APPENDIX

Comments of the Debates about the underwater oxygen treatment for DCS
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With the increased use of the underwater oxygen recompression treatment amongst non-medically trained divers, it was inevitable that some illogical and optimistic beliefs would develop. There is an equal, but opposite tendency amongst diving medical physicians, to invoke critical comments on practices with which they have not been associated. Both attitudes are understandable in view of the sometimes extreme personal and emotional involvement in this sport. The diver working in remote localities, has a desperate need for recompression facilities, and he may hopefully see the underwater oxygen decompression unit as the answer to all his problems. Likewise, the diving physician who works in an elaborate hyperbaric facility would see no real value, when this simple unit is compared to his own, for more sophisticated facilities. An attempt will now be made to answer some of the claims that have been made by divers and diving physicians - or which have been attributable to them, perhaps incorrectly.

1. Inappropriate Cases for Treatment

It was originally hoped that the treatment regime would be sufficient for treating minor cases of decompression sickness and prevent deterioration of more severe cases whilst suitable transport was being arranged. It was presumed that the treatment would not be successful in treating these severe cases per se, and that it would not be applicable to patients who had any degree of clouding of consciousness, or who were unco-operative.

A change of pattern has developed, and some patients have been subjected to underwater oxygen recompression, when they previously would not have been considered as suitable candidates. Although it is not recommended, semi-conscious patients certainly have been recompressed in the water, using these techniques. The other modification of the original attitude, has resulted from the observations that, for both the very recent case and for the very long standing case, there is often dramatic improvement even though classified as type 2, or severe decompression sickness.

It is commonly observed that improvement continues throughout ascent at 12 minutes per metre. Presumably the resolution of the bubble is more rapid at this ascent rate, than the expansion due to Boyle's Law. This is also consistent with our knowledge of treatment of saturation DCS cases. Some cases which did not respond adequately at the maximum depth of 9 metres, subsequently responded during the decompression procedure.

Despite the above comments, there is no doubt that the underwater oxygen recompression treatment is not applicable to all cases, and especially when the patient is unable or unwilling to return to the underwater environment in safety. It is also of very little value in the cases where gross decompression staging has been omitted, or where disseminated intravascular coagulation syndrome has supervened. I would personally be reluctant to administer this regime when the patient has either epileptic convulsions of clouding of consciousness. Reference to the case reports reveal that others are less conservative.

2. Oxygen Toxicity

Fear of oxygen convulsions or respiratory oxygen toxicity, especially in the underwater environment, would be valid if the conventional oxygen therapy tables were used. In the latter case there would also be considerable difficulty in

alternating the air breathing periods with the oxygen, underwater. To omit the air breathing periods of these tables would greatly increase the likelihood of oxygen toxicity. Such is not the case with the techniques described here. The maximum depth of 9 metres ensures that oxygen convulsions are most unlikely to develop. Significant respiratory oxygen toxicity is also most unlikely at this pressure and duration. It is however, recommended that once the person has reached the surface, both chest x-ray and lung function measurements should be performed routinely - while intermittent oxygen is utilised to reduce the likelihood of recurrence of symptoms. Fear of oxygen toxicity is more common amongst non-medically trained personnel, who often are not aware of the safety margin for oxygen toxicity.

The use of oxygen on the surface, to reduce the recurrence or progression of decompression sickness, does entail some risks. It is essential that the attendants under these conditions are very aware of the problems with oxygen and the danger of fire. It is also important they understand the value of a close fitting face mask. In many cases divers feel more at ease when breathing through a demand valve system, similar to their conventional amateur SCUBA apparatus.

3. Emergency Termination of Treatment

This is s a very valid and very common worry for those patients and attendants undergoing underwater air recompression treatment. There are many causes for this termination, and they range from environmental and operational to clinical and psychological causes. When planned decompression stops have to be omitted, both the patient and the attendant can be affected by decompression sickness due to the extra underwater exposure increasing some of the tissue nitrogen levels. Such is not the case if oxygen is used underwater. The denitrogenation associated with the hyperbaric oxygen breathing will be more likely to reduce the bubble size and improve the clinical state of the patient.

Fortunately the depth of 9 metres ensures that the attendant, irrespective of his previous diving exposure, will be unlikely to develop any symptoms of decompression sickness, even if the treatment has to be aborted at any stage.

4. Hypothermia

One of the common comments in Australia is that this underwater treatment regime is very applicable to the semi-tropical and tropical areas (where it was first used), but not applicable to the southern parts of the continent, where water temperatures may be as low as 5-10°C. There are certain inconsistencies with this statement. Firstly, if the diver has become ‘bent’ while diving in these waters, then he is most likely to already have excellent thermal protection suits available to him. Also, the duration underwater for oxygen treatment is not excessive, and it is at a depth at which his wet-suit is far more functional than at his maximum diving depth. If he is wearing a dry suit, the argument is every less applicable.

As a general rule, it is probable that the conditions for underwater oxygen recompression treatment will be far less likely to produce hypothermia than the conditions under which the patient developed his decompression sickness. If the alternative is underwater air treatment, then the depth, duration and hypothermia stress exceeds those of the underwater oxygen.

5. Adequacy of Equipment in Remote Areas

This is a very valid doubt. Fortunately in most areas there are cylinders of oxygen (for medical and first aid reasons), and the main problem is in obtaining

a high pressure hose connected to a demand valve, suitable for the patient's use. These problems are not usually beyond the capability of the local divers in combination with the hospital or first aid station. Various emergency modifications have had to be used in the past. These have employed industrial oxygen instead of medical oxygen, SCUBA cylinders filled with oxygen, medical high pressure hose replacing underwater hose, etc. The availability of appropriate equipment for this treatment has been improved by Commonwealth Industrial Gases (Medishield), Australia, supplying a packaged unit that divers take with them when they visit and dive in remote areas. This unit still required the addition of an oxygen cylinder to make it functional. It is also of value in the treatment of drowning cases, who require intermittent positive pressure oxygen respiration over prolonged periods.

The facilities for underwater air recompression therapy are also less than adequate in most situations. Nevertheless, there may be conditions in which compressed air is readily available, and when there may not be sufficient oxygen. Under these conditions the efficiency of one treatment must be weighed against the other, or a combination of both be improvised.

6. Seasickness

This common malady has been the cause of many problems in the treatment of decompression sickness using compressed air underwater. The main reason is the greater depth required for compressed air treatment, thereby necessitating a return of the diver to the open ocean. This is likely to cause severe seasickness, in both the diver and the attendant, and is well understood by any diver who has undergone decompression staging in the ocean, tethered to a boat. The time factor for air treatment is much longer than that for the customary decompression staging from an uneventful dive and the likelihood of seasickness is proportionately greater, resulting in premature termination of the treatment.

With the underwater oxygen regime, a maximum depth of 9 metres is required and this can usually be achieved in either sheltered inlets, bays or even off the end of the wharf.

7. Operator Expertise and Training

This is a necessity when one is utilising a recompression chamber, where fire and explosion must be seriously considered hazards, together with the other operational difficulties well known to hyperbaric personnel. Expertise would also be required if there were to be a change of gases, eg. from air to oxygen or vice versa, as in the case of the conventional oxygen tables, if they were transposed unchanged from the recompression chamber to the underwater environment, this has been proposed by Italian workers. Some degree of operator expertise is also required in the underwater air treatment, when cylinders have to be changed without surfacing the divers, or where compressors have to be maintained.

There is very little operator knowledge or training needed when using the underwater oxygen regime. The equipment requires only that the operator screw the regulator into the oxygen cylinder, fit the full face mask onto the diver's head and follow the tables as described on the unit. There is very little that can go wrong. The hose is of a length insufficient to allow the diver to be exposed to neurological toxicity with oxygen. Oxygen does not escape into the surrounding boat area, and therefore there is no serious problem from accidental fire or explosion. In the event of Murphy's Law applying, and somehow or other the treatment being terminated, neither the patient nor the attendant are in danger of aggravating decompression sickness. Thus there seems to be many fewer problems with the underwater oxygen treatment than with the alternatives.

8. Safety of the Diving Attendant and the Boat Tenders.

Mainly because of the shallow depth required for the underwater oxygen treatment, both the boat crew and the divers are less likely to be exposed to serious environmental hazards. The diving attendant is not subjected to the likelihood of nitrogen narcosis, decompression sickness or hypothermia. Each one of these dangers may accompany the underwater air treatment. The dangers which are associated with hyperbaric chamber operation are also not present, and the boat tenders do not require to return to the depths necessary for underwater treatments - these usually imply and open ocean exposure.

9. Requirement for Medical Supervision

Occasionally one hears that the treatment should only be used when a physician is available to supervise it. This does not seem either relevant or practical, in my opinion. It certainly was so in early days, when it was an experimental procedure, performed with some trepidation. There is little that a physician would be able to do to either improve or facilitate the underwater oxygen treatment regime. He would certainly be of value in the initial assessment of the case, and for its subsequent management.

10. Transport Availability

Some claim that the underwater oxygen treatment is more value when there are no transport facilities available. Initially this was also our own teaching, but with the logic that comes from hindsight, one only needs a 3 hour gap between the instituting of underwater oxygen treatment and the arrival of transport, to be able to utilise this system. It is probably just as important to treat the serious cases early, even though one may not get full recovery, than to do nothing and watch the symptoms progress during these hours.

There is no doubt, especially in serious cases, transport should be sought while the underwater treatment is being utilised.

11. Misuse of Equipment

It has been stated that if this equipment is available for treatment of decompression sickness cases, other divers may well misuse it, decompression on oxygen underwater, and perhaps running into subsequent problems. This is more an argument in favour of educating divers, than depriving them of potentially valuable treatment facilities. An analogous argument can be used to not promote good diving equipment on the grounds that it may increase the extent of diving! Carried to the logical extremity, one could well use this type of argument to totally prohibit all types of diving equipment, including recompression chambers, and thereby hope to circumvent all diving related problems.

12. Pulmonary Barotrauma Cases

It has been argued that this treatment is unlikely to be of any value for those patients suffering from air embolism. Such may well be the case. The treatment was never proposed for this, and nor was it ever suggested that the underwater oxygen treatment be used in preference to recompression facilities where they exist, or where they can be obtained. It is, however, possible that the treatment may be of value for those cases of mediastinal emphysema, and perhaps even a small pneumothorax.