APPENDIX

2W Diver Survival Kit Mark II

Presentation: The kit is vacuum packed in two strong PVC canvas satchels which incorporate a window showing the representation of the contents and dressing procedure. The compressible items have been selected for their recovery properties after such packing. Tie cords are fitted to assist in installation. Closure is by sealed zips.

Contents

Thermal Undersuit plus towel: dryness increases comfort.

Survival Bag. The Holofil™ bag has a full harness fitted to hold the diver back onto the seat in a slouched forward position, away from the risk of fouling the bottom hatch. There is an inflatable seat cushion and waterproof back and bottom section. External (retractable) insulated arms allow the diver to work yet remain insulated. Bag and harness are sized for divers 5'4" to 6'6".

Breathing System integrates thermal regenerator and CO_2 scrubber. Dead space is only 0.05 litre. Testing at Robert Gordon Institute of Technology is reported to show 95% heat recovery in heliox at 300 m. The oral nasal has been selected for maximum comfort.

Consumables. A high energy pack ensures energy balance and 1.5 pints of water is supplied to offset dehydration. Also, four sanitary bags are included.

Training

It is vital that emergency equipment be used properly. A video cassette recording is available on request.

SPUMS SCIENTIFIC MEETING 1980

THURSDAY JUNE 26th

DECOMPRESSION SICKNESS SESSION ONE

Dr John Miller

My first case history is about a young lady of 22 who was on a package deal holiday from Switzerland to the Caribbean who was diving at about 100 feet. She saw a big fish which surprised her. She shot towards the surface. She was held by her companions a short while at about 70 feet and then she went to the surface. She arrived on the surface unconscious and needing artificial respiration, she was also paralysed. She was taken to the nearest recompression chamber and recompressed. She regained consciousness, but she was difficult to deal with. She was very slow in mentation and she was still paralysed. They did as much for her there as they could by treating her with one of the short oxygen tables. Then they telephoned us and we made arrangements for her to be shipped to our facility. She was recompressed at Duke and subsequently made a fairly good recovery. But she still had some residual paralyses of her hip, which has taken about 4 to 5 months to regress. It is fairly typical of what we are doing.

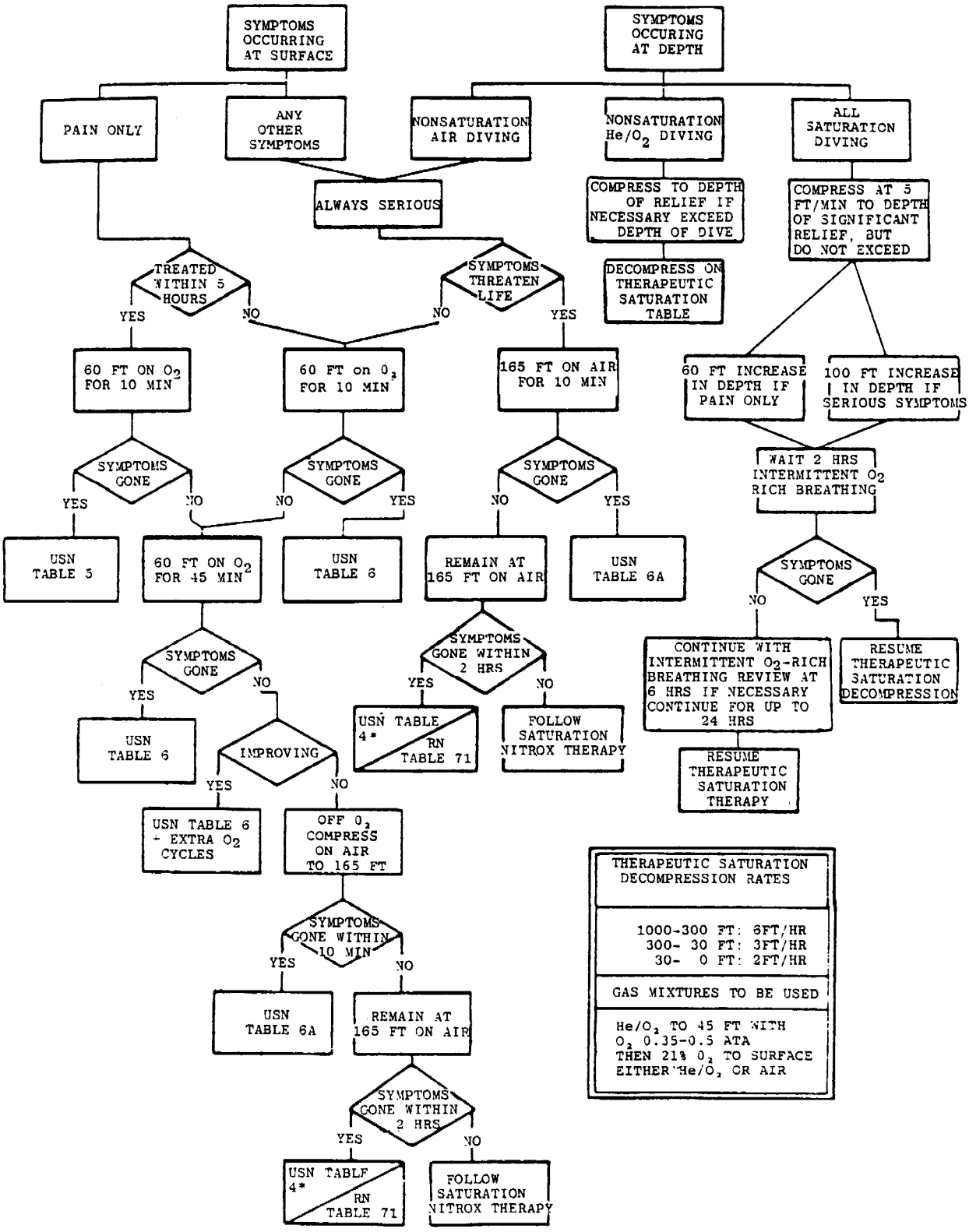
This girl had both a cerebral air embolism and probably decompression sickness. The majority of the cases that we get from the Caribbean and the Bahamas are a mixed type of lesion. Another one that we had was a young woman taking an instructor's course. She was supposed to be doing a simulated rescue where she was the victim unconscious on the bottom of a twenty foot tank. Another student was to go down and give her a breath from his regulator, then support her airway and take her to the surface. He hyperinflated her lungs with an almighty push on his purge button and then managed to support her airway by placing his whole hand around her larynx. He forcefully dragged her to the surface despite her protests. She was recompressed in the chamber there for her cerebral air embolism. She was a little slow to regain consciousness so they stayed longer than 30 minutes at 165 feet. In these circumstances they should have used US Navy Table 4, but they used an "exceptional exposure" decompression. This gave her decompression sickness which they then treated inadequately. She developed a recurrence. They did that five times, with each recurrence getting worse and worse. Eventually they shipped her to us. She required a very prolonged treatment indeed.

I want to talk about the elements in the treatment of decompression sickness. Recompression is the standard thing to do, and the other things that are important are oxygen and fluid therapy, adequate time an depth and then the use of specific pharmacological agents.

Figure I is a simple man's approach to treating a diving accident, particularly decompression sickness when you have recompression facilities available. It has proved to be very effective. I included the possibility of having unlimited recompression facilities available, but most chambers do not have unlimited capability. So there are cut off points along the way to go into. Either you have symptoms occurring on the surface after a dive or at depth during decompression. We generally regard symptoms that occur at depth as being potentially more serious than similar symptoms which started at the surface. This is because a patient who develops symptoms at depth is not nearly as far into his decompression as a patient who develops symptoms at the surface. That is why you go through a complicated system of calculating the time between dives and the various sort of categories that you can get into for a second dive during the day.

The symptoms can be pain only, limited only to the joints, or involving other organs as well. The other organs are generally the central nervous system and/or the lungs. Usually if one has severe decompression sickness involving the lungs, otherwise known as "the chokes", unless that is treated very rapidly the patient will die. I do not know of any patients who have spontaneously recovered from the chokes. This is not true in most other cases of central nervous system decompression sickness. It is true in a number of cases of cerebral air embolism. Regardless of what you do they do not survive.

THE DUKE UNIVERSITY FLOW-CHART FOR THE TREATMENT OF DECOMPRESSION SICKNESS



* Always use the oxygen version of USN Table 4, for both patient and attendant (s)

The idea is to establish a number of points, based on the pathophysiology of decompression sickness, in order to make decisions. The first is whether the interval between development of symptoms and the start of treatment exceeds 4 to 6 hours. It takes that time for all the intravascular phenomena to stabilize around the gas phase. Many patients who are treated after the 4 to 6 hour period are more difficult to treat than if you have them immediately after they develop symptoms. Then there are a number of decision points whether or not the patient has got better after a given time period or treatment.

The first thing is to recompress the patient to 60 feet, breathing oxygen. It is usual to deliver oxygen with air breaks, either as 25 minutes of oxygen with a 5 minute air break or 20 minutes of oxygen with a 5 minute air break, the idea being to avoid the onset of pulmonary oxygen toxicity. We evaluate at the end of the first oxygen period. The decision tree gives you the choice "symptoms better" or "not better". If they are better and it is the pain-only bend, you can use a short oxygen treatment like USN Table 5. If not better, you have to stay longer.

The philosophy is one of doing something that is rational in relation to the pathophysiology. We are trying to treat the symptoms and the underlying condition. We recompress, then assess the patient by symptoms without any attempt to nominate beforehand what sort of table we are going to use. At the same time we continue with whatever adjuvant therapy was instituted. We use this flow chart primarily to be able to know where we have been during the treatment. With this series of steps you can eventually get yourself either out of your own chain of capabilities or ultimately into the bottom of the chart which says "followed saturation nitrox therapy", which I will be dealing with in Singapore.

The right hand side of the flow chart is primarily designed for oxy-helium diving, either bounce or saturation. You recompress to 60 feet on oxygen, if the patient is not better with a standard table 5 or table 6, you immediately go to saturation oxy-helium treatment. We do not need to deal with that any further.

There are occasions such as cerebral air embolism or somebody who has the chokes or somebody who has a very high cord or lower brain stem decompression sickness, when you would be prepared to jump straight to 165 feet simply because the symptoms are threatening the patient's life. Again if you follow that through you eventually get to the saturation point. Most people are put on USN Table 5 partly as an inducement for people to report their symptoms on a Friday afternoon. Most of us now use Table 6 most of the time. 85% of cases get completely better with one or the other of these two Tables. When they do not then you have a problem. Our solution is on the flow chart. We go to 165 feet and stay for an indeterminate period of time, as long as 8 hours. Then we follow a proven safe pathway back from 165 feet to either 100 feet or 60 feet. At 100 feet we change to a safe oxygen environment so that we can stay there as long as we like. Then we follow an appropriate way out when the rate of improvement of the patient has obviously slowed down.

You can see the rationale that we have for using this type of flow chart. Although it may not be ideal, it is rational. It saves a lot of time in making decisions simply because a lot of the thinking is done for you beforehand. It also restricts the number of Tables that are used to a relatively small number. Also, if we have a record of what we have done we can then compare responses between patients.

The adjuvant therapy we use is mainly balanced salt solution, or in the Australian situation Hartmann's solution. We have slowly stopped using dextran over the last three years. In many instances of central nervous system oedema steroids have been demonstrated to be effective. Whether or not they are effective in cerebral air embolism or central nervous decompression sickness, we do not know. We still use steroids and we tend to use it in neurosurgical dosages. But we really do not know whether we are treating the patient or treating ourselves. We stopped using heparin. It sounds good, reversing coagulopathy with low dose heparin, but 5,000 units subcutaneously, if you give it to enough patients, will occasionally produce total heparinization of the patient, although it is theoretically not possible. 1,000 units every 6 hours does nothing but keep the intravenous open. I prefer to avoid those sorts of complications. We use appropriate antibiotics and other therapy as required according to the patient's condition.

Many recompression facilities that people consider to be pretty basic can in fact be used for saturation treatment at a pinch. It is not that difficult to set up a scrubbing system for CO2. In fact quite a nice scrubbing system consists of a pair of pantihose. You take a couple of handfuls of soda lime and pack it down into the toe and you knot the pantihose above that lump. Then you put another couple of handfuls in and knot above that. You keep on doing that until the whole pair of pantihose is filled. You hang that up in the chamber. That acts as a very good CO2 absorber. As the CO2 starts to rise a bit, and you can tell that as you get a little bit headachy, you massage the legs of the pantihose and by doing so you change the active surface that is available. Oxygen addition is no great problem. Venturis are used for all sorts of purposes and they are relatively inexpensive. A venturi to add oxygen provides a good mixer for the gas in the chamber. At a pinch you can get by with a sheet of masonite and do a Rolf Harris wobble-board routine to stir the gas.

During saturation treatment at 100 feet you have to get the oxygen down from 0.8 atmospheres to 0.5 of an atmosphere. You can do that in two ways. If you have not spent a lot of time at 165 feet, you can have the patient and the attendants in the chamber breathe the oxygen down. Then you just add little bits of oxygen as you need it. Or you can add additional

nitrogen, which is not much of a problem if you have access to nitrogen.

All you need in terms of gas supply and gas analysis, is a simple oxygen analyser, which is pretty cheap, a supply of sodalime, a sheet of masonite, a few pairs of pantihose and of course, oxygen. You also need some sort of cover over the chamber because if it is out in the hot sun the people inside will get very hot and become dehydrated very, very quickly. Once you have a cover over the chamber you do not need a sophisticated cooling system to cool it. If you have adequate evaporation then wet blankets on the chamber will remove heat from the chamber. If you are in a humid, hot climate then cooling is somewhat more difficult, but it can be done if you play a spray of water on the chamber. Saturation treatment can be done in most small chambers, but it is uncomfortable and messy. It is not something to be embarked upon lightly. Because of these problems and the staffing and logistical problem of handling this sort of operation for the necessary length of time the patients are likely to be sent to a major centre rather than treated with nitrox saturation in the chambers around the Caribbean. Generally speaking, the major centres they go to are ourselves or the chamber at Brooks Air Force Base at San Antonio, Texas.

Chairman (Dr Tony Slark)
I would like to tell you a story about a patient of mine which was similar to the story you opened with. She was diving under a ledge when she saw jaws looking at her, so she said. She darted straight to the surface. When she reached us she was, as you said, "a bit slow in mentation". Her only comment was "Aw shit". After being on the long oxygen Table for about half an hour she brightened up a great deal. Her symptoms all disappeared and she would not stop talking.

Dr John Miller
Our Swiss girl had a remarkable increase in her level of mentation during her treatment. She went from speaking only German to becoming multi-lingual during the course of 24 hours. We also have had one of these strange birds that people did not like. That was the lady who was on the instructor's course. She arrived in a gold lame bikini. She was young but very well used. She was on her third husband at the age of 24. She had scars from various riding and motor cycle accidents. She and her husband ran a travel business among other things. They were both learning to fly with the idea that they would get groups of people together, fly them, in their own tax deductable aeroplane, to the Caribbean and then teach them how to dive. She was a fine young lady whose libido was to say the least, extraordinary.

Dr Jimmy How
In the treatment of decompression sickness you really have to deal with each individual patient. It is not just the application of a table or the application of a particular flow chart. I think we have to determine the response. I fully agree with John Miller that one should hang on at 60 feet and then wait and determine the type of table according to these patient's response. I am frightened to have tables and flow charts in case we begin not to think at all and just flow into it in one way or the other. Most of us here, I think, are not doing treatment at all. But you may see patients who turn up at your clinic or at your hospital. I would like to tell you about a case to emphasize how important it is that doctors do not fall into the trap of applying tables in our minds and forgetting that the patient has to be examined clinically to determine what really is wrong with him.

This happened last week while I was anxiously waiting for you all to turn up. We had a case that was three weeks delayed. This chap had a dive to 100 feet for 90 minutes. When he surfaced he had swelling on his face and swelling around his neck. That was all he had. He was not dyspnoeic. He went to a general practitioner. He was examined and treated for nephritis for about a week. He was not getting any better. Then he went down to the Government outpatients. He was again examined and asked to go home. Finally a registrar saw him and when they took the history they found that he had got a diving history so they thought it could be bends. They quickly sent him over to us to think about maybe pulmonary barotrauma or some form of decompression sickness. Now all of these doctors probably did not do enough clinical examination of the patient. My doctor saw him, examined him and gave me the history. I said "Have you examined him?" and he said "Yes. The chest was clear, everything was clear". But I was not happy. With the swelling of the face many things could have happened. There could be lymphoedema from decompression sickness or there could be a ruptured lung with air tracking up both sides of the neck. So I said "You cannot put him the chamber until we have a chest X-ray and have a look at it". We took a chest X-ray and the right apical lobe was completely opaque. We examined the case again and we found dullness and diminished air entry on the right side. Watching carefully while he breathed we could see that the chest was not moving equally. Now I stress all this because we really look at our cases. Sometimes the moment you think of the bends you refer the patient to a chamber just because he has been diving. People forget that he is a patient any more and people forget about clinical examination. This patient had a complete opacity of the right upper lobe. Had we put him into the chamber, we would have been in a bit of a problem.

At the moment he is still in hospital being bronchoscoped. Your guess is as good as mine as to what the diagnosis is. It could be a carcinoma, it could be something from the mediastinum, or it could be an effusion into that part of the lung. Clinical examination is really important before putting the patient in the chamber. I say this because we sometimes get misdiagnoses sent to our hospital. It is common in Singapore where decompression sickness is really not well known at all. We have no lectures in the University on such illnesses. It is important that knowledge of decompression sickness be propagated. I find that proper clinical examination will usually reveal the