

In-Water Recompression

(article reproduced from Undercurrent In-Water decompression)

You've sustained DCS hit in a remote location, hours by air from the nearest hyperbaric chamber. It could be serious. The air ambulance cannot fly due to weather, and even if it could it's uncertain if the chamber is operational. What to do? Don't be surprised if your captain suggests sending you back down. While in water recompression might sound like folk medicine, it is a valid emergency technique when performed under the direction of someone properly trained.

In-water recompression (IWR), not to be confused with re entering the water to complete a missed deco obligation, is a legitimate emergency substitute for chamber recompression. It emulates hyperbaric treatment by taking the bent diver back to depth, while he breathes high concentrations of O₂. Depending upon the method used, he may stay down as long as ninety minutes at thirty feet (though some methods go deeper and total time is longer)

Of course, IWR preceded the hyperbaric chamber. When a hardscrabble diver realised he could reduce surface pain by going back to depth, IWR got a foothold. It was possibly first used by bent sponge divers off Key West in the late 1800s, but it may have evolved independently wherever there were divers. Hawaiian black coral divers and Australian pearl divers returned to depth breathing compressed air. As oxygen became available, treatment improved considerably, though compressed air is still used -- but not advisedly -- when oxygen is unavailable.

Four IWR protocols have been developed to be applied after a diver experiences the first DCS symptoms. Commonly called the Australian, U.S. Navy, Hawaiian, and Pyle methods, each differs in submersion depth, time and ascent requirements. Each requires its own equipment, personnel knowledgeable in IWR, skilled tenders and adequate pure O₂ or other gas. All have plenty of success stories, as the cases we cite later show.

Not surprisingly, major recreational dive training agencies are circumspect about IWR. Since it is not accepted as an appropriate technique, the lawyers of an injured diver -- at least in American -- might have a field day. PADI Educational Consultant Leroy Wickham told Undercurrent that they do not teach IWR, nor would they recommend it except under extraordinary circumstances and then only by qualified and properly equipped personnel. Several technical agencies, IANTD and TDI among them, touch on IWR in trimix classes, and the entire procedure for the Australian variant is published in IANTD's "Technical Diver Encyclopedia."

IANTD founder Tom Mount told Undercurrent that IANTD does not yet teach IWR because of its lack of broad acceptance. He includes a caveat that IWR is only to be done by qualified and properly equipped individuals in remote areas where a chamber is not available. When pressed for an example of such a location, he named Bikini, in the North Pacific, where chamber treatment could be 36 hours away. Fascinatingly, he mentioned that he had directed IWR on about 15 divers over the years, including his wife during a trip a Roatan before a chamber was available there. His reported a startling 100% success rate.

Dive medicine organisations note that fatigue, cold, panic, seasickness or an exhausted gas supply can result in incomplete treatment, worsening of the DCS and possible O₂-induced convulsions and hypothermia. Joel Dovenbarger, VP of Medical Services at DAN, told Undercurrent that IWR should only be considered in remote areas where conventional and proven methods are unavailable, and where there are trained personnel and logistical support.

Despite warnings, the sobering reality is that in Type II hits with serious vascular obstruction, irreversible brain damage can occur after 7 minutes, irreversible spinal cord damage after 15 minutes and lung damage after 10-20 minutes. In addition, research has consistently shown that the sooner DCS is treated, the more salubrious the outcome.

So, IWR has its champions. Veteran technical diving expert Bret Gilliam has knowledgeably written on the topic. Richard Pyle, a diver-academic at Bishop Museum in Honolulu, is a vigorous champion. Another solid supporter is Dr. Ann Kristovich, Women Divers Hall of Fame member and co-leader of Proyecto De Buceo Espeleologico Mexico Y America Central. She holds that if travel time to a recompression chamber would take longer than 30 minutes, then she would use IWR.

Australian Dr. Carl Edmonds told participants at an in water recompression workshop that "if you've got a three-hour gap between the patient getting symptom and getting a MEDIVAC going, then you might as well use ...underwater [recompression] immediately."

There is a strong theoretical basis to speculate that the procedure could be beneficial if applied correctly. It should reduce bubble growth, due to both increased pressure and the wash out of nitrogen by high blood levels of O₂. Additionally, the increased PO₂ from breathing pure oxygen could mitigate tissue hypoxia secondary to gas embolisation.

The most popular method, the Australian procedure, mandates continuous breathing of 100% oxygen at a depth of 30' for 30 minutes for mild symptoms up to 90 minutes for severe ones. Ascent rate is not to exceed 1' per 4 minutes, and inspiration of pure O₂ is to continue for 12 hours.

The Hawaiian method, reasoning that increasing pressure provides decreasing bubble size, directs a "spike" on air to 30' deeper than the depth at which symptoms resolve, but not more than 165', for 10 minutes. The diver then ascends to 30' and breathes surface supplied oxygen for prolonged periods.

The US Navy method requires substantial amounts of pure O₂, and recommends using a 100% O₂ rebreather. It directs descent to 30' for 30 minutes for Type I DCS and 90 minutes for Type II, followed by an ascent completed in two 60-minute segments, one at 20' and a second 10'. After surfacing, pure oxygen is to be inspired for 3 hours. The Navy recommends IWR when a hyperbaric facility is more than 12 hours away.

Richard Pyle has developed the latest method. Based on research, but not empirical evidence -- none of the models is -- his method administers 100% oxygen at the surface for 10 minutes, during which they assess the progression of symptoms. If

IWR is appropriate, the diver, with a tender, is lowered to 25' breathing 100% oxygen for 10 minutes. If symptoms resolve after 10 minutes, the depth is maintained and pure O₂ continued for 90 minutes, interspersed with 5-minute periods breathing air or EAN every 20 minutes. Should symptoms persist more complex procedures at deeper depths are applied.

Pyle got interested in research after he himself got bent. He told the in water recompression workshop that "I was 19 and immortal. I did some stupid dives. . . . [Afterwards] I was having rapidly progressing quadriplegia. I was the only one on the boat for 10 minutes before I could hear my buddy's bubbles. I hobbled over to the side and buddy breathed with him for all of 7 minutes at 10 feet on air and emerged. I could not detect any symptoms at all....They remained undetected for 20 minutes, long enough for me to drive the boat back to a dive shop, alert them, get some more tanks, and have them get the recompression chamber operable." Pyle says his legs were not coordinated and he was falling down, but after four more hours breathing air at 20 feet, then chamber treatment, he had no more ill effects.

Data supporting IWR is like Pyle's, which lacks scientific rigor, but is nevertheless impressive. The results cut across a hodgepodge of divers, variants and gases, but meta-analysis does suggest the procedure works. An overwhelming majority of bent divers have come out of IWR either asymptomatic or improved, with only a fraction being worsened or having an ambiguous result. This is especially provocative given that much of the reported IWR was done using compressed air rather than recommended 100% O₂. Here are a few interesting cases, compiled by Pyle.

In the Central Pacific, a diver had partially completed his decompression following 15 minutes at 200 ft, when he saw a very large and inquisitive tiger shark rising above and passing between him and the boat, He decided to abort decompression. After a rapid ascent from 40 ft, he hauled himself over the bow of the 17-foot Boston Whaler (without removing his gear) and instructed his startled companion to haul up the anchor and drive the boat rapidly to shallower water. By the time they re anchored, the diver had increased pain in his left shoulder. He re-entered the water and completed his decompression, emerging asymptomatic.

After ascending from his second 10-minute dive to 190 ft, a Hawaiian diver followed the decompression ceilings suggested by his dive computer. As he neared the end of the schedule, he suddenly noticed weakness and incoordination in both arms, and numbness in his right leg. He immediately descended to 80 ft where, after 3 minutes, the symptoms disappeared. After 8 minutes at 80 ft, he slowly ascended (his companion supplied him with fresh air tanks) over 50 minutes to 15 ft. He remained at this depth until his computer had "cleared." He felt tired after surfacing, but was otherwise asymptomatic.

In cases where DCI results from gross omission of required decompression, divers may anticipate the probable consequences, and return immediately to depth as soon as possible to complete the required decompression, says Pyle. After a second dive to (100 ft), this Australian diver omitted decompression due to an intimidating tiger shark. Within minutes of surfacing, he developed back pain, progressively increasing incoordination, and partial leg paralysis. After two unsuccessful attempts

at air IWR, he was transported to a hospital, 100 miles away, 36 hours after the onset of symptoms. Due to adverse weather, they could not transport him to the recompression chamber, 2,000 miles away, for an additional 12 hours. By this time, he was unable to walk and had cerebral symptoms. They returned him to the water to 27 ft, where he breathed 100% oxygen for 2 hours, then decompressed at 3 ft every 12 minutes (the Australian Method). Except for small areas of sensitivity on both legs, other symptoms had disappeared.

Carl Edmonds reported on a case that occurred in the Solomon Islands. At the time, the nearest recompression chamber was 2,200 miles away and prompt air transport was unavailable. Fifteen minutes after a 20 minute dive to 120 ft, and 8 minutes of decompression, a diver developed respiratory distress, then numbness and partial paralysis, severe headaches, involuntary spasms, clouding of consciousness, muscular pains and weakness, pains in both knees and abdominal cramps. No significant improvement occurred after 3 hours of surface-breathing oxygen, so they returned her to the water, breathing 100% oxygen at 30 ft. Her condition was much improved after the first 15 minutes, and after an hour she was asymptomatic, with no recurrence of symptoms.

Shortly after a third dive to 120-160 ft, a Hawaiian diver developed uncontrollable movements of the muscles of his legs. Within a few minutes, he became numb from the nipple-line down and unable to move his legs. He could hold a regulator in his mouth, so a full scuba tank was strapped to his back and they rolled him into the water to a waiting tender diver. The tender verified that the victim could breathe, and dragged him down to 35 ft. When the symptoms did not regress, the victim was pulled deeper. At 50 ft, he regained control of his legs and indicated that he was feeling much better. They later supplied him with an additional scuba tank, ascended to 25 ft for a period of time and then finished his second tank at 15ft. Except for feeling "a little tired" that evening, he regained full strength in his arms and legs and remained asymptomatic.

Although most of the reported attempts at IWR have used only air, the practice is discouraged due to the risks of additional nitrogen loading. Nonetheless, these cases were successful.

So, while IWR obviously requires much further study and adjustment, it may have a promising future under the unique set of circumstances for which it is designed. After all, breathing oxygen at depth is just what a hyperbaric chamber is all about. The day may come when it's an accepted procedure to treat divers and the training and medical agencies will open the door and let it come out of the closet and it becomes.

But don't expect that anytime soon. As Richard Overlock, MD, told the recompression workshop. "There is such a horrendous bias against the concept of in-water recompression that nobody wants to admit they did it." Getting hard data will be a long time coming.

In addition to interviews, much of the material in this article comes from two sources, *In-water Recompression as an Emergency Field Treatment of Decompression Illness*, by Richard L. Pyle and David A. Youngblood, from the *Journal of the South Pacific Underwater Medical Society*, 1997, and *In Water*

Recompression, The Forty Eight Workshop of the Undersea and Hyperbaric Medical Society, published September 1999. This 108 page paperbound publication, which contain much fuller discussions of all the methods and the problems, and commentary from conference participants, is available for \$22.50 from the Undersea and Hyperbaric Medical Society, 10531 Metropolitan Ave, Kensington, Md 20895.