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Feasibility of In Water Recompression for Precautionary and Treatment of Decompression Illness in Remote Locations

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Abstract

Divers taking a precautionary safety stop at 15 fsw would benefit from using enriched air up to 100% oxygen as the breathing gas. This would enhance off gassing of nitrogen. In water recompression (IWR) to treat decompression illness, has been discouraged by the diving medical community until recently. In the absence of a nearby recompression chamber, it may be medically beneficial to recompression in the water. IWR breathing oxygen rich mixtures up to 100% is a much more effective procedure than breathing air. Commercially available equipment were evaluated. Essential equipment for IWR using oxygen include adequate thermal protection, an adequate supply line, supply of oxygen, a closed-circuit rebreather or an open circuit with full face mask with a non return valve. One major problem with IWR using enriched air is providing adequate oxygen supply and storage. Oxygen concentrators with booster pumps are currently commercially available. The cost of the oxygen generation and storage equipment as well as other required supplies compare favorably with the expense of transporting a single diver one time, from a remote dive location to the nearest hyperbaric facility. Precautionary 100% safety stops and IWR are feasible technically, and 100% precautionary safety stops and IWR are economical.

Keywords: bends prevention, decompression, live aboard, safety stop

Introduction

A safety stop is a halt in the planned ascent to the surface. The duration is typically three to five minutes at a depth of 15 to 20 fsw. The goal of a safety stop is to reduce the risk of decompression injury. So called precautionary safety stops allow time for the body to off gas nitrogen and add an extra margin of safety. Precautionary safety stops are usually taken breathing air but are more beneficial with enriched air and likely to be most beneficial breathing 100% oxygen. Divers taking a precautionary safety stop at 15 fsw would benefit from using enriched air up to 100% oxygen as the breathing gas. Safety stops with enriched air up to 100% would be especially useful for divers participating in multiple dives over multiple days such as divers on live aboards and/or dive instructors and/or underwater scientists or commercial divers.

If one compares critical nitrogen in air versus 100% oxygen on a hypothetical dive to 60 fsw for 60 min with a five minute precautionary safety stop, the 100% oxygen dive is comparable from a perspective of critical tissue nitrogen of a dive for only 48 min.

In addition, in water recompression (IWR) has been suggested as a treatment alternative to transporting a diver suffering from mild to moderate decompression illness in a remote location far removed from a recompression chamber (Pyle and Youngblood, 1995; Walker, 2002; Francis, 2005).

It has been recognized that one of the causes of a failure of decompression sickness to respond to recompression is a delay in treatment. IWR can be administered with air or enriched air up to 100% oxygen. IWR employs water as the recompression pressure, and air supply is by compressors on the dive boat. It has been used successfully in Northern Australia and Hawaii (Pyle and Youngblood, 1995); admittedly there are problems with IWR with air. There are compressed air supply limitations with amateur and semi professionals who have SCUBA or simple portable air compressors. Environmental conditions may not be conducive to IWR. Considerable depths may be required, and sea state and boat safety may become issues. Hypothermia is a difficult problem to overcome, and there is always the possibility of sea sickness in the diver and/or attendants.

Comparing oxygen to air as the recompression gas, the former is associated with increased nitrogen elimination gradients, additional nitrogen loading is prevented, and there is increased oxygen to the tissues. Importantly, depths and recompression times are reduced.

Let us consider the pros and cons of IWR. Advantages include immediate treatment with little or no delay and results reported have generally been favorable (Pyle and Youngblood, 1995; Francis, 2005). Problems with IWR include gas supply, environmental conditions, hypothermia and the sea state.

Barriers to IWR may be divided into four categories, namely, professional, logistical, technologic and economic. Professional barriers involve reluctance or refusal on the part of medical personnel involved in treating patients and establishing treatment protocols to accept this treatment concept. Logistical barriers relate to issues such as boat location and safety during the IWR as well as issues relating to sea state during the treatment. Technological barriers involve the available of the appropriate equipment such as oxygen generators and compressors with boosters to make available the quantity of necessary gas at the appropriate pressures available. Lastly, there are perceived economic barriers which relate to the significant expense of the equipment.

Methods

Barriers to precautionary enriched air up to 100% oxygen safety stops and IWR with enriched air up to 100% oxygen as the treatment gas were explored by evaluating currently available oxygen generators, compressors with pressure boosters, and oxygen storage equipment. The cost of these equipments and supplies were compared to the costs of transportation and treatment of mild to moderate decompression sickness in remote locations.

Results

Precautionary safety stops have been advocated by the diving medical community and dive education and training organizations for years. Currently with the widespread use and availability of enriched air, scuba divers have been utilizing enriched air for safety stops in a haphazard manner. With currently available technology to generate large volumes of high percentage oxygen up to 100%, safety stops with 100% for the breathing gas are now feasible. This is for the small group or individual diver as well as scuba divers taking multiple dive multiple day dive trips, even to remote locations. On a typical live aboard, 20 divers would take five minute safety stops on 100% for up to six dives per day. Available technology can produce the quantities of 100% oxygen for large numbers of dives and divers.

There appears to be a greater acceptance of IWR for mild to moderate DCS in remote locations by the hyperbaric medical community as evidenced by the conclusions of a workshop dedicated to this topic (Mitchell et al., 2005). Furthermore at least three different protocols for IWR using 100% oxygen have been published and used (Pyle and Youngblood, 1995; Walker, 2002).

The cost of evacuating and treating an injured diver with mild to moderate DCS ranges from $8,000 for evacuation and $3,000 to $29,000 for the treatment once transported. The cost of IWR including all the necessary equipment for the treatment as well the equipment to provide 100% oxygen for large numbers of divers making precautionary safety stops is approximately $15,000 (Dick Clark, National Baromedical, personal communication, 2008). On the other hand a cost benefit analysis and risk assessment was performed by Drewry which considered hidden costs of medical legal considerations which affect treating physicians' decision making (Drewry, 2005).

Discussion

It is feasible for scuba divers to routinely take precautionary safety stops on enriched air up to 100% oxygen with currently available technology, even for live aboards with divers making multiple dive multiple day dive trips. In addition, it is feasible and is cost effective to utilize IWR on 100% oxygen for mild to moderate DCS in remote locations.

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