followed by DCS but DCS was very likely after a rapid ascent from a deep dive.

Safe diving

For divers who use a dive computer and are taking advantage of its multi-level capacity, any rule to avoid reverse profiles would seem irrelevant.

For those still using a dive table, the avoidance of reverse profiles is an important practical rule that results in more bottom time.

Conclusions

The final statement of the meeting was "We find no reason for the diving communities to prohibit reverse dive profiles for no-decompression dives less than 40 msw (130 ft) and depth differentials less than 12 msw (40 ft)".

In the 21 pages of the General Session discussion it appears that the consensus, give and take a few, was that conservatism, staying well within the times at depth, ascending slowly and decompressing longer than required by the tables, appears to be the best way to avoid decompression sickness. This discussion, the Introductory Session and the Medical Session were the easiest for medicos to understand. Two major sessions, Physics/Physiology and Physiology/ Modelling were dominated by mathematics. The Operational Experience Session was very interesting.

Nowadays most divers use dive computers. Computers rarely are victims of DCS, but divers can be! In fact, in some series of Decompression Illness reports, 50% and more of the affected divers were using computers.

Dr Guy Williams is Immediate Past President of SPUMS. He has a general and diving medicine practice. His address is 1239 Nepean Highway, Rosebud, Victoria 3939, Australia. Phone +61-3-5981-1555. Fax +61-3-5981-2213. E-mail <guyw@surf.net.au> .

A SUMMARY OF THE UNDERSEA AND HYPERBARIC MEDICAL SOCIETY NEAR DROWNING WORKSHOP

Chris Acott

Key Words

Drowning, incidents, near drowning, physiology, treatment.

Introduction

The Undersea and Hyperbaric Medical Society (UHMS) Workshop on near-drowning was held in 1997.

One of the most interesting presentations was by Carl Edmonds on drowning and near-drowning.[1] Table 1, chosen from that paper, shows what I consider to be the interesting parts of his data. This reported 100 Australian divers, who fitted the requirements for being classified as dying from drowning.

TABLE 1

COMPARISON BETWEEN 100 DROWNED DIVERS AND 48 WHO SURVIVED NEAR-DROWNING

Taken from tables in C Edmonds, *Drowning with scuba*.[1]

	Drowned	Survived
Training		
No training	38%	4%
Under training	8%	15%
Experience		
None	37%	31%
Novice	30%	35%
Some	27%	29%
Equipment		
Faults	31%	18%
Misuse	43%	38%
Buoyancy		
Overweighted	25%	27%
BCD not inflated	52%	31%
BCD failed to inflate	5%	8%
BCD inflated before incident	12%	-
Victim inflated BCD	15%	35%
Buddy operated BCD	16%	25%
Overall inflated BCDs	31%	60%
Air		
Out of air	49%	27%
Low on air	11%	8%
1/4- 1/2 cylinder	11%	20%
>1/2 cylinder	29%	45%
Water environment		
Poor visibility	26%	18%
Current	55%	31%
Rough	44%	41%
Weight belt		
Not ditched	66%	48%
Ditched by victim	10%	19%
Ditched by rescuer	20%	25%

They were selected from Douglas Walker's Australian Diving-related death reports. Their stories were compared with those of 48 divers who had survived near-drowning and completed a questionnaire on various diving-related web sites.

In many ways the two groups were very similar. The drowned and the near-drowned had much the same diving experience. However, 38% of the drowned victims had no training while only 4% of the survivors had not been trained. Equipment faults and misuse of the diving equipment featured in both series, but the survivors had just above half the rate of faults of those who died.

Divers were over weighted in 25% of the drowned and in 27% of the near-drowned. Too often people learning to dive are over weighted by the diving instructor. This is to make it easier for them to get down and to keep them on the bottom doing the various things that the instructor want to teach them. Often when people learn to dive carrying 26 kg of weight belt they will always use 26 kg. About 5 years ago, in South Australia, a husband was teaching his wife to dive. They were on the Port Norlunga jetty and he had over weighted her, then told her to jump in with the snorkel in her mouth. He turned his back on her and started to fiddle with his equipment. Apparently he never actually told her how to inflate a buoyancy compensating device (BCD) to stop herself from sinking, so when she jumped in the water with a snorkel in her mouth she sank. Her husband was busy with his equipment and about 2 or 3 minutes later he heard someone say "Hey there's somebody on the bottom down there". She had drowned. She was dead. He had forgotten to tell her about putting the regulator in her mouth before entering the water as well as forgetting to instruct her in inflating her buoyancy jacket. She died because she was overweighted and did not know how to use her equipment.

The BCD was inflated in 31% of the drowned divers whereas in the survivors the BCD was inflated in 60%. In the drowned group, out of air and low air situations featured in 60% of the deaths. Of the near-drowned survivors it was only about 35% who were out of air or low on air. Only 11% of the drowned divers still had between a half and a quarter of their air remaining. Twenty per cent of the survivors had that much remaining air. Only 29% of the drowned divers still had more than half a cylinder remaining, but in the survivors it was 45%. Most of the near-drowned divers (65%) had enough air to get themselves out of their problem.

Rough water exposure was much the same for both groups but currents were reported in nearly double the number of dead divers than in survivors. Poor visibility was a factor in 26% of drowned divers but only in 18% of the survivors. Perhaps they could actually see their way out of the wreck or see their way to the surface. In wrecks and caves it is very easy to stir up silt and lose visibility.

Retained weight belts featured both in the drowned (66%) and near-drowned (48%). It seems that divers want to save money and not their lives when they fail to ditch their weight belts when in trouble. Carl always tells people to take their weight belt off as soon as trouble starts and to hold it well away from your body. Then if it needs to be dropped it will fall away clear of the body, and if you go unconscious you will drop your weight belt as your grip relaxes. I do not understand why people in trouble on the surface, struggling to keep their head out of the water, would not ditch the weight belt unless it was to save money.

From Edmonds' data survival depended on training, education, water skills, good buoyancy control and a rescuing buddy . Failure to ditch the weight belt featured in both drownings and near-drownings and fatalities. In the latter 60% were either out of air or low on air.

Why do divers run out of air?

The Diving Incidents Monitoring Study (DIMS) has data on out of air causes (Table 2). The main cause is failure to check the air supply both before and during the dive. The only safe way to dive is to check whether the cylinder is full and the valve turned on fully before you get in the water. This known failure to check air supplies always worries me when people start talking about redundant air systems . One wonders whether divers with two air supplies will always check the second air supply that is theoretically supposed to be there to keep them out of trouble.

Equipment failure is usually an inaccurate contents gauge. Some people had inaccurate contents gauges and when they found it difficult to breathe and tapped their old analogue contents gauge the needle just suddenly went straight to empty. Debris in the tank obstructing the valve, rupture of an air hose, vomitus in the mouthpiece and sudden failure of the second stage to deliver air also featured. Many people think that rupture of the air hose from the first stage to the second stage will always occur at the start of the dive when the tank pressure high. That does not necessarily happen, sometimes it is well into the dive.

Contributing factors include poor dive planning. Most divers have no idea on how much air they consume during a dive. Sometimes they decide to do a dive to 50 m. But they do not realise that they will need a much greater air supply than for their usual less-than-18 m dive;

a) for getting to 50 metres and
b) to do decompression on the way up.

I was taught to use the rule of thirds, which people do not seem to use these days. A third of the supply to enjoy the dive, a third to get back to the boat, and a third to have on the surface just in case there is some trouble.

TABLE 2

CAUSES OF OUT OF AIR INCIDENTS FROM DIVING INCIDENTS MONITORING STUDY DATA

Failure to check air supply
Before and during dive.

Equipment failure
Inaccurate contents gauge.
Debris in tanks.
Rupture air hose, not necessarily at start of dive.
Vomitus in mouth piece.

Poor dive planning
Air consumption for depth and dive time not calculated before dive.
Failure to apply rule of thirds, one third in, one third out and one third for emergencies.

Stupidity
Inappropriate response such as:
Doing a safety stop when low on air,
Continuing the dive when using octopus regulator,
Inattention.

Poor buoyancy control
Frequent use of air for buoyancy adjustments.

Poor buddy diving
Buddies diving too far apart so that one goes from low on air to out of air while trying to alert buddy to the problem.

Stupidity is the only way to describe some inappropriate responses. One of these is doing a "safety stop", which by definition is not a decompression stop, when both divers are low on air. The result is almost always one, and often two, out of air ascents. Another is continuing to dive when one diver is out of air and is given the buddy's octopus regulator. Amazingly this happens and they continue the dive and the two of them run out of air very quickly. The final inappropriate behaviour is inattention, neglecting the air supply, while being fully occupied by what is going on around you.

Poor buoyancy control occurs usually when the diver is overweighted and air needs to be added to the BCD the frequently in order to maintain neutral buoyancy. This frequent topping up depletes the air supply very rapidly.

Finally poor buddy diving, when the buddies are separated greater than 5 or 6 m. If one buddy becomes low on air, by the time he or she actually gets to the buddy they are often out of air.

The Workshop

Brown and Piantadosi discussed the hospital management of near-drowned people including general measures, management in the intensive care unit (ICU), brain resuscitation and the status of patients and their prognosis.[2] Table 3, compiled from their paper, demonstrates their management plans. One checks for pre-disposing factors, for cervical spine and skull fractures. This will involve X-rays. One also checks for evidence of ear and sinus barotrauma because they may serve later as portals of intracranial infection if they become infected. The management in ICU is standard cardiac support, fluids and monitoring. Inotropes, fluids and the management of various electrolyte abnormalities that may occur are often needed. Salt water, when it is swallowed can act as a very good osmotic diuretic or cause osmotic diarrhoea.

The initial chest X-ray may be normal. Respiratory care using intermittent positive pressure ventilation (IPPV) and positive end expiratory pressure (PEEP) may be needed. If antibiotics are to be used these must be determined by accurate microbiology sensitivity testing. The treatments for brain resuscitation used in intensive care units in the 1980s, such as Hyper therapy have been reviewed in the 1990s and shown to be of no benefit. Corticosteroids, osmotic diuresis and the use of frusemide is no longer

TABLE 3

HOSPITAL MANAGEMENT OF NEAR DROWNING

From Brown and Piantadosi Near-drowing; hospital management.[3]

General Measures
Check for predisposing factors
Check for spine and skull fractures
Sinus, ear, skin barotrauma may serve as portals for infection

Management in ICU
Inotropes, fluids, monitoring
Electrolyte abnormalities etc.

Respiratory Care
Initial chest X-ray may be 'normal'
IPPV +/- PEEP
Accurate microbiology as required

Brain resuscitation
— HYPER reviewed - no benefit
— Use of corticosteriods, osmotic diuresis, hypothermia not advocated
— ICP monitoring - no benefit

advocated, nor is hypothermia though to be useful. No benefit has been shown from intracranial pressure monitoring which was popular in the 1980s. Brown and Piantadosi used a classification system of near-drowned people. It involved assessment at 1-2 hours after resuscitation. Category A were awake and fully conscious, category B had blunted consciousness but were rousable and category C were comatose. They state that about 80% of child and adult near-drowning victims survive without sequelae and 2-9% survive with brain damage. About 12% of all near-drowning victims die. About 90% of category A and B and about 50% of category C patients survive with full recovery. About 10-23% of category C patients survive with permanent neurological injuries.

Chris Dueker presented a paper on *Myths in near-drowning* in which he discussed laryngeal spasm.[3] He also debunked dry drowning. Breathing against a closed glottis will cause a negative intrathoracic pressure, which may cause pulmonary oedema. Just before death from anoxia the vocal cords relax and may allow fluid to be aspirated. In my early anaesthetic days consultants cheered their juniors by saying "If you just keep trying to oxygenate the patient, the cords will open just before he dies and you can get some oxygen into him then". I never waited for that but used to use suction fairly quickly.

Dueker discussed so-called protective role of hypothermia and discounted this in divers because divers actually do wear suits to protect them from becoming hypothermic. This protection is limited and can be overcome by long exposures to cold water. Dueker considered that in most waters divers will not get any protective effects from hypothermia. He disagreed with the use of the Heimlich manoeuvre (an abdominal thrust), which is the agreed primary treatment of respiratory obstruction by foreign objects, in near drowning as respiratory obstruction is rare in near-drowning and when it occurs is usually aspirated material, which will need to be removed by a finger or repositioning rather than by delaying resuscitation by squashing the belly and perhaps increasing hypoxic injury. The Heimlich manoeuvre should not be used in near-drowned people to try and clear the lungs of fluid because it will not do that.

Other topics discussed were *Open water rescues and field resuscitation* by Dennis Graver.[4] Drew Richardson has a paper to present at this meeting on these topics. Bill Hamilton, who was our guest speaker in the Maldives in 1996, spoke on *Rescues in special circumstances*.[5] His presentation was as good as the presentations he gave in the Maldives, I don't go on any further than that, and Claes Lundgren presented an excellent paper, *Does the cardiovascular diving response have a protective effect in near drowning incidents?* which I decided not to review here.

Carl Edmonds also presented a paper on the mechanisms of the drowning syndromes,[6] and Chris Dueker presented a paper on *Expectations for recovery*.[7]

Two papers about drowning appeared in the South Pacific Underwater Medicine Society Journal in 1997 and 1998 and were forerunners of Carl Edmonds' two papers at the UHMS Workshop in 1977 which was published in 1999.[8,9]

References

1 Edmonds C. Drowning with scuba. *Near Drowning 47th Workshop of the Undersea and Hyperbaric Medical Society*. Kensington, Maryland: UHMS, 1999; 19-29 Discussion 30-33

2 Brown SD and Piantadosi CA. Near drowning: hospital management. *Near Drowning 47th Workshop of the Undersea and Hyperbaric Medical Society*. Kensington, Maryland: UHMS, 1999; 47-53

3 Dueker CW. Myths in near drowning. *Near Drowning 47th Workshop of the Undersea and Hyperbaric Medical Society*. Kensington, Maryland: UHMS, 1999; 15-18

4 Graver DK. Near drowning: open water rescues and field resuscitation. *Near Drowning 47th Workshop of the Undersea and Hyperbaric Medical Society*. Kensington, Maryland: UHMS, 1999; 35-40

5 Hamilton RW. Rescues in special circumstances. *Near Drowning 47th Workshop of the Undersea and Hyperbaric Medical Society*. Kensington, Maryland: UHMS, 1999; 41-45

6 Edmonds C. Drowning syndromes - the mechanism. *Near Drowning 47th Workshop of the Undersea and Hyperbaric Medical Society*. Kensington, Maryland: UHMS, 1999; 3-9

7 Dueker CW. Expectations for recovery. *Near Drowning 47th Workshop of the Undersea and Hyperbaric Medical Society*. Kensington, Maryland: UHMS, 1999; 55-57

8 Edmonds C, Walker D and Scott B. Drowning syndromes with scuba. *SPUMS J* 1997; 27 (4): 182-190

9 Edmonds C. Drowning syndromes - the mechanism. *SPUMS J* 1998; 28 (1): 2-9

Dr C J Acott FANZCA, DipDHM, is the Co-ordinator of the Diving Incident Monitoring Study (DIMS) and a consultant for the Diver Emergency Service. He is Director of Diving Medicine, Royal Adelaide Hospital Hyperbaric Medicine Unit, Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital, North Terrace, Adelaide, South Australia 5000, Australia. Phone +61-8-8222-5116. Fax +61-8-8232-4207. E-mail <cacott@optusnet.com.au>