

In-water recompression for severe decompression illness in competitive freediving: a case report

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Abstract

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Introduction: Decompression illness (DCI) is a recognised risk of freediving. When timely hyperbaric oxygen therapy (HBOT) is unavailable, oxygen-based in-water recompression (IWR) may be considered.

Case report: A 49-year-old competitive freediver developed severe neurological DCI within minutes of surfacing from a dive to 117 metres of seawater at a sanctioned competition, with altered mental status, right facial droop, right hemiparesis and aphasia. With an anticipated 24–48 h delay to HBOT, emergency IWR was initiated with a full-face mask and 100% oxygen. Incremental ascent from 18 msw over 14.5 min produced substantial recovery. Residual gait instability and pronator drift prompted a second oxygen-IWR 5.5 h later from 15 msw over 41 min, achieving complete resolution.

Discussion: While this case had an excellent outcome, IWR carries significant risks including oxygen toxicity and drowning, and review identified serious safety and ethical failures. Patient selection is key; perceived benefit must be weighed carefully against risk.

Conclusions: IWR may be considered for DCI when HBOT is not promptly accessible. No IWR guidelines exist specifically for freedivers. The success of this case does not establish that deeper exposures were necessary or superior to shallower protocols. IWR is high-risk, requiring proper selection, trained personnel and favorable conditions.

Introduction

Decompression illness (DCI) encompasses decompression sickness (DCS) and arterial gas embolism (AGE).¹ It is an increasingly recognised complication of freediving, particularly after repeated dives or single dives beyond 100 metres of seawater (msw).^{2–4} Definitive treatment is hyperbaric oxygen therapy (HBOT),⁵ which is often unavailable within a clinically useful timeframe from the remote locations where deep freediving competitions are held.

In-water recompression (IWR), returning a symptomatic diver to depth to breathe oxygen on a defined schedule, has been used when timely HBOT is not feasible.^{5,6} Expert guidance supports oxygen-IWR for moderate-to-severe or progressive DCS where trained personnel, equipment

and conditions permit, and lists altered consciousness, vertigo, vomiting, shock and physical incapacity among contraindications.⁵ The principal published schedules, the Australian and US Navy protocols, recompress to 9 msw.^{6,7} Both derive from compressed-gas diving; none is validated for freediving. Appropriate patient selection is therefore a paradox: those with significant DCI most likely to benefit from very early recompression may also be riskiest to manage underwater.

A recent case series described 13 DCI incidents among six competitive freedivers, six treated with IWR at 5–25 msw with no protocol consistency. Only one was medically supervised, the rest self-diagnosed and self-treated. The authors concluded that freediving-specific IWR guidance should be developed.⁸

Table 1

Timeline of events, clinical findings and interventions; time is given from surfacing. CWTB – constant weight with bi-fins; DCI – decompression illness; IWR – in-water recompression; NRB – non-rebreather mask

Time (h:min)	Event and findings	Intervention
0:00	Surfaced from 117 msw CWTB dive; initially well	On-site medical oversight available
0:08	Began breathing oxygen at 3 msw (standard practice after dives deeper than 80 msw)	100% oxygen by second-stage regulator at 3 msw
0:10	Difficulty maintaining position on line; signalled distress	Assisted to beach by safety and medical team
0:14	Unresponsive to voice; right facial droop; right hemiparesis; aphasia	High-flow oxygen by NRB at > 15 L·min ⁻¹ ; severe neurological DCI suspected
0:15–0:32	Emergency oxygen-IWR #1; improved mentation within one minute at 18 msw	100% oxygen via full-face mask; 18 msw with incremental ascent over 14.5 min
0:32–0:48	Post-IWR #1 on surface	100% oxygen via NRB at 15 L·min ⁻¹
0:48	Ambulated with assistance to medical vehicle; vital signs stable	Monitoring and supportive care
1:10–1:20	Fingertip paresthesia; abnormal sensation right leg	Re-examination by neurosurgeon: paresis and aphasia resolved; residual gait instability and right pronator drift
6:20	Non-emergency oxygen-IWR #2	100% oxygen by second-stage regulator; 15 msw with incremental ascent over 41 min
7:05	Complete resolution of pronator drift and gait instability; vital signs stable	Ongoing monitoring

We report a physician-supervised case of severe neurological DCI treated with staged oxygen-IWR at a sanctioned competition, describing the decision-making, schedules, outcome, and the failures identified on review.

Case report

The patient provided written informed consent for anonymous publication of his clinical details.

A 49-year-old male competitive freediver (172 cm, 67 kg) presented with acute neurological symptoms after a competition dive. He was a non-smoker with no medical comorbidities or medications. He had a prior history of DCI self-treated with IWR, and no baseline neurological deficit.

The incident occurred on day six of a competitive diving program. Seas were calm, visibility exceeded 20 m and water temperature was 29°C. His competition dives were: day one, constant weight (CWT) 111 msw (3:04 min:s); day two, constant weight with bi-fins (CWTB) 108 msw (3:08); day three, rest; day four, CWTB 114 msw (3:18); day five, rest; day six, CWTB 117 msw (3:23), the incident dive. All prior dives were completed successfully without lung squeeze or DCI.

Table 1 summarises the timeline. On surfacing at 10:40 he was alert and oriented without focal deficit, self-extracted onto the platform, and examined normally. He conversed in full sentences with normal speech and no facial asymmetry, showed intact fine motor function, and ambulated normally.

He was not cyanotic and there was no clinical evidence of hypoxaemia. He later reported right upper limb paresthesia beginning three to four minutes after leaving the water, which he did not disclose at the time.

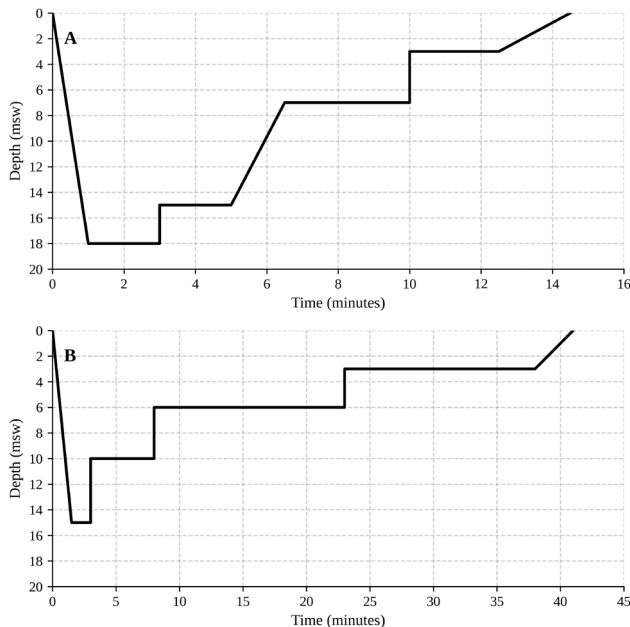
At 10:48 he moved to an underwater line to breathe 100% oxygen at 3 msw for five minutes, routine practice after dives deeper than 80 msw. He swam there unaided, was handed to the in-water medic, and descended without difficulty. At approximately 10:50, after two minutes breathing oxygen, he was seen struggling to hold position and signaling distress. He was recovered to the beach by safety divers, placed supine at the water's edge, and given oxygen by non-rebreather mask at > 15 L·min⁻¹. By 10:54 he was unresponsive to loud voice with right facial droop, right upper and lower limb hemiparesis and aphasia. Severe neurological DCI was suspected.

Given rapidly evolving focal deficits and an anticipated 24–48 h delay to a chamber, the medical team, safety diving team and event organiser jointly decided on emergency oxygen-IWR. The patient could not consent because of his altered mental status. He was known to both teams and had openly advocated IWR in emergencies. The decision rested on the high probability of permanent deficit or death given the delay, and his previously expressed wishes.

On-site personnel included certified scuba divers, an anesthesiologist/intensivist, a neurosurgeon, a respiratory therapist and a paramedic with equipment for advanced resuscitation. Safety divers capable of repeated 18 msw

Figure 1

In-water recompression (IWR) depth profiles; depth scales are identical, time scales differ. (A) Emergency oxygen-IWR following the incident dive, total duration 14.5 min. (B) Second, non-emergent IWR performed approximately 5.5 h later, total duration 41 min



breath-hold dives observed the patient. An escorting scuba diver accompanied the patient throughout, breathing 100% oxygen because no air cylinder was available.

The first IWR ran from 10:55 to 11:12. A full-face mask (Guardian, Ocean Technology Systems, Santa Ana, CA) delivering 100% oxygen was fitted, allowing facial visualisation. Safety divers floated him the short distance from shore to the decompression line with continuous hands-on support and dived him to 18 msw. He then ascended incrementally to the surface over 14.5 min, head-up throughout (Figure 1A). Within a minute at 18 msw he was audibly humming on exhalation, could grip the line, and later reported feeling “*a lot better straight away*”.

He resumed oxygen by non-rebreather at 15 L·min⁻¹. At 11:28 he walked with assistance to the medical vehicle; vital signs were stable (SpO₂ 100%, blood pressure 125/73 mmHg, respiratory rate 14 breaths·min⁻¹, heart rate 55 beats·min⁻¹). At 11:50 he described fingertip paresthesia and an abnormal sensation in the right leg. Examination at 12:00 showed resolution of hemiparesis and aphasia but residual gait instability and right pronator drift. Now competent, he declined evacuation despite strong recommendation and requested a second IWR.

After verbal consent and a time-out, a second oxygen-IWR was performed at 17:00 under physician supervision with two alternating safety divers. He self-descended to 15 msw and ascended incrementally over 41 min (Figure 1B), head-down, breathing oxygen by second-stage regulator.

Pronator drift and gait instability resolved completely, with no oxygen-related complications. Re-examination after this session found him at his neurological baseline, with complete resolution of all symptoms. He was withdrawn from the competition and advised not to dive until assessed by a diving physician.

Discussion

A left hemisphere syndrome with dense right-sided deficits evolved over 14 minutes after surfacing, improved promptly with IWR and resolved entirely after a second session. This lateralised cortical presentation suggested AGE. In breath-hold diving this has been proposed to occur without pulmonary barotrauma, through right-to-left shunting of decompression-derived bubbles across a patent foramen ovale or intrapulmonary anastomoses, though the pathophysiology remains debated.⁹

No consensus defines a ‘reasonable timeframe’ to HBOT before consideration of IWR; clinical deterioration is suggested beyond delays of two to six hours,^{6,10} while the US Navy Diving Manual considers IWR when anticipated chamber delays exceed 12–24 h.⁷ This patient met several prerequisites for attempting IWR: severe, rapidly evolving deficits; prolonged anticipated delay to HBOT; warm calm water with established safety infrastructure; full-face oxygen delivery; and personnel able to observe continuously and abort. Nonetheless, the presentation included altered consciousness and physical incapacity, both plausible contraindications due to drowning risk. Mitigation comprised a full-face mask, continuous hands-on control, escorting safety divers and physician supervision, but a full-face mask neither guarantees prevention of aspiration nor permits assisted ventilation should breathing cease. Taking an incapacitated patient underwater remains high-risk and requires extreme caution. IWR also trades the controlled conditions of a chamber for immediacy, defensible only where the benefit of early recompression clearly outweighs the added hazard.

The first schedule began at 18 msw, deeper than the 9 msw of commonly cited protocols;^{6,7} the second at 15 msw. Both were selected pragmatically. Reasoning from Boyle’s law, the team expected the greater ambient pressure at 18 msw to produce greater bubble volume reduction than a 9 msw schedule, and judged that this might promote faster reversal of a presumed cerebral arterial gas embolism. The 18 msw schedule was devised by the event organiser and had reportedly been used in unpublished freediving cases; the second reflected milder residual symptoms and stability.

The outcome was excellent, but recovery does not establish that the deeper exposures were necessary, safer or superior to established shallower protocols. Optimal IWR strategy for freediving is unknown; reported depths span 5–25 msw with no consistency between protocols.⁸ A deeper schedule produces greater bubble volume reduction and may promote

more rapid redistribution of bubbles occupying vessels on the arterial side of the cerebral microcirculation, though this is unproven. These potential benefits come at the cost of a greater risk of oxygen toxicity seizure and consequent drowning, plus, because of the greater distance to the surface, a longer ascent to reach the surface medical team should IWR need to be aborted. The risk of an oxygen toxicity seizure is substantially greater in water than in a dry chamber, where a convulsion can be managed without risk of drowning, and an irritable injured brain probably adds further to that risk. To be clear, we are not recommending the tables used in this case over published alternatives; we share them to add to a sparse literature.^{11,12}

Review identified several failures. There was no pre-established IWR plan despite the known delay. The escorting diver breathed 100% oxygen at 18 msw because compressed air was unavailable, an avoidable toxicity risk in a diver managing a patient; escorting divers should breathe compressed air. This was a major shortcoming. A full-face mask was not used for the second session; now competent, the patient chose a mouthpiece for comfort and familiarity. In retrospect we would recommend a full-face mask for both sessions, since it offers better airway protection should an oxygen toxicity seizure occur. Treatment proceeded without consent in a patient unable to give it, justified as necessary to prevent death or serious harm, but this remains a concern a favorable outcome does not resolve.

For future remote events, improvements include pre-emptive IWR discussion and protocol selection with athletes and staff, a possible pre-consent form where evacuation is not timely, equipment checks, role assignment and abort criteria. We recommend a full-face mask and a pre-procedure timeout before any attempt at IWR. An aspirational goal for teams intending to use IWR is specific training in the use of 100% oxygen in water, together with rehearsal of IWR scenarios; preparation of this kind would avoid situations such as the unavailability of compressed air for the escorting diver that occurred here. Documented, supervised cases remain rare; most reported freediving IWR is self-administered without oversight.⁸ We include our shortcomings to help others prepare better and avoid making the same mistakes.

Conclusions

Severe neurological DCI can occur in competitive freediving, often far from hyperbaric facilities. Where timely transport to HBOT is not possible, oxygen-IWR may be considered in carefully selected cases. Here, complete recovery followed two physician-supervised IWR sessions from 18 msw and 15 msw, though this does not establish that deeper exposures were necessary or superior. IWR remains high-risk, warranted only when anticipated benefits clearly outweigh risks, with proper training, equipment and safety protocols in place. This case adds to the limited literature on IWR and provides insight into its potential application in competitive freediving emergencies.

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