PRACTICE

The procedure is to ready a seat for the diver to sit on. This is more comfortable than sitting in the bight of a rope.

The diver must wear a wetsuit, including hood, because he is probably already cold from his dive, and is certainly going to get cold sitting still even in tropical water, because he will not be generating any noticeable amount of heat. Shivering is undesirable as it increases his oxygen usage, makes his muscles move and will precipitate the formation of extra bubbles in his body. The diver has to be overweighted so that he will stay at the depth chosen. If he is sitting it is a good idea to have weights on his ankles so that they do not tend to float up. This means that the diver must be attached to a safety line which is attached to the boat or jetty so that he cannot sink further than the length of the line. So we now have two lines. One to hold his seat, and one to catch him if he slips off.

Then there is the full face mask and the oxygen cylinder on the boat or jetty.

There has to be a team to carry out the procedure. At least one person to watch the time, the depth and the oxygen supply. Two attendants for the patient. More people are an asset.

The patient and his attendant disappear over the side and the patient is lowered to a depth of 9 m.

He then stays there for 30 minutes, regardless of how soon his symptoms are cured. In most cases these symptoms have been cured within the first 30 minutes. If the symptoms are not completely cured after 30 minutes the patient spends another 30 minutes at 9 m. If he had a neurological bend he spends at least 60 minutes before the ascent is commenced. If there are still symptoms remaining at the end of the hour, the time is extended by another 30 minutes.

So after 30, 60 or 90 minutes the return to the surface starts. Ascent is at the rate of 1 m every 12 minutes, or alternatively, for those who date from the pre-metric days, one foot every four minutes. You will have noticed that one foot every four minutes is slightly slower than 1 m every 12 minutes, and I think that the slower rate of ascent is to be recommended. Also the ascent of a foot at a time is nearer a lineal decompression than an ascent of a metre. For a given time span lineal decompression is a better method than a staircase decompression. At this rate the ascent takes about two hours.

If symptoms recur during ascent the ascent is halted for 30 minutes. I have never heard of this being necessary.

If the oxygen runs out the patient is brought straight to the surface. NEVER give the patient compressed air.

When the diver is out of the water, he is then given oxygen to breathe. Alternating oxygen on for an hour, oxygen off for an hour for twelve hours.

I have used the Edmonds table in a single man chamber. It seemed better at the time to compress the patient on oxygen in a small single man chamber than to lower him into the sea as dusk approached as we would have had to go some way out from the island of Moen to get the 9 m of water we needed. It was a wrong decision for the bus ride over a very pot-holed road converted him from being a person with mild neurological decompression sickness, stocking anaesthesia of both feet, into a paraplegic with the left arm also paralysed, who was having difficulty with his breathing. However, within half an hour at thirty feet with oxygen, he was able to move all three paralysed limbs. He was then taken to 60 feet but had little further improvement. Nitrogen loads in the body take a long time to decay. This man had last dived more than 48 hours before he appeared, mildly drunk, at the hotel that we were staying in. Travelling for 15 minutes over a very pot-holed road converted him from a mild case to a very severe case of decompression sickness so that there must have been a lot of gas available to form enlarged bubbles, even forty eight hours after diving.

Any procedure that gets this extra gas out of the body is to be recommended, and if somebody develops decompression sickness they should be given first aid consisting of oxygen to breathe and fluid to drink, because all divers are slightly dehydrated by the end of a dive, and two aspirin to inhibit platelet aggregation. As soon as this has been done, the buddy races to the telephone and gets advice as to what should be done next. Which in most cases on the Australian mainland, is to transport them immediately, at low level, to the nearest chamber.

However, if you are on the island of Truk in the middle of Micronesia, there is no quick arrival at the nearest chamber in Guam. It would be a very expensive trip indeed to charter a Lear jet, if there is one at Guam, to fly over to Truk and then pick up the patient and fly him back to the US Navy Hospital at Guam. Far better to arrange for an in-water recompression, in warm water with good visibility and watch the symptoms disappear.

TRANSPORTATION OF PATIENTS SUFFERING FROM DECOMPRESSION SICKNESS

Chris Acott

I am keenly interested in the transportation and retrieval of patients. I will discuss general aspects of patient transport with special reference to the transportation of patients with decompression sickness (DCS).

One would always like to know the overall general medical condition of the patient, however this is often hard to obtain. Is the patient deteriorating? Will he need specialized help before transport? Will transport at this stage adversely effect the patient?

DCS patients are usually stable, and need to be transported to the nearest recompression chamber as soon as possible. However the patient may be unconscious, fitting, or in respiratory difficulties, or have a spinal cord lesion that is progressing rapidly.

TABLE II

TRANSPORT MODES AVAILABLE

ROAD TRANSPORT

ADVANTAGES	DISADVANTAGES
Patient only transferred in and out of ambulance	Slow
Able to stop en route to perform procedures	
Ample room and lighting	
Adequate supply of everything	
Cost effective	
Able to transport in all conditions	Subject to road conditions
Altitude usually not a problem	But the ambulance may have to travel over a mountain range which is greater than 1000 ft. No way of knowing the altitude that you are at.

AIR TRANSPORT

FIXED WINGED AIRCRAFT

ADVANTAGES	DISADVANTAGES
Shorter transit time	Need airstrip May take long time to mobilise aircraft Subject to weather conditions
No peak hour traffic problems	Patient may be transferred several times, ie. ambulance to plane and back etc.
Adequate oxygen supply 2 x D cylinders, 1500 L each giving oxygen at 15 L/min for 3 hours.	
Can fly at sea level if altitude a problem	May be hazardous Expensive in fuel
Can use aircraft pressurized to ground level	Requires time to mobilize such an aircraft
Adequate space and lighting. Can use ECG	Inability to change therapy enroute Noise levels make monitoring of breath sounds difficult. BP only by palpation.

HELICOPTERS

ADVANTAGES	DISADVANTAGES
No airstrip needed Practically land anywhere	Need down draught to take off
More stable than fixed winged aircraft in adverse conditions	
Cruising speed 110-130 mph	
Adequate room and oxygen supply	The average Bell helicopter not as roomy as the road transport
Flights can be kept below 1000 ft	
Bad weather only limits flights 10 days per year, in the Sydney area	
Vibration and noise not a problem	Vibration may perhaps cause extra bubbling in DCS but there is no evidence of this.
Not subjected to increase in vibration level at take off and landing	Expensive

In the majority of cases First Aid can be administered by the diver's buddies or other non-medical people. The recommended routine is to give 2 aspirin tabs, give 100% oxygen, give 2 litres of fluid orally or intravenously (IV) and keep the patient still.

Spinal cord lesions will need a catheter before transport, and an IV dose of dexamethazone to help in the treatment of spinal cord oedema.

Mobilization of resources is essential. Notification of the nearest recompression chamber, and discussion with them about the general condition of the patient is necessary. The total time for transport is very important. This time including the time needed to mobilize the ambulance. Other factors are the distance to be travelled, the weather and road conditions. Fog, winds and rain will lengthen the transport time, time needed to get to the patient. When air transport is used the time needed to travel to and from airstrips has to be included.

Other things that must be considered are the ability to change therapy en-route, the ability to monitor the patient en-route, an adequate oxygen supply, proper suction facilities and the capabilities of the escort. One must consider whether the effects of transport will adversely effect the patient, ie. vibration or altitude.

TABLE I

GENERAL CONSIDERATIONS FOR CHOOSING TRANSPORT MODE

General condition of the patient

Will transport at that stage adversely effect the patient?

Ability to change therapy en route

Ability to monitor the patient

Adequate supply of drugs and oxygen for the journey

Distance to be travelled

Communications

Actual time of transport
(a) time to mobilize transport
(b) time to travel the distance

Altitude is important when transporting DCS patients. The bubbles in the body will obey Boyle's Law, Pa1/V, therefore any reduction in pressure, as happens with an increase with altitude, will cause an increase in the size of the bubble, and hence make the condition of the patient worse. At 8000 ft (commercial aircraft) the bubble volume will increase 25-30%. With increasing altitude the partial pressure of oxygen will decrease. At 8000 ft the atmospheric pressure will be 567mm Hg, the alveolar O_2 66mm Hg. All patients will need O_2 by mask at the highest concentrations possible. Using a flow of 15 litres a minute (lpm) a D cylinder will last 90 minutes.

Several modes of transport are available, road, aeroplane or helicopter. Table II lists the various advantages and disadvantages of each method.

The definitive treatment of all cases of DCS is recompression. The sooner that it is done the better. Optimally the best form of transport would be under pressure, so that the treatment has already begun during transit. A two-man portable recompression chamber is the safest. Here an attendant is present with the patient, so he can administer therapy en-route. These chambers can also lock onto the mating larger chamber, so allowing transfer under pressure. One man chambers are available, but once the patient is in them, it is impossible to get to the patient unless the chamber is decompressed. They should not be used for transporting patients. Failing a portable chamber, the patient is best served by keeping him at sea level (1ATA), giving him 100% oxygen and transporting him rapidly to the nearest chamber.

Aircraft pressurized to ground level can be hard to obtain. An RAAF Hercules would take considerable time to mobilize to Rockhampton. Commercial aircraft are only pressurized to 8000 ft. There are small fixed winged pressurized aircraft but they are not readily available. We are very fortunate, indeed, here in central Queensland that the Ambulance Service has a pressurized-to-ground-level small aircraft for patient transport,

There is one other problem. Often DCS patients are in a lot of pain. The people attending him may be tempted to give him ETONOX (Nitrous oxide and oxygen mixture) to breathe. Please DO NOT. ETONOX will only make his condition worse as the nitrous oxide diffuses into the bubbles and makes them larger.

Transportation of these patients should be done quickly, safely and with consideration of the problems involved. Mobilization of resources is important as is using them to the best possible advantage to the patient, especially considering the major problem of DYSBARISM.

DISCUSSION

Dr J Williamson

The poor old sports divers really got it in the neck today. I would like to assure people, if they are not already aware of this, that these errors in diving technique and complications are not confined to sports divers. People who dive as part of their work are usually under close and strict supervision and that is very good. But left to their own devices they can get into heaps of trouble and they sometimes do.

There is no such thing as a safe dive so any doctor presented with a diver with symptoms, should not be put off by the fact that their apparent profile is well within the so-called limits of a diving table. There is no such thing as a safe dive. One must always remember that all divers are unreliable witnesses. This does not mean to say they intentionally set out to deceive but very often they quite often say and believe things which on closer enquiry are found not to be true.

I would like to challenge John Knight's statement that there is no danger of CNS toxicity oxygen treatment at 9 metres. That is quite untrue.

Dr J Knight

I did say that CNS oxygen toxicity had been seen at that depth in closed circuit users. I am not aware of it ever having occurred at 9m in somebody who was not using closed circuit equipment in which the CO_2 level has risen. There may be a possibility of it but I have not heard of it.

Dr J Williamson

Well you have heard of it now because we had it in Townsville. I think the important point to make in this regard is that when you are looking at thresholds for anything, in particular oxygen toxicity, but also a lot of other things, a lot of the experience is based on divers sitting comfortably and dry and not working in chambers. But when you put cold, frightened, sick divers back into the water the thresholds are quite different.

Dr J Knight

Could I ask if your case appeared in the SPUMS Journal? If it did, some other explanations have been advanced. Carl Edmonds feels that it was a case of salt water aspiration not oxygen toxicity. But you saw it so you ought to know.

Dr J Williamson

There is no question of it having occurred. The sequence of events was just right down the line for oxygen toxicity. There was no question of salt water aspiration. Are you postulating that salt water aspiration can produce convulsions?

Dr J Knight

No. I would suggest that you have just given the explanation. Divers are poor witnesses. Unless you were actually in the water with him, if he shivered and shook it might well be interpreted as a convulsion by somebody who did not know better. I would not accept a convulsion unless he goes unconscious and he is seen to be unconscious by somebody who knows what unconsciousness is. I do not think most divers are in that category.

Dr J Williamson

As nearly as we can verify all that, all those conditions were satisfied. The people were quite expert in the diving field. As it happened, Vic Callan and I appeared on the scene within minutes after he was brought back to the surface. I think there is very little doubt that this man convulsed.

Dr I Gibbs

I would just like to say a little bit in support of what Dr Williamson just said. I'm ex-Royal Navy and I spent a couple of years at HMS VERNON which is the main Royal Navy diving school in Portsmouth. We used to see a lot of oxygen toxicity in Navy divers trained for the highest levels of professional skill. They were all tested in the chamber so their oxygen tolerances were known. We knew that they were never diving more than 30 feet because there was not more than that to dive in. They may have been exerting themselves and they were probably cold and so on but I would suggest that the incidence of oxygen toxicity amongst the general population would probably be considerably higher at shallower depths than applied to these Navy divers.

Dr J Knight

Are you saying that the clearance divers developed CNS oxygen toxicity without getting raised PCO2 while they were swimming about.

Dr I Gibbs

No. What I am trying to say is that there was a significant incidence of oxygen toxicity at less than 10 metres in blokes who had been specifically tested to prove that they had not got a low threshold to oxygen. I would suggest that the normal civilian population would be more prone to oxygen toxicity than the naval divers. I have reservations myself about the desirability of putting, as Dr J Williamson says, tired frightened people in the water at 9 metres and hoping that they will not have a fit.

Dr J Knight

That is one reason for having the full face mask so that they will not drown if they go unconscious. After all the Royal Navy users full face masks so that their divers can go unconscious quite safely. In water oxygen recompression is not ideal treatment if there is a chamber within easy reach. It is for those people who are not close to a chamber. The great majority of people who get bent do not have neurological bends and most of them cure quite quickly.

All I can say is if there had been any major problem, it would have been round the diving medical world very fast, because few people approve of this treatment. People have spent a lot of time unsuccessfully trying to find cases where it did not work, or had to be abandoned, and the patient was worse as a result.

I think it should not be used off the Queensland coast where one can get a helicopter out and be taken to Townsville and recompressed. On the other hand in Madang the time to get a Lear jet that can pressurise to surface over to Madang and then back to Townsville is going to be more than 6 hours in all probability.

In sheltered, warm water I would prefer to be recompressed on oxygen in the water rather than wait more than 6 hours for treatment. I am not telling everybody to do it. I am saying that I think it is safe enough to risk my life being treated in that way when the alternative is a long wait for treatment.

Question

If you used a Magill circuit, even though it is slightly less convenient than a Mapleson C circuit, you would probably be able to cut flow down to 5 or 6 litres a minute (lpm) rather than 15 lpm, which would give you three times as much oxygen for each cylinder.

Dr C Acott

It is difficult to put Magill circuit into an oxygen cylinder in an aircraft. I take a Mapleson C with me and an ordinary Hudson mask. I have high flows on it, around 13 to 15 lpm. I was using 15 lpm as an example. You have got to know how far you have got to go and how much oxygen you have got on board. It is no use getting up there and finding out you have run out of oxygen.