Underwater Oxygen Treatment of decompression sickness

Dr Carl Edmonds

Introduction: Since 1970, in remote regions of the Indo-Pacific, a new option was added to the armamentarium for treatment for decompression sickness. It was closely supervised and directed by the respective officers-in-charge of the Royal Australian Navy School of Underwater Medicine. Initially it had no official sanction, but developed in response to an urgent need for management of cases in remote localities - remote in both time and distance from the few hyperbaric facilities. This is elaborated further under the section termed “The Problem”.

Because of the success of this treatment, and its ready availability, it became known and practiced, even when the experts were not available to supervise it. The reasons for this were twofold. Firstly, the non-recompression ancillary therapies are not particular efficacious on their own. Secondly, the conventional underwater air decompression treatments posed considerable operational difficulties - elaborated in the section termed “Traditional Solutions”.

The techniques of underwater oxygen therapy, and the equipment used, are described under their respective headings. It was designed to make for safety, ease and ready availability, even in medically unsophisticated countries. Advantages and disadvantages of this type of therapy, together with many of the questions that have arisen because of it, are described under the section labelled “Discussions”.

The physiological principles on which this treatment is based are well known and not contentious, although the indications for treatment have caused some confusion. Like conventional oxygen therapy tables, it was first applied mainly for the minor cases of decompression sickness, but was subsequently found of considerable use in the potentially serious cases. This is considered under sections labelled “Case Reports” and “Underwater Oxygen in Perspective”.

The Problem

For almost two decades the Royal Australian Navy, at the School of Underwater Medicine, accepted responsibility for the treatment of cases of decompression sickness presenting in this part of the Indo-Pacific region. During most of this time, it had the only large recompression chamber permanently staffed with experienced diving medical personnel. The catchment area extended to a radius of about 6,000 kilometres around Sydney, Australia.

Australia is an island continent, with one of the longest habitable coastlines of any single country - approximately 30,000 kilometres - and eminently suited to diving. Amateurs relish the warm waters of the Great Barrier Reef, while professional diving encompasses the pearl, abalone, salvage and oil industries. There are traditional ties, and often protectorate or treaty responsibilities with other countries of the Indo-Pacific. Many of these islands have either very limited or no airport facilities. Medivac of decompression sickness patients to Australia often required a return flight originating in Sydney. Where possible, use was made of aircraft that would be cabin pressurised to ground level, and in many cases there would be a time lapse in excess of 24 hours between the patient being “bent” and receiving treatment. The costs, in time and money, and the commitment of service facilities and aircraft, made treatment of minor cases impracticable. The delays made serious cases worse. As an aggravating factor, the clear warm waters encourage the type of diving which results in severe decompression sickness.

During the middle of the ’70s, the incident rate of decompression sickness reported to the Navy School of Underwater Medicine was approximately one every two weeks. The majority of these cases were far distant from Sydney locality, and in many cases the medivac transfer of these patients to Sydney was not possible.

Traditional Solutions

A whole gamut of treatments, other than the conventional recompression therapy, have been applied to decompression sickness. These include some which have a physiological basis, some which are of interest from the pharmacological aspect, and others which are merely novel in their approach. None have received universal acceptance as an isolated therapy. They include such regimes as: intravenous fluid replacement, with low molecular weight dextran, plasma and other fluids; anticoagulants; anti-lipaemic agents; steroids; hypothermia; etc.

By far the most traditional of the non-chamber treatments, is the underwater recompression therapy. In this situation the pressure is exerted by the water, instead of a recompression chamber. Air supply is usually from compressors sited on the diving boat. Although this treatment is frequently ridiculed by those in the cloistered academic environs, especially when they possess elaborate recompression facilities, it has frequently been the only therapy available to severely injured divers, and has had many successes. This is certainly so in those remote localities such as Northern Australia, in the pearl fishing areas, where long times were spent underwater and standard diving equipment was used. Underwater air treatment continued to be used, in the absence of available recompression chambers.

Despite the value of the underwater recompression therapy, many problems are encountered with it. These are well recognised by both divers and their medical advisers. It is of interest that two of the diving medical text books written in English, do not mention this therapy at any stage! The US Navy Diving Manual briefly mentions it as a possible treatment and recommends the application of the conventional air tables as far as possible and seems to infer that Table 2A is perhaps the acceptable one. This involves taking divers underwater, to a maximum depth of 165 feet or 50 metres and with an overall duration of 11 hours. The Royal Navy Diving Manual recommends a somewhat more reasonable approach with Table 81, at a depth of 100 feet or 30 metres and duration of almost 5 hours. Most of the underwater air treatments are more practical than these and a typical example is that given by Sir Robert Davis, in which the duration depends upon the depth required for relief of symptoms. Most regimes are makeshift, and are varied with experience.

The problems are as follows. Most amateurs or semi-professionals, other than the navies and multinational diving companies, do not carry the compressed air supplies or compressor facilities necessary for the extra decompression. Most have only SCUBA cylinders, or simple portable compressors that will not reliably supply divers (the patient and his attendant) for the depths and durations required. Environmental conditions are not usually conducive to underwater treatment. Often the depth required for these treatments can only be achieved by returning to the open ocean. The advent of night, inclement weather rising seas, tiredness and exhaustion, and boat safety requirements, make the return to the open ocean a very serious decision. Also because of the considerable depth required, hypothermia from the compression of wet suits, becomes very likely. Seasickness, in the injured diver, the diving attendants and the boat tenders, becomes a not inconsiderable problem. Nitrogen narcosis produces added difficulties in the diver and attendant. The treatment has often to be aborted because of this. These difficult circumstances, producing decompression

sickness in the attendants, and aggravating it in the diver. Underwater air treatment of decompression sickness is not to be undertaken lightly. In the absence of a recompression chamber, it may be the only treatment available to prevent death or severe disability. Despite considerable criticism from authorities distant from the site, this traditional therapy is recognised by most experienced and practical divers to often be of life saving value.

Underwater Oxygen Therapy

The value of substituting oxygen for air, in the recompression chamber treatment of decompression sickness, is now well established. The pioneering work of Yarborough and Behnke (1939) eventuated in the oxygen tables described by Goodman and Workman (1965). They received widespread acceptance, and revisions and modifications are now incorporated in Tables 5 and 6 by the US Navy Diving Manual, the Comex tables, and the Australian Therapy Tables. The advantages of oxygen over air tables include: increasing nitrogen elimination gradients; avoiding extra nitrogen loads; increasing oxygenation to tissues; decreasing the depth required and the hyperbaric exposure time; and improving the overall therapeutic efficiency. The same arguments are applicable when one compares underwater air and underwater oxygen treatment.

a. Technique

Oxygen is supplied at a maximum depth of 9 metres, from a surface supply. Ascent is commenced after 30 minutes in mild cases, or 60 minutes in severe cases, if significant improvement has occurred. These times may be extended for another 30 minutes, if there has been no improvement. The ascent is at a rate of 12 minutes per metre. After surfacing the patient should be given periods of oxygen breathing, interspersed with air breathing, usually on a one hour on, one hour off basis, with vital capacity measurements and chest x-ray examination if possible.

b. Equipment

The equipment required for this treatment includes the following: a G size oxygen cylinder (220 cu ft or 7000 litres). This is usually available from local hospitals, although in some cases industrial oxygen has been used from engineering workshops. This volume of oxygen, at the depth varying between 9 metres and the surface, is insufficient to produce either neurological or respiratory oxygen toxicity. A 2-stage regulator, set at 550 kPa is fitted with a safety valve, and connects with 12 metres of supply hose. This allows for 9 metres depth, 2 metres from the surface of the water to the cylinder, and 1 metre around the diver. A non-return valve is attached between the supply line and the full face mask. The latter enables the system to be used with a semi-conscious or unwell patient. It reduces the risk of aspiration of sea water, allows the patient tot speak to his attendants, and also permits vomiting to occur without obstructing the respiratory gas supply. The supply line is marked off in distances of 1 metres from the surface to the diver, and is tucked under the weight belt, between the diver’s legs, or is attached to his harness. The diver must be weighted to prevent drifting upwards in an arc.

A diver attendant is always present, and the ascent is controlled by the surface tenders. The duration of the 3 tables are 2 hours 6 minutes; 2 hours 36 minutes, and 3 hours 6 minutes. In the unit currently marketed in Australia by Commonwealth Industrial Gases, there is an optional extra piece of equipment - a positive pressure mask. This allows the unit to be used for the treatment of drowning victims, with intermittent positive pressure oxygen resuscitation.

Discussion

It was originally hoped that this treatment regime would be sufficient for management of minor cases of decompression sickness, and to prevent deterioration of the more severe cases while suitable transport was being arranged. When the regime is applied early, even in the severe cases, the transport is often not required. It is consistent observation that improvement continues throughout the ascent, at 12 minutes per metre. Presumably the resolution of the bubble is more rapid at this ascent rate, than its expansion due to Boyle's law.

Certain other advantages are obvious. During the 3 hours continuous hyperbaric oxygenation, the tissues become effectively denitrogenated. Bubbles are initially reduced in volume, in accordance with the hyperbaric exposure and the resolution is speeded up by increasing the nitrogen gradient from the bubble. Attendant divers are not subjected to the risk of decompression sickness or nitrogen narcosis, and the affected diver is not going to be made worse by premature termination of the treatment, if this is required. Hypothermia is much less likely to develop, because of the enhanced efficiency of the wet suits at these minor depth.

The site chosen can be in a shallow protected area, reducing the influence of weather on the patient, the diving attendants and boat tenders. Communications between the diver and the attendants are not difficult, and the situation is not as stressful as the deeper, longer, underwater air treatments or even as worrying as in some recompression chambers. (When hyperbaric chambers are used in remote localities, often with inadequate equipment and insufficiently trained personnel, there is an appreciable danger from both fire and explosion. There is the added difficulty in dealing with inexperienced medical personnel not ensuring an adequate face seal for the mask. These problems are not encountered in the underwater environment.

Underwater Oxygen - Perspective

The underwater oxygen treatment table is an application, and a modification of current regimes. It is not meant to replace the formal treatment techniques of recompression therapy in chambers. It is an emergency procedure, able to be applied with equipment usually found in remote localities and is designed to reduce the many hazards associated with the conventional underwater air treatments. The customary supportive and pharmacological adjuncts to the treatment of recompression sickness are in no way avoided, and the superiority of experienced personnel and comprehensive hyperbaric facilities, is not being challenged. The underwater oxygen treatment is considered as a first aid regime, not superior to portable recompression chambers, but sometimes surprisingly effective and rarely, if every, detrimental.

Case Report

Because of the nature of this treatment being applied in remote localities, many cases are not well documented. Twenty-five cases were well supervised before this technique increased suddenly in popularity, perhaps due to the success it had achieved, and perhaps due to the marketing of the equipment by CIG (Medishield). Three more recent cases are now described.

Case 1

A 68 year old male salvage diver.

Two dives to 100 feet for 20 minutes each were performed with a surface interval of 1.5 hours - while searching for the wreck of the Pandora, about 100 miles from Thursday Island in the Torres Strait.

No decompression staging was possible allegedly because of the increasing attentions of a tiger shark. A few minutes after surfacing, the diver developed paraesthesia, back pain, progressively increasing inco-ordination and paresis of the lower limbs.

Two attempts at underwater air recompression were unsuccessful when the diving boat returned to its base mooring. Symptoms were worrying and the National Marine Operations Centre was finally contacted for assistance.

It was 36 hours, post dive, before the patient was finally flown to the regional hospital on Thursday Island. Both the Air Force and the Navy had been involved i the organisation, but because of very hazardous air and sea conditions, and very primitive air strip facilities, another 12 hours would be required before the patient could have reached an established recompression centre (distance 2000 miles).

On examination at Thursday Island, the patient was unable to walk, having evidence of both cerebral and spinal involvement. He had marked ataxia, slow slurred speech, intention tremor, severe back pain, generalised weakness, difficulty in micturition, severe weakness of lower limbs with impaired sensation, increased tendon reflexes and equivocal plantar responses.

Because of the involvement with pearl divers, an underwater oxygen unit was available on Thursday Island, and the patient was immersed to 8 metres depth (the maximum depth off the wharf). Two hours were allowed at that lesser depth and the patient was then decompressed. There was total remission of all symptoms and signs, except for small areas of hypoaesthesia on both legs.

Case 2

23 year old female sports diver.

Diving with 72 cu ft SCUBA cylinder in the Solomon Islands. (Nearest recompression chamber is 2000 miles away and prompt air transport was unavailable). Dive depth was 110 feet and duration approximately 20 minutes, with 8 minutes decompression. Within 15 minutes of surfacing she developed respiratory distress, then numbness and paraesthesia, very severe headaches, involuntary extensor spasms, clouding of consciousness, muscular pains and weakness, pains in both knees and abdominal cramps. The involuntary extensor spasms recurred every ten minutes.

The patient was transferred to the hospital, where neurological decompression sickness was diagnosed, and she was given oxygen via a face mask for three hours without significant change. During that time an underwater oxygen unit was prepared and the patient was accompanied to a depth of 9 metres, in the bay. Within 15 minutes, she was much improved, and after 1 hour she was asymptomatic. Decompression at 12 minutes per metre was uneventful and the patient was subsequently flown by commercial aircraft to Brisbane.

Case 3

A 19 year old male trainee diver, under dubious instruction.

Depth approximately 150 feet duration 15 minutes. Twenty minutes after surfacing, he had the first of three epileptic convulsions, extending over a one hour period. Between convulsions there seemed no other evidence of decompression sickness other than mild back pain. There was no personal or family history of epilepsy.

A 9 metre oxygen treatment was given, without complication and without sequelae.

This is presented for discussion as it is an excellent example of the type of case that can be made complicated by the 60 foot oxygen therapy tables, when a convulsion during treatment can be attributed to either decompression sickness or oxygen toxicity. This would cause considerable management problems - especially if one is not sure of the original diagnosis! To subject such a patient to the deeper air tables may considerably hinder treatment if one's provisional diagnosis is wrong. Alternately to not recompress may result in further damage from decompression sickness or the perseverance of a potentially remedial epileptogenic focus.

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Is father unfair to his son?

Patricia Sneddon, blonde haired and ten years old, has earned her title of "Bubbles". She has been scuba diving for 18 months and swims in the Manly Marineland tank, mainly for fun. Apart from the sharks the pool contains a few gropers, stingrays, and turtles, as well as hundreds of small fish. She says that the sharks don't worry her (there is only one big male she won't pat, because he snaps), but the turtles are apt to bite fingers. Her father, who has been diving in the pool for a few years, organised her first dive after she pleaded for a go. "Her mother was worried stiff - when Bubbles first went in, but I know she is safe", he said. That was a year ago. "I love it. It's better than ordinary diving. And they wouldn't touch me: I'm a girl", she told and interviewer.

This happy-go-lucky schoolgirl is too young to dive for money, so she does it for experience, and to overcome school holiday boredom. Her younger brother Adam, aged 6 years, is considered to be still too young to dive, with or without sharks. But then everyone knows that fathers tend to spoil their daughters".

MD and SH, January 1979

APPENDIX

Comments of the Debates about the underwater oxygen treatment for DCS
Carl Edmonds

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.