



## Gallant Aquatic Ventures International

an independent research firm searching for Innovative Resolutions in Extreme Environments

### **GAVI Consensus Statement regarding In Water Recompression**

On April 28-29 2014 in San Diego, CA, Richard Sadler, M.D., FACS, CDR Joseph Dituri USN (ret), M.S. Simon Mitchell, MB ChB, PhD, FANZCA, Craig Jenni, JD, Richard Moon, MD, CM, MSc, FRCP(C), FACP, FCCP; and Richard Pyle, PhD met to discuss the topic of In Water Recompression (IWR) with the intent of polling industry leading physicians and divers in the use and practice of IWR. The following is a consensus statement and list of guidelines that came from the invited speakers and input of dive industry professionals.

A consensus statement is a recommendation(s) or general guidelines developed using available evidence and expert opinion in areas where high quality clinical data is limited or does not exist for controversial clinical dilemmas. These guidelines are systematically developed recommendations that assist the practitioner and diver in making decisions. These recommendations may be adopted, modified, or rejected according to needs and constraints and are not intended to replace local institutional policies. They are NOT to be considered a standard or “best practice” for emergency response of decompression illness (DCI). Their use cannot guarantee any specific outcome. These guidelines are subject to revision as warranted by the evolution of medical knowledge, technology, and practice. They represent basic recommendations that are supported by a synthesis and analysis of the current literature, expert opinion, and open forum commentary combined with any existing data.

These statements represent the opinion, beliefs and best judgments of the aforementioned subject matter experts. As such, they are not necessarily subjected to the same level of formal scientific review as standards. Each person, institution or practice should decide individually whether to implement the principles in this statement based on a careful evaluation of risk vs. benefit, and on the sound judgment of the participants involved situation at that time.

#### **Statements:**

- The definitive emergency response of DCI continues to be a combination of pressure and oxygen in high concentrations.
- Oxygen and pressure are preferred over surface oxygen alone in the emergency response of DCI.
- It is determined that IWR is a viable methodology for first aid (an intermediate step) prior to definitive emergency response of DCI.
- Immediacy of emergency response with oxygen and pressure may be fundamental to effect optimal outcomes in selected symptomatic divers.
- The intrinsic advantage of immediacy in IWR surpasses the potential risks for appropriately selected symptomatic divers.
- IWR has potential for improving outcomes in those divers with symptoms that have rapid onset and a poor prognosis.
- IWR is rarely a complete and sole emergency response for DCI. All symptomatic divers of DCI shall, if they opt for IWR, be evaluated by a physician knowledgeable in diving and hyperbaric medicine as soon as possible following IWR.



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## Recommendations for implementation of IWR:

- During IWR the diver must be accompanied by a tender.
- The effectiveness of IWR will be lessened if the diver becomes cold. Maintenance of optimal thermal comfort is therefore important.
- Indications: While acknowledging the potential benefits of IWR, the potential risks of IWR limits its applications to those divers with symptoms associated with poor outcomes. (Appendix I - Tier System)-and severe pain.
- Emergency response time should extend 60 minutes after the resolution of symptoms the total emergency response time must NOT to exceed 120 minutes at depth.
- The emergency response protocol should be terminated at any time if deemed necessary by either the tender or diver-symptomatic diver.
- The breathing mixture should be as close as possible to 100% oxygen (with the goal of achieving a PPO<sub>2</sub> of 1.6 ATM/BAR); mixtures containing less than a minimum FiO<sub>2</sub> of 0.80 (80% inspired oxygen concentration) should not be used for IWR.
- Emergency response depth should not exceed 20 ft (6m), even if the breathing mixture contains less than 100% oxygen.
- Periods of breathing air (“air breaks”) are not required due to additional complexity.
- The planned ascent rate should be 1ft (0.3m) / min. if possible.
- In the event of an emergency (such as loss of consciousness in the treated diver) a rapid ascent should be made to the surface. If the diver is convulsing and the mouthpiece is retained, (eg during use of a retaining strap or if a full face mask is used) ascent should be delayed until the seizure has stopped. If the mouthpiece is not retained an ascent should be made immediately, even if the convulsion continues.
- If symptoms return during ascent from the planned IWR, the diver may return back to 20ft (6m) if the total time at 20ft (6m) has not yet exceeded 120 min.
- After exiting the water following IWR, the symptomatic diver must not re-enter the water even if symptoms recur.
- Mild activity (e.g., gentle finning movement) is acceptable and encouraged during IWR.
- For severe DCI (e.g. paralysis), judgment will be required to weigh the benefits of quicker IWR with short delay to evacuation vs. immediate evacuation to a hyperbaric facility that may be many hours away. Consultation with an offsite diving medical expert is recommended”.



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## **Practical and logistical considerations for equipment:**

Pre - emergency response informed consent of all potential IWR participants should ideally be obtained. In order to facilitate this, a webinar or video on line should be used where IWR is explained and a standard waiver is signed. Trained IWR divers should practice IWR regularly in order to maintain proficiency.

A regulator retention (gag) strap is strongly recommended to hold the regulator in place in the unlikely event of an oxygen seizure. (See Appendix II Airway Protection)

The use of a full face mask is recommended for trained users. Significant caution is advised for the untrained user. (Appendix II Airway Protection)

While rebreathers are recognized as a potential tool for administration of oxygen during IWR, their use in IWR by divers untrained in their use should only be attempted under expert supervision.

The symptomatic diver's depth should be controlled by the use of a stable reference line.

Control of the symptomatic diver and in water tender should follow the principles outlined in the sidebar.

A community database of IWR incidents & outcomes will be maintained by Duke University (<http://dukedivemedicine.org/>) for Gallant Aquatic Ventures International and the general public. This information will be shared freely with all interested parties.

The group determined the most important information required during assessment of an injured diver and IWR is a timeline or chronology of events, along with key relevant data describing the symptomatic diver and circumstances of the incident. The following information should be captured:

Point of contact information for further details:

1. Age
2. Race
3. Gender
4. Symptomatic diver training level (Recreational / Technical / None).
5. Dive profile / Breathing gas(s)
6. Time of symptom onset.
7. Order of symptom progression
8. Time of symptom resolution.
9. Surface oxygen use and duration.
10. IWR Protocol / complications, Temperature / thermal protection.
11. Free narrative space.
12. Outcome/degree of recovery (Complete / Partial / None) and whether diver was referred for evaluation, hyperbaric emergency response, etc.
13. Name and contact information of reporter.

## **Diver control Principles:**

1. Some form of positive contact with the diver/symptomatic diver is mandatory. The diver / symptomatic diver must never be un-tethered. Examples of Positive Control:
  - a. Diver / symptomatic diver is connected to the down line with a separate line.
  - b. Diver / symptomatic diver is tethered to the accompanying diver with a line.
  - c. The use of a quick release (snap) shackle in either case is reasonable.
2. The surface support team and tender should be prepared for a sudden deterioration of the diver/symptomatic diver.
3. If reasonably foreseeable adverse conditions cannot be mitigated, the IWR protocol should be terminated.



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## Appendix I: Tier System

**Tier I** *Common non-specific symptoms that may not be DCI and do not represent a significant threat.*

**Lethargy**  
**Nausea**  
**Headache**

**Tier II** *Symptoms and signs that are likely to be DCI but which are not likely to result in permanent injury nor death.*

**Lymphatic obstruction** (*swelling under the skin*)

**Musculoskeletal pain** (*Note: When pain arises in the hip [especially both hips at once], abdomen or spine. This may be referred from spinal cord involvement. Be particularly alert for progression to Tier III symptoms in these patients.*)

**Rash** (*May vary from fine red rash to blotchy bruised appearance, and may be itchy or sore. The rash is often localized to one body area, but may be more generalized.*)

**Subjective sensory changes** (*Altered skin sensation and “tingling”*)

**Tier III** *Symptoms and signs that are likely to be DCI (or arterial gas embolism) and which indicate a risk of permanent injury or death.*

**Changes in consciousness or obvious confusion**

**Difficulty with speech**

**Walking or balance disturbance**

**Sensory loss (such as numbness) that is obvious to the diver or examiner**

**Weakness or paralysis of limbs that is obvious to the diver or examiner**

**Bladder dysfunction (inability to pass urine)**

**Sphincter (bowel) dysfunction**

**Loss of coordination or control in the limbs**

**Shortness of breath**

**NOTE:** This classification of DCI symptoms and signs is intended to aid selection of subjects for IWR. It is not intended as a guide to selection of divers for referral to definitive care. To be clear, all divers with symptoms in any of the tiers should be discussed with a diving medicine expert as soon as possible.



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## Appendix II: Airway Protection

Protection of the symptomatic diver's airway is of paramount importance. The workshop consensus recommendation of a maximum oxygen partial pressure of 1.6 ATA minimizes but does NOT REMOVE the risk of seizure. The consequences of aspiration underwater are potentially life threatening. Options to mitigate this risk of aspiration are discussed here-in.

All previous IWR protocols require or strongly advocate the use of a full face mask (FFM), primarily to mitigate the consequences of a hyperoxia-induced seizure underwater. These previous protocols also incorporate breathing near-100% oxygen at depths in excess of 6m/20 feet, where the inspired oxygen partial pressure is in excess of 1.6 bar/atm. As advantageous as a FFM may be in the event of a seizure underwater (for reducing the probability of drowning), the use of a FFM also imposes some difficulty (and risk) for divers who are not trained in their use; particularly in terms of diver comfort level, proper fit and sealing, and (depending on the specific style of mask) techniques for clearing water from the mask and performing the Valsalva maneuver. In the context of these recommendations, a maximum depth of 6m is advocated for IWR (a depth at which near-100% oxygen is commonly breathed by technical divers for decompression). At 6M, the incidence of hyperoxia-induced seizure is extremely low and the potential net benefits of using a FFM depend on the degree of training and familiarity the afflicted diver already has with this equipment prior to attempting IWR. Therefore, a "gag strap" is recommended in cases where the symptomatic diver is not already trained in the proper use of a FFM, or when a FFM is not available.

The purpose of the gag strap is the same as the full face mask; to prevent loss of the mouthpiece / gas supply and to provide a degree of airway protection in the event of loss of consciousness. Although more controversial than a full face mask for this purpose, the gag strap is arguably supported by data. Gemp et al<sup>1</sup> reported 54 underwater loss of consciousness events in military divers leading to only 3 fatal drownings. In this series there were 26 cases of CNS oxygen toxicity with seizures, with an 11.5% major complication rate: two deaths (caught under a barge) and one non-fatal moderate water aspiration. The use of the Drager-style gag strap with strap and lip sealing flange was used in all cases. Although this is an uncontrolled series, and notwithstanding the potential for other factors to influence outcome in the military setting, the unexpectedly high survival following these events suggests that gag straps are effective in most cases. Improvisation of gag straps by divers is not encouraged.

However, a recent informal survey of a few manufacturers by a former US Navy diver revealed a lack of familiarity with a regulator retention strap save for the ones that are available for specific rebreathers. It therefore does not appear that a purpose-built, commercially manufactured regulator retention strap would be readily available to divers, possibly encouraging improvisation, with mixed results. It has also been suggested that involuntary contraction of the masseter muscles during a grand mal seizure could result in damage to the mouthpiece, possibly leaving fragments in the mouth or causing a leak. It must be noted, however, that this study involved the use of the Drager gag strap which has several important design features that probably enhance efficacy. Similar straps can be purchased and are recommended.

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<sup>1</sup> Gemp E, Louge P, Blatteau J-E, Hugon M. Descriptive epidemiology of 153 diving injuries with rebreathers among French military divers 1979-2009. *Mil Med* 2011;176:446-450



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**Full Face Mask:** This is the traditional “best practice”.

### **Advantages include:**

1. The airway is maximally protected (not perfectly) from ambient water in the event of a seizure.
2. Should a seizure occur, the tender has more options for a controlled ascent.
3. Allows for communication with the symptomatic diver if appropriately wired.
4. Adds additional thermal protection.
5. Lessens jaw fatigue by not requiring a mouthpiece.

### **Disadvantages include:**

1. Minimum cost of approximately 500-750 USD
2. It may not be an adequate fit to the symptomatic diver's face.
3. Optimal safe use requires training, including techniques on clearing, purging, and adjusting the usual five point strap system.
4. Vomitus may be difficult to clear, creating a second risk of aspiration.
5. The FFM may not be suitable for use with a rebreather.

**Judgment should be used when making the decision to use a Full Face Mask.**

**Regulator Retention Strap (“Gag Strap”)** This consists of a strap around the head/neck attached to the second stage regulator and a rubberized flexible flange around the mouth, preventing loss of regulator and a barrier to water in the event of seizure.

### **Advantages include:**

1. Less costs than a FFM estimate less than 100 USD
2. Requires minimal training
3. Quick to set up and implement
4. Reduce jaw fatigue during long dives.
5. Acceptable effectiveness. (A published report (Gemp) demonstrated 3 deaths from 54 seizures).

### **Disadvantage include:**

1. Not as protective of the airway as a FFM
2. Properly designed devices are not widely available.