7. REPORT ON HYPERBARIC FACILITIES FOR DIVING ACCIDENTS *

Preface

In response to a large number of requests for advice on the treatment of diving accidents and on recommendations to assist in the planning of hyperbaric units, the following report has been prepared. Over recent years a need for recompression facilities has become more pressing, due to the increased number and depth of diving operations. Many of these are carried out by amateur or semi-professional groups, quite unable to administer or finance any of the support recompression chambers (RCC) that may be required in emergencies.

It is axiomatic that the most satisfactory way of dealing with diving morbidity and mortality is to prevent it occurring by adequate training and licensing of the amateur and professional divers at risk. Unfortunately such an aim seems to be beyond the capabilities or inclination of either the Government Departments concerned or the multitudinous diving clubs and groups, many claiming to be ‘national’.

Accepting that even in the most highly trained group there will be occasional diving accidents requiring recompression, and considering the proliferation of so many amateur groups, abalone divers, semi-commercial divers and professionals now at risk, the number of diving accidents and deaths will continue escalating.

The ideal solution to this problem is to supply, at the site of diving, recompression facilities and trained staff capable of handling the illnesses concerned viz. Pulmonary Barotrauma and decompression sickness (burst lung and bends). The current facilities for the treatment of such cases throughout Australia are inadequate in every state. Nevertheless, the problem has to be kept in perspective and it would be impracticable to suggest that equipment, trained personnel and finance could be made available to supply RCCs at the site of all diving operations.

Where there is an RCC, and where oxygen is supplied to this chamber, the facility can be of immense benefit to patients other than diving accidents, eg. those with gas gangrene (saving both life

* Written in February, 1971, but still applicable to-day.

and limb), carbon monoxide poisoning and other medical disorders.

Problems

Having reiterated the obvious requirement for recompression facilities throughout Australia, it is prudent to highlight some of the deficiencies which become evident when recompression treatment is considered.

a. Medical staff specialised in this field are needed to decide upon the advisability of recompression, to select the most suitable recompression regime and to take the clinical responsibility of subsequent management. Not only is specialised training required in this field, so is experience and constant practice. It is difficult for lay administrators to realise two related facts, viz. doctors are not interchangeable with each other, and recompression injudiciously performed can be as dangerous as it is beneficial. Unlike most forms of medical treatment, recompression exposes both the patient and therapist to certain dangers, aggravated considerably by the current use of oxygen at high pressure. It is of note that the recompression treatments available in Australia at this time suffer more from inadequate specialised medical advice than any other single factor. Fortunately this is capable of being rectified.

b. The absence of recompression equipment. There appears to be kudos in the acquisition of a RCC, and many small groups acquire or build these chambers, only to subsequently let them deteriorate, because of the absence of adequate use and maintenance. Some states simply do not have any recompression chambers available. Often they are not aware of this, having confused a RCC with the aviator's decompression chamber, or believe they have a commercial chamber available, which when inspected by even the most optimistic diver is clearly unable to be used in any successful therapeutic regime. Other states have home made chambers available, and although these may be of value in the initial stages of therapy their use will often greatly complicate subsequent and more satisfactory treatment. Certain hospitals with small chambers used for radiotherapy have often the mistaken belief that these chambers are adequate for the treatment of diving accidents. In fact they may be of value in treating minor cases of bends, but they are also likely to aggravate other cases with the inadequate therapeutic regimes available to them. It is also

necessary to have adequate compressor facilities, gas mixtures, etc.

Once adequate equipment has been obtained, it requires regular and vigilant maintenance. Without this, the facilities become unsafe in practice, as well as imparting quite an unjustified confidence in the local diving and medical population. Of the four recompression chambers I have examined outside New South Wales during 1969-70, one was literally overgrown with weeds; one had no pressure gauge adequate below 30 psi; one was rusted beyond repair; and another had no portholes and no lighting system. A proposal was made for the latter to be remedied by the insertion of a lighting arrangement which could only be described as explosive.

c. Specialised staff capable of running and maintaining the chamber as described above, are required. These include engineering type personnel, as well as a supervisor able to ensure correct procedure and techniques during the recompression therapy (usually referred to as the Diving Officer).

d. An administrative authority. It is necessary that one authority takes over the administrative aspects of recompression treatment. This administrative authority must be responsible for the ensuring of adequate training of personnel, maintenance of chamber facilities and rostering of staff so that the recompression facilities are able to be used. It need not also be the financing authority.

e. Communication and emergency alarm systems. It is a necessary part of the administration authority's responsibility to ensure that all involved groups are aware that the facilities do exist, and of the method of initiating this system without undue delay. Most of the recent diving accidents have been greatly complicated by the initial reluctance to obtain adequate assistance at the earliest opportunity.

f. Finance. This problem is the one that most people seem to tackle first, and although extremely important it is perhaps the least restrictive. Recompression facilities available in Australia vary from between $4,000 and $100,000 at different establishments. Most are concerned only with

obtaining the minimal satisfactory conditions, and these can be obtained for approximately $5,000. Finance for the current chambers has been obtained by the commercial diving companies, the Royal Australian Navy, donations direct to hospitals from various charities, State Departments of Health, etc.

g. Transport of the patient to the recompression facilities. It is characteristic of the geographic features of Australia that most of the coastline is not within easy reach of the capital cities. Much of the diving is performed at locations which are remote or accessible over difficult terrain. Such is especially the case with Western Australia, Queensland and Tasmania. Transport of diving casualties in aircraft not pressurised to group level (and this includes most commercial aircraft) is contraindicated, unless the aircraft is prepared to fly at extremely low altitudes. This is often impossible, and therefore in many cases it may be necessary to take a portable recompression chamber to the patient, and not vice versa. When only a few hundred miles are involved, the use of helicopter transport, either from commercial or armed services, is the most acceptable and rapid method.

   A difficulty in providing fixed recompression facilities at areas in which diving is occurring is the migratory tendency associated with divers. A commercial abalone site at one time may become fished out, with the divers moving on to more productive fields. Similar variations occur in the popular sites for amateur divers, and these are often limited by the availability of compressors, social conveniences, etc.

Therapy for Diving Accidents

a. First Aid. This is almost invariably performed by fellow divers. The quality is reliant upon the degree of training obtained from the diver's club. There is usually unnecessary and avoidable delay at this stage, and with the patient receiving such homespun remedies as a hot bath, a few beers, etc.

b. Local Medical Treatment. This may be obtained from either medical practitioners or district hospitals. The quality of the treatment is very variable and certain hospitals in popular diving resorts obtain advice and assistance rapidly once a diving casualty is admitted. Unfortunately this is not widespread, and

there is a reprehensible tendency to ‘observe’ the patient for many hours prior to taking any other action.

c. Specialised Medical Advice and Treatment. Usually by this stage the patient has been subjected to either fruitless or harmful short recompression attempts, or has languished in a hospital bed, with or without symptomatic therapy.

Although it is unlikely that the sequence of events from first aid to specialised medical attention be altered appreciably, the quality of management of the patient could be markedly improved and the speed with which he moves through this sequence could be appreciably lessened. If this were so, then subsequent morbidity could be greatly reduced.

Different Systems of Recompression Facilities

a. Specialised hyperbaric facilities and personnel available at peripheral centres ie. adjacent to diving areas. This is of course ideal, but is usually impracticable because of the problems previously referred to. It is also doubtful whether the number of diving accidents warrants multitudinous small centres throughout Australia, held at readiness, and costly in both time and effort.

b. Specialised hyperbaric facilities and personnel at major centres throughout each state. One could envisage a system whereby centres were staffed every few hundred miles throughout diving areas. This would ensure that diving accidents were within a three hour by road radius of a diving accident centre. This would also mean that states such as Queensland would require many of these, whereas South Australia and Tasmania could get by with three each. Whether the number and degree of diving accidents warrants the outlay needed for this system, would have to be decided by each state. The use of such a system does not obviate the need to use an air ambulance type service, as many diving accidents will occur in areas remote from those mentioned, or in areas cut off from major highways by mountains.

c. Specialised hyperbaric facilities and personnel available at capital cities. This is the most economical system, with each chamber being ensured of many uses, and with minimal requirements for trained personnel. It does however, impose a heavier burden on the requirement for an efficient transport system from the site of the accident to the capital city. This is discussed later under aeromedical evacuations. Fortunately many diving groups

are centred in or near the capital cities, and thus these cities would require recompression facilities in any case; there is also the proximity to major hospitals, so that hyperbaric oxygenation may be given to the greatest number of medical patients requiring it.

Irrespective of which of the above systems is used, there are two factors which need to be considered:

a. Aeromedical evacuation of casualties from diving areas, or transport of portable chambers to the diving area. The less the number of centres equipped with hyperbaric facilities, the more efficient the air evacuation needs to be. The only way of avoiding the necessity for this is to have recompression chambers and experienced personnel wherever diving is carried out, and this is a practical impossibility. The ability to transport patients, recompression chambers, or patients in recompression chambers, to areas with more adequate facilities and more specialised personnel will be needed.

b. Standardisation of equipment and training is essential if there is going to be any rational integrated system of treatment of diving accidents. Unless this does occur, there will be complete confusion in the first aid management, indications for treatment, recompression regimes utilised, and the transport of patients to major recompression facilities. Standardisation is most important when it comes to the ability to transport a patient from one chamber into another while still under pressure. As the Royal Australian Navy is the possessor of the largest number of recompression chambers, and as it has ordered for construction during 1971 a series of large chambers and portable chambers, all with the same interlocking system, it is strongly recommended that all other groups utilise the same interlocking facility. If one diving group decides to have its own special chamber, not able to be mated with the others around Australia, then any patient placed in that chamber will not be able to receive the advantages of the more sophisticated chambers at the larger centres.

Therapeutic Recompression Chambers

The adequacy of hyperbaric therapy is to a considerable degree limited by the forethought given to the recompression chamber design. There are many chambers available, and many firms prepared to supply recompression chambers which are less than adequate for therapeutic

purposes. Most of the chambers have been designed for surface decompression viz. the decompression of healthy young men, not suffering from pulmonary barotrauma or decompression sickness, not requiring resuscitation and not requiring physiological monitoring. Requirements for therapeutic recompression chambers are quite different, as one is often dealing with a seriously ill patient unable to be left unattended and often requiring minor surgical procedures during decompression. The different types of chambers available for therapeutic recompression are as follows:

a. Large Chambers. These are fixtures, able to take one or more patients as well as medical staff, and having two locks - one to transfer medical equipment and food in to the occupants, and the other to allow medical personnel to enter and leave the chamber during treatment. These chambers are of great value for both diving accidents and hyperbaric oxygenation in medical conditions. They are usually placed in or alongside major hospitals. All the large chambers designed in recent years have a TUP (transfer under pressure) facility, so that suitable portable chambers may be mated to them, and patients transferred from the smaller to the larger chamber, while still under pressure. All these chambers have capabilities for breathing oxygen or nitrogen/oxygen mixtures independently from the chamber environment. The cost is usually in excess of $10,000, ready to run.

b. Portable recompression chambers. This type of chamber allows extreme flexibility in both the transport and and the treatment of diving accidents. The modern portable chambers have sufficient room to take two men, one patient and one attendant. This is required because of the obvious first aid and resuscitation needs of a seriously ill patient. It is also needed whenever one administers oxygen to a patient with decompression sickness or pulmonary barotrauma, under pressure. They are also cheaper than the large chambers, and serve as an ideal chamber for the initial treatment. Indeed, the full treatment may be carried out in many cases, in one portable two man chamber. When this chamber is moved to a site where it is able to mate with either a large chamber or another two man chamber, there is no limitation to the adequacy or flexibility of treatment which can be given. The chambers are manufactured for approximately $5,000 in Australia.

   It is extremely important to realise that the portable one man chambers which are on sale from most diving equipment manufacturers are designed initially for surface decompression,

not therapeutic recompression. The purchase of a one man recompression chamber for treatment of diving accidents is completely irrational if one attempts to cope with anything other than the most minor case of decompression sickness. The use of this type of chamber is now obsolete in therapy. When attempting to treat pulmonary barotrauma, serious complications are to be expected with this equipment.

c. Transit bags. This concept, of having a material bag which is able to be pressurised to a low pressure eg. 15 psig, and in which the patient can be placed, while breathing air or oxygen from an external supply, is being investigated at this time. If these transit bags are able to be developed satisfactorily, then they would be a relatively cheap way of giving initial and strictly first aid therapy to the diver at the site of the accident. They presumably could be purchased by diving groups at a reasonable price, and used to transport the patient to the site of a recompression chamber, in which the bag could be placed holus bolus with the patient, the chamber pressurised and the patient then released from the bag. These bags are not available commercially at this stage.

Recommendations

The following recommendations are made regarding the acquisition of recompression facilities for the treatment of diving accidents in Australia.

1. Recompression facilities should be available in each capital city, sited at or adjacent to one major teaching hospital or repatriation hospital in that city. It should be under the administrative control of that hospital. If there are other areas in the state scheduled to have recompression facilities, then the capital city recompression facility should be a large fixed chamber. If this is not financially possible, or if there are not other areas in the state likely to have recompression facilities, the capital city hospital should have a portable two man recompression chamber available, with transport facilities, eg. able to be put on the back of a small truck, together with compressor and/or gas cylinders.

2. If financially possible, other areas in the state adjacent to diving centres should acquire portable two man recompression chambers, and organise transport facilities.

3. Medical staff should be rostered to give on-call service. The training of this medical staff could initially be performed at

the RAN School of Underwater Medicine, at HMAS Penguin in Sydney, if application is made to the Secretary, Department of the Navy, Canberra.

4. The RAN School of Underwater Medicine could remain the central area for consultation, treatment, instruction and information into diving accidents. It is likely that the current RAAF and RAN attitude to assist in the medivac facilities in transporting and treating divers will be continued. This would be far more efficiently conducted if the injured diver were in a portable two man RCC, with an attendant.

5. All recompression chambers, be they RAN or civilian, should have the same transfer under pressure facility incorporated in the new RAN recompression chambers.

(CARL EDMONDS)
President
SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY