneumothoraces or causing expansion of nitrogen bubbles / increased nitrogen load
- For ventilated patients, higher PEEP settings (8-10 $cmH_20$) may be beneficial if drowning is suspected, but beware of the patient who has suffered a cardiac arrest underwater, and whose myocardium is stunned

- Removal of the 'hydrostatic squeeze' caused by immersion when casualties are brought out of water may lead to a significant reduction in venous return, and divers are invariably dehydrated after breathing dry gas - have a low threshold for fluid filling, targeting euvolaemia.  This also helps to increase the volume in to which the nitrogen is dissolved
- Agitation may be a symptom of decompression illness and/or nitrogen narcosis
- Check glucose and correct hypoglycaemia
- Hypothermia is to be expected, and tympanic thermometers may be inaccurate
- Be vigilant for signs of decompression illness in other members of the dive team
- Expert advice recommends keeping casualties horizontal and minimising changes in position that may theoretically cause redistribution or propogation of nitrogen emboli. This should not delay evacuation – getting the patient out of the water and evacuated is the priority.

**3. DESTINATION**

The predominant pathology will determine the most appropriate destination for the patient. In the case of drowning or suspected medical / surgical pathology (e.g. STEMI, subarachnoid haemorrhage, etc.) nearby destinations include University Hospitals Coventry and Warwickshire, Leicester Royal Infirmary and Glenfield Hospital.

When the primary concern is decompression illness, it may be appropriate to transport the patient directly to a recompression centre. Take advice from the Diving Diseases Research Centre ( 01752 209 999) [DDRC] - they will help to identify the most appropriate centre. This telephone number is programmed into operational mobile phones.

In hours this number will ring directly to an on call Dive Doctor, out of hours it will ring to a call handling service, specify you are air ambulance / HEMS and you will be put straight through to the doctor.

Nearby centres include;

- Category 1 (capable of receiving critically ill patients)
  - Hull - North of England Medical Hyperbaric Unit, Spire, Hull and East Riding Hospital
  - The Wirral - N W Emergency Recompression Unit, Murrayfield Hospital
  - Great Yarmouth – East of England Hyperbaric Unit, Lowestoft Road, Gorleston

- Category 2 (not capable of receiving critically ill, anaesthetised patients)
  - Rugby - Midlands Diving Chamber, Rugby Hospital

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Category 3 and 4 chambers have lower levels of medical provision and are unlikely to be useful in the acute/HEMS setting.

When patients are taken to a hyperbaric chamber it is helpful if their **dive computer** (or the team mate's computer) accompanies them.

## 4. TRANSPORT

There is a theoretical risk that air travel may exacerbate decompression illness. However, unpressurised flights of up to 1000 feet above sea level have not been shown to have a significant clinical effect. Make the Captain aware of the need to avoid flying at higher altitude although flight safety is the clear priority.

## 5. Abbreviations

| **Abbreviations** | **Definitions** |
|---|---|
| PEEP | Positive end expiratory pressure |
| STEMI | ST elevation myocardial infarction |

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