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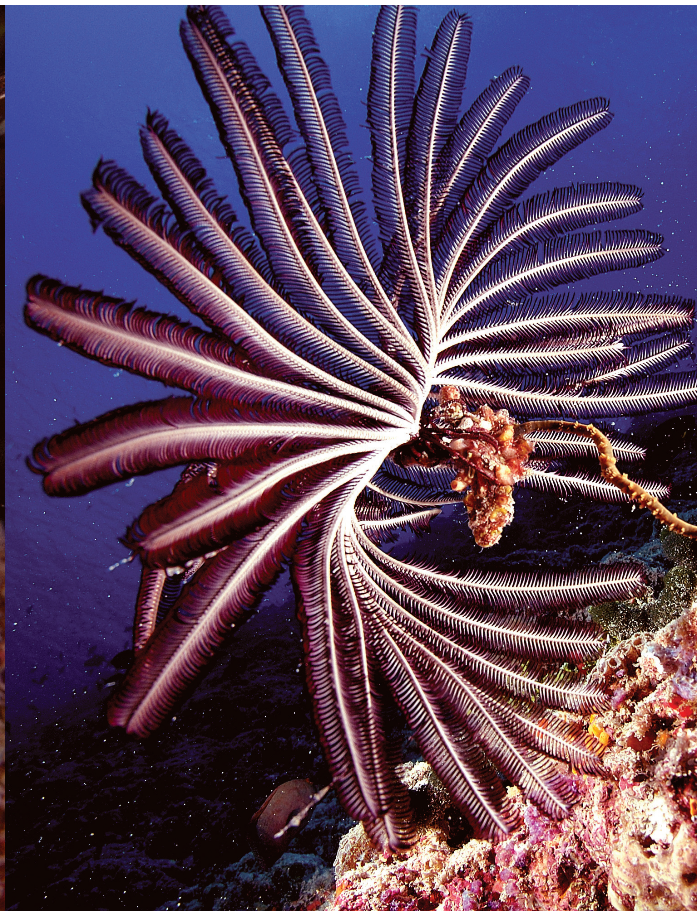

Project Stickybeak 1999

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To promote and facilitate the study of all aspects of underwater and hyperbaric medicine
To provide information on underwater and hyperbaric medicine
To publish a journal
To convene members of the Society annually at a scientific conference

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The Society's financial year is January to December, the same as the Journal year.
The 2006 subscription will be Full Members A$132.00 and Associate Members A$66.00, including GST.
There will be an additional surcharge of $8.00 for journal postage for all members living outside Australia.

The Editor's offering

It is four years since the 1998 Project Stickybeak case reports were published.[1] That it has taken so long for the 1999 cases to see the light of day in this issue is disappointing. At committee meetings in the past few years, Douglas Walker has regularly complained about the increasing difficulty he has faced in gaining access to diving fatality records in this p.c.-conscious, privacy-regulated world. In addition, he no longer has access to New Zealand data, but between the NZU Accident Recorder, Dr Lynn Taylor, and myself, we hope to redress this from our side of the Tasman.

At best, assembling these case reports requires considerable detective work and great patience with the coronial process. All too often key facts and information are missing from the final jigsaw puzzle because the pieces are drawn from many sources, police records and autopsy reports vary enormously in quality and it is often difficult to separate fact from supposition. Finally, their intepretation is easily coloured by the researcher's own perspective, as illustrated in the exchange of opinion in the Journal between Drs Acott and Walker over the South Australian series.[2,3]

The difficulties encountered are well illustrated by one of the cases in the 1999 series, which initially appeared twice in two very different forms. This was because data were assembled from differing sources for what looked like two separate incidents and it was only when the two were compared side by side by a reviewer that the remarkable similarities between the two became evident. In turn, this reflects how painstaking one must be with such surveys. In the presentation of this latest series, the individual reports have a structure slightly different to that in the past.

Douglas Walker's work needs to be continued. If he will forgive a personal remark, he is getting fairly long in the tooth, and this one-man band does need a succession plan. I hope that his close publishing association with John Lippmann and DAN-SEAP will ensure this, but it will take a medically qualified researcher to continue the work – keen volunteers, please!

The Project Stickybeak publications are used and regularly quoted throughout the international diving literature and there is little doubt as to their value. However, simple tabulation of fatalities is not enough, as I have commented in a previous editorial.[4] This research needs to be taken that important step further through meaningful interrogation of the database already created, just as Carl Edmonds did with Douglas in the late 1980s.[5]

Some years ago, Simon Mitchell presented me with the challenge of reviewing the decompression illness severity scoring and the weighting of the various components that they were developing for the lignocaine trial (sadly never completed) in Auckland. In the long run there was a reasonable consensus amongst us all, but it was no easy task. The excellent review paper by Dr Mitchell in this issue on severity scoring represents the current state-of-the-art in this field. Certainly, both for quality assurance and research purposes, we need good descriptors of presenting diver populations so that we may compare apples with apples in assessing outcome data.

The cost of hyperbaric oxygen therapy (HBOT) has always been an issue of contention amongst clinicians, many of whom do not refer patients for HBOT "because it is too expensive". For years, hyperbaracists have argued that the cost-benefit equation for HBOT is often at least cost neutral and in many circumstances, cost reducing. One paraplegic diver successfully treated per year saves about as much money in terms of lifetime spinal injury care as our hyperbaric unit in Christchurch costs to run annually. Robert Marx has long argued the cost savings of HBOT in treating osteoradionecrosis of the jaw, though this has recently been questioned, and there is preliminary evidence of significant cost savings in the treatment of diabetic ulcers.

In my hospital, a 30-treament course costs approximately the same as the average acute care and rehabilitation costs of treating a fractured neck of femur in the elderly. Yet clinicians still see it as a very expensive, unproven technology. Therefore, providing detailed cost analyses of HBOT, such as that published here from the Prince of Wales Hospital (POWH) unit, that can be combined with efficacy (numbers needed to treat) will be important for the future of hyperbaric medicine. The economy of size is well demonstrated, in that POWH provides approximately 3.5 times the amount of HBOT that we do in Christchurch, at only 2.5 times the cost.

The new Society website is up and running. Log in a.s.a.p.

Sarah Webb and I wish all Society members the very best for the Festive Season and health and good diving for 2006.

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Michael Davis

Front cover photos of common lionfish (turkeyfish) and stemmed crinoid (feather star) courtesy of Martin Sayer. Nikon D-70 with 60 mm lens (left) and 14 mm lens (right).

Original articles

The effects on performance of cyclizine and pseudoephedrine during dry chamber dives breathing air to 30 metres' depth

Graham McGeoch, F Michael Davis and Lynn Fletcher

Key words
Performance, nitrogen narcosis, medications, nasal decongestants, motion sickness, hyperbaric research

Abstract

(McGeoch G, Davis FM, Fletcher L. The effects on performance of cyclizine and pseudoephedrine during dry chamber dives breathing air to 30 metres' depth. *SPUMS J*. 2005; 35: 178-82.)
Twenty-four subjects ingested pseudoephedrine (60 mg), cyclizine (50 mg) or placebo approximately two hours before a dry chamber dive breathing air to five or 30 metres' seawater depth (msw; 151 or 404 kPa). Each subject did six dives, the sequence of drug ingestion and dive-depth order assigned according to a counterbalanced design. Tests of grammatical reasoning, manual dexterity and simple arithmetic were performed. A small decrease in performance occurred at 30 msw in grammatical reasoning (P = 0.02) and manual dexterity (P = 0.02) irrespective of the drug taken. The type of drug affected grammatical reasoning performance (P = 0.002) such that performance impairment at depth for cyclizine was more than for pseudoephedrine (P = 0.007) or placebo (P = 0.002). The effect of drug on manual dexterity was not significant (P = 0.23). There were no depth or drug effects on the simple arithmetic test. There were no significant effects of drug order for either manual dexterity (P = 0.93) or grammatical reasoning (P = 0.10), but performance improved for both manual dexterity (P < 0.001) and grammatical reasoning (P < 0.001) over the dive series despite pre-dive practice. Pseudoephedrine showed little or no effect on performance under these conditions, but the minor impairment with cyclizine suggests that it should be used with caution prior to air diving in open water conditions.

Introduction

Self-medication for various ailments including motion sickness and nasal congestion is common amongst sport divers.[1] There remains uncertainty about how this practice might affect performance at depth or diving safety.[2,3] This study investigated the effects on diver performance during simulated air dives in a dry decompression chamber of two drugs, an anti-emetic, cyclizine, and a nasal decongestant, pseudoephedrine, both widely used by divers. The aim of this study was to determine if either cyclizine or pseudoephedrine affected diver performance at depth. In the process, any interaction between the effects of the drugs and of depth and whether there was a drug-order effect in the experimental model used were also assessed. Although the present study was performed back in 1982, given the limited information in the literature on drugs and diving and the widespread use of the study drugs by divers, the results are highly relevant today.

Subjects and methods

Twenty-four experienced, male recreational divers aged between 21 and 50 years (average age 31.1 years; 95% CI 26.6, 35.5) with an average of 281 dives (95% CI 152, 411) were recruited from local recreational diving clubs. The only exclusion criterion was known allergy to either drug. The project was approved by the Christchurch Hospitals Ethical Committee, but at the time of the study, 1982, written informed consent was not required of such participants in New Zealand and consent was verbal. All participants were made fully aware of the potential risks of barotrauma and decompression sickness. Neither food nor drink was taken for four hours prior to each dive. Two hours before each dive the subjects ingested with water a capsule of pseudoephedrine (60 mg; Sudafed), cyclizine (50 mg) or placebo. Subjects were asked to report any unusual feelings that occurred after drug ingestion or during the dives. The identity of the drug and the depth of each dive were blinded for both subjects and in-chamber observers. Each subject took the same drug on two consecutive dives, six dives being completed in all. There was an interval of at least one week between dives for each subject. To minimise practice effects, the performance tests were practised twice before the dive series, once outside the chamber and once during a simulated dive in the chamber at ambient pressure. In addition, the order of presentation of the drugs and depths of dive was varied according to a counterbalanced experimental design over the six dives. With twenty-four subjects this utilised half of the forty-eight possible random sequences for drug/depth order.

The divers were compressed singly or in pairs with an observer in a multiplace recompression chamber on air to the equivalent of five or 30 metres' seawater depth (msw; 151 or 404 kPa). The depth of the dives was disguised from the subjects by masking gauges, by having a standard descent time and by keeping noise levels constant (achieved by having the air intake and exhaust open simultaneously). Five minutes after starting the dive, performance testing was commenced. Three tests were presented, always in the same sequence. Instructions were repeated to the diver by the observer in a prescribed manner before each test on each dive.

The three tests employed were chosen for their known validity in repeated measures testing and/or because of their past repeated use and known sensitivity for diver performance testing.[4–8]

GRAMMATICAL REASONING

This test is described in detail elsewhere.[7] In summary, it comprises a series of 64 sentences claiming to describe the order of the two letters A and B, which follow the sentence as a letter pair AB or BA (e.g., A follows B – AB; B does not precede A – AB, etc). The subject has to decide whether the sentence gives a correct description of the letter pair corresponding to that sentence and put a tick in a 'true' or 'false' column. Three minutes are allowed to complete as many items as possible. At each testing, the subject is given a different set of sentences. The number of sentences completed and the number of errors made are the performance measures in this test.

MANUAL DEXTERITY

A modification of the Bennett Hand Tool Dexterity Test was used.[5,8] A full description of this test as used for previous diver performance studies appears elsewhere.[5] In essence, the time taken to transfer two sets of nuts, bolts and washers using spanners in a set sequence from one vertical brass plate to another is the measure of performance.

SIMPLE ARITHMETIC

A series of 20 five-digit additions is presented and the subject completes as many as possible during a three-minute period. The time taken (if less than three minutes) and the number of correct and incorrect answers are recorded. At each testing the subject is given a different set of additions.

STATISTICAL ANALYSIS

Analysis was performed using SPSS (SPSS (1999) version 10 <www.spss.com/spss10>). Pair-wise comparison of groups was effected using paired comparison t-tests. In order to investigate any order effect, an analysis of variance with repeated measures was carried out by dive number. Over each dive the design was counterbalanced with respect to drug, depth of dive and number of subjects so the effect of these should be eliminated. The data were then analysed by drug order (pseudoephedrine–cyclizine–placebo, placebo–pseudoephedrine–cyclizine, etc), drug type and dive depth using repeated measures analysis of variance.

Results

Abnormal symptoms such as undue tiredness, nausea or feeling drunk were reported by nine divers following 13 dives; seven at five msw and six at 30 msw; four with placebo, two with pseudoephedrine and seven with

Table 1
Average results for grammatical reasoning, manual dexterity and simple arithmetic tests by dive depth and drug (placebo, pseudoephedrine 60 mg and cyclizine 50 mg)

Depth	**5 metres**			**30 metres**		
Drug	**Placebo**	**Pseudoephedrine**	**Cyclizine**	**Placebo**	**Pseudoephedrine**	**Cyclizine**
Grammatical reasoning						
Mean number done	36.4	36.0	33.4	35.0	33.4	32.4
(95% CI)	(32.1, 40.7)	(32.2, 39.9)	(30.3, 36.5)	(30.4, 39.7)	(30.3, 38.6)	(28.6, 36.1)
Mean number of errors	5.3	5.3	4.6	6.6	6.1	5.4
(SD)	(5.7)	(6.5)	(5.2)	(5.9)	(6.0)	(5.2)
Manual dexterity						
Mean time (sec)	199.0	197.7	188.9	204.3	201.7	201.5
(95% CI)	(182.3, 215.7)	(175.6, 219.9)	(171.1, 206.7)	(184.4, 224.1)	(183.1, 220.3)	(176.5, 226.4)
Simple arithmetic						
Mean time	109	102	103	109	119	112
(95% CI)	(89.4, 129.0)	(83.8, 119.6)	(81.6, 123.4)	(85.2, 133.7)	(92.8, 145.0)	(86.4, 137.7)
Mean number of errors	1.4	1.6	1.7	1.5	1.9	2.1
(SD)	(1.8)	(1.9)	(1.7)	(2.2)	(1.8)	(1.8)

cyclizine. The study code was broken once when a subject had a minor road accident after a five msw placebo dive. He was told only that the dive had not contributed to his accident. There were no missing data for any of the three performance tests for any of the drug/depth combinations. A summary of the data is presented in Table 1.

DEPTH EFFECT

There was a small but significant effect for depth in grammatical reasoning, such that subjects completed more items at five msw than at 30 msw (main effect of depth: $F(1,18) = 6.436$; $P = 0.021$) and there was a small but consistent trend ($P = 0.01$) shown for one more error at 30 msw than at five msw. For the manual dexterity measure, subjects performed more slowly (about 3% prolongation) at 30 msw than at five msw (main effect of depth: $F(1,18) = 7.22$; $P = 0.02$). No effect of depth on the arithmetic task was observed (main effect of depth: $F(1,18) = 0.91$; $P = 0.35$).

DRUG EFFECT

For the number of items completed in the grammatical reasoning test, there was a significant effect for drug (main effect of drug: $F(2,36) = 7.68$; $P = 0.002$). *Post hoc* tests revealed a significant difference in numbers completed between placebo and cyclizine (placebo mean 35.7, cyclizine mean 32.9; $P = 0.002$) but not between placebo and pseudoephedrine (placebo mean 35.7, pseudoephedrine mean 35.2; $P = 0.51$). There was also a significant difference between the two active drugs (cyclizine mean 32.9; pseudoephedrine mean 35.2; $P = 0.01$). However, error rates were not significantly different between the two drugs and placebo.

There was no significant effect of either drug compared with placebo on the time taken to complete the manual dexterity task at either five or 30 msw (main effect of drug: $F(2,36) = 1.54$; $P = 0.23$). Fewer arithmetic errors occurred with placebo than with pseudoephedrine and fewer with pseudoephedrine than with cyclizine, but this trend did not reach statistical significance (main effect of drug: $F(2,36) = 2.83$; $P = 0.07$. Mean errors: placebo = 1.44; pseudoephedrine = 1.73; cyclizine = 1.90).

ORDER EFFECT

For grammatical reasoning, the drug effect was influenced by the order in which the drugs were presented ($F(10,36) = 4.50$; $P = 0.001$), but this is difficult to interpret because there was also a dive-order effect, with performance improving significantly ($P < 0.001$) over the dive series. Unlike speed of performance, the percentage of errors did not change with dive number.

For manual dexterity, there was no significant interaction effect of depth and drug order ($F(5,18) = 0.26$; $P = 0.93$). The speed of performance increased significantly ($P < 0.001$) during the series of dives although this did not appear to be linear over all dives, most improvement being between the first and second dives. There was a significant interaction ($P = 0.001$) between each drug and the order in which the drugs were presented implying that the effect of a drug was influenced by that order. Overall, there was no effect of drug order (main effect of drug order: $F(1,5) = 0.26$; $P = 0.93$). However, as for grammatical reasoning, no clear pattern could be identified.

In the simple arithmetic test, there was no dive number (main effect of dive order: $F(5,115) = 0.77$; $P = 0.57$) or drug order (main effect of drug order: $F(1,5) = 1.65$; $P = 0.20$) effect.

Discussion

Self-medication for various ailments including motion sickness and nasal congestion is common amongst sport divers. A postal survey of experienced Australian and USA divers reported that 11.5% used anti-emetics before most or all dives and a quarter used them occasionally.[1] Ten per cent used pseudoephedrine before most or all dives and 36% occasionally. It is important to test individual drugs, as there is evidence that behavioural effects of any particular drug may change under pressure in ways not predictable from their characteristics at ambient pressure or likely class behaviour.[9]

Cyclizine is an antihistamine popular in the treatment of motion sickness. Other drugs in this group, including dimenhydrinate, an antihistamine which is also frequently used by divers, have been shown to decrease performance under hyperbaric air conditions.[2,10] Dimenhydrinate adversely affects mental flexibility at depth and this effect, when added to the adverse effect of depth on memory, may contribute to the dangers of diving.[2] Transdermal scopolamine has become popular with divers in some countries in the last 20 years and has not been shown to significantly affect diver performance although it has a number of other side effects.[3] No studies on cyclizine in divers have been located in the literature. An increase in error rates and prolongation in learning time were observed in the present study following cyclizine ingestion, and this effect was additional to the narcotic effect of depth at 30 msw.

Pseudoephedrine is a decongestant related to adrenaline with few cardiac or central nervous system side effects, which is used widely by divers. Anecdotally, some slowing of judgement and impaired coordination have been reported under normal ambient conditions, but no objective effects on visual performance were seen in one study.[11] Pseudoephedrine has not been shown to cause significant alterations in psychometric performance at 3 ATA (20 msw, 300 kPa) that might increase the risk of diving.[2] In the present study, pseudoephedrine had little or no effect on the performance measures used.

Nine divers in 13 dives reported mild non-specific symptoms, such as lethargy and poor concentration. These occurred in small numbers with both drugs and with placebo and at both depths, and were too few to analysis statistically. This was a reasonably experienced group of recreational divers, the majority being naive to dry recompression chamber diving and unable to consistently identify the depth of the 'dives'.

There are two broad approaches to the study of diver performance: either the analysis of a single complex task or the use of a battery of simpler tests of cognitive or mental performance that are sensitive to environmental stress.[12] Based on the work of the Navy Biodynamics Laboratory performance evaluation tests for environmental research (PETER), the three tests used were chosen as having limited learning effects and being sensitive to environmental effects. They had been used in previous diver performance studies by one of the authors,[4,6] or used extensively for other diver performance studies.[5,7,13,14]

Despite prior practice, a counterbalanced experimental design to minimise repeated-measures and drug-order effects and selection of tests regarded as having a limited learning effect,[4] any changes related to depth and drug ingestion were partially masked by a significant learning effect in two of the tests. There is some evidence from the analysis to suggest that the order of presentation of the drugs also altered the learning curves, but a much larger group of subjects would be required to test this hypothesis. A power analysis was carried out retrospectively which showed a power of 80% to detect a difference in means of 1.5 points at the 5% significance level if such a difference truly existed, confirming that the sample size was sufficient. Other aspects of the experimental design could have interfered with performance changes related to depth and drug ingestion. For instance, it was noted in the dives where subjects were paired that some degree of competition between them tended to develop in the manual task, where an individual's performance was visible and audible to the other. In addition, environmental factors such as noise levels, temperature and humidity, though similar, could not be rigidly controlled for every dive.

In this study, grammatical reasoning and manual dexterity were slightly impaired at 30 msw compared with five msw depth, which is in keeping with previous studies.[15,16] This was not so with the arithmetic test, which has been reported previously to be a sensitive and reproducible test.[17] The drug effect in the arithmetic test approached statistical significance ($P < 0.07$), but there was almost certainly a loss of sensitivity from the test being simplified and shortened to minimise the bottom time at 30 msw to remain within the no-stop limit on the US Navy air decompression tables. This finding is similar to that reported by Williams et al.[3]

In only the grammatical reasoning test did either cyclizine or pseudoephedrine significantly impair performance at depth and this was more marked with cyclizine. Even so, the drug effects observed were smaller than the effect produced by 30 msw depth alone, which in itself was small. Such impairment may not be sufficient to be of practical significance.[16] However, a relatively trivial decrement in performance in a dry pressure chamber may become a dramatic decrement when subjects are tested in the more stressful conditions of the open sea.[10,15]

Conclusions

The findings of this study are consistent with the limited literature on drug effects on diver performance. Pseudoephedrine exhibited a very minor effect on grammatical reasoning. We have demonstrated that cyclizine had a small adverse effect on grammatical reasoning, which is increased at depth, but had no effect on a manual task. This confirms the findings of other studies on sedative antihistamines. Although the changes in performance with both drugs were small, it would be unwise to make an unconditional extrapolation from the dry chamber to the open water condition because of the increased complexity of interaction of the various modifying stresses in open water diving.[12] Based on reviewed evidence and this study, pseudoephedrine should be reasonably safe to use before air diving, but cyclizine should be taken with caution before air dives as its detrimental effects on performance could well be enhanced in a stressful environment. There is still a need for further chamber and open water testing of the effects on diver performance of commonly used medications despite the passage of two decades since this study was conducted.

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Conflict of interest

The authors declare that there were no conflicts of interest in conducting this study.

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Provisional report on diving-related fatalities in Australian waters 1999

Douglas Walker

Key words
Diving deaths, scuba, breath-hold diving, diving accidents, solo diving, CAGE, case reports

Abstract

(Walker D. Provisional report on diving-related fatalities in Australian waters 1999. *SPUMS J*. 2005; 35: 183-93.)
In 1999 there were eleven diving-associated deaths in Australia for which data, sometimes incomplete, are available. Five deaths were associated with scuba diving and six with use of snorkels. Four scuba divers died from cerebral arterial gas embolism (CAGE) and one from running out of air. Four of the snorkellers were over 65 and three of these died from cardiac causes. One snorkeller was attempting to reach a deeper depth than he had previously achieved and hyperventilated before the dive. The sixth snorkeller was found floating just under the surface in shallow water.

Introduction

Coronial information is available about 11 diving-related fatalities in 1999, six involving use of snorkels and five the use of scuba equipment. The main facts in these cases are discussed. Unrecognised health problems in older tourists were an important factor in the deaths of four snorkellers. The facts are summarised in Table 1 and the case reports appear below.

Case reports

CASE BH 99/1

This woman, her husband and their six-year-old child were day-trip visitors to an island. It is thought they did not attend the talk about the safe use of a snorkel provided on the trip out. After disembarking they went to the beach near the landing jetty. Here there was a notice stating that swimming was prohibited in this area. All three entered the water. The victim had used a snorkel only once before, seven years earlier.

After about 15 minutes of snorkelling alone, the husband returned to his wife and child, who were standing in shallow water about 15 metres from the shore. He suggested that she remain there until he returned from taking his daughter back to the beach. Because the mask he had been using had leaked, he changed his mask before returning to where he had left his wife. He was unable to see her among the others in the water so he quickly returned to the shore and ran down the jetty to ask for help from the crew of the boat which had brought them. A surface check using binoculars was unsuccessful, then he saw her lying in a small boat moored at the jetty with people attempting to resuscitate her.

Some men had seen her floating in the water beneath the jetty. At first they had thought it was a mannequin which someone had thrown into the water as a joke, then realised it was a real woman. There was a slight delay before they noticed that, although she had a snorkel, she was not coming up for air. One of them walked to a nearby bar and asked the barman to look at her, saying “She doesn’t look too healthy”. The barman responded quickly, yelling for assistance before jumping in the water. She was pulled into a boat and CPR was immediately instituted. This succeeded in maintaining her alive and she was transferred to the local hospital. She died the next day from near-drowning cerebral anoxic damage.

Comment

It is probable that this woman would have survived had she stood up. A possible reason for her failure to do so may have been the shock and surprise of breathing in water through her snorkel. Although she was not wearing fins, this need not have necessarily compromised her safety in the shallow water close to the beach. The notice prohibiting swimming near the jetty was probably designed to keep swimmers out of the path of boats approaching the jetty.

A strange feature of this case was the action of the vessel’s owners, who instructed their solicitor to prevent the police from taking statements from the crew. Equally strange is the fact that this was legally permissible. As there is no reason to suppose the incident was in any way due to any act or omission of the crew this ‘pre-emptive strike’ appears to have been the result of a fear lest some error be alleged in their management.

Summary

SNORKELLING; FIRST USE FOR 7 YEARS; DID NOT ATTEND INSTRUCTION SESSION; NOT WEARING FINS; SHORT TIME OF SEPARATION; SILENT DEATH BY DROWNING IN CALM SHALLOW WATER CLOSE TO OTHERS; NO KNOWN HEALTH FACTORS.

Table 1. Summary of diving-related fatalities in Australian waters

Case	Age	Training and experience	Dive group	Dive purpose	Depth (metres) Dive	Depth (metres) Incident	Weight belt On	Weight belt Kg
BH 99/1	35	None	Buddy separation before incident	Recreation	< 2 m	< 2 m	None	-
BH 99/2	71	Some experience	Solo	Recreation	?	Surface	None	-
BH 99/3	24	Some experience	Solo	Recreation	22 m	Ascent	On	5
BH 99/4	75	Some experience	Solo	Recreation	2 m	Surface	On	?
BH 99/5	68	None	Buddy separation before incident	Recreation	?	Surface	None	-
BH 99/6	70	Some experience	Buddy separation before incident	Recreation	2 m	Surface	None	-
SC 99/1	31	Some training No experience	Group separation before incident	Class	2 m	2 m	On	?
SC 99/2	29	Trained No experience	Group separation before incident	Recreation	10 m	10 m	On	?
SC 99/3	65	Trained Experienced	Buddy separation before incident	Recreation	15 m	Ascent	On	?
SC 99/4	60	Trained Experienced	Buddy separation during incident	Recreation	?	Ascent	?	?
SC 99/5	31	Trained Some experience	Buddy separation during incident	Recreation	?	18 m	On	6

CASE BH 99/2

This man and his wife were making a day trip to the Barrier Reef. During the outward journey there was a talk on snorkelling techniques and the passengers were required to complete a medical questionnaire. On this form he declared himself as having none of the listed conditions as he had been in good health since two "minor heart attacks" in 1982. During the morning snorkelling, wearing a wetsuit and fins supplied by the company, and using his own mask and snorkel, he had no problems. After lunch the vessel moved to another location, and while his wife watched he snorkelled in the prescribed area. She saw him rest at a float station to adjust his mask, then swim back to the vessel and cling onto the bottom step of the snorkelling platform. He spoke to his wife, who noticed that he had a "ghastly pallor", then he lost consciousness and floated away. She screamed for help and a diving instructor quickly entered the water and brought him to the dive platform at the vessel's stern, as this was at water level. The crew gave CPR and only ceased after medical advice by radio to do so.

Autopsy findings

At the autopsy there was noted to be emphysema involving the outer two thirds of both lungs, and carbon deposits on their surfaces. There were pericardial adhesions and proximal blockage of the inter-ventricular coronary artery. The lower abdominal aorta and the iliac arteries were described as "egg shell" calcified. Death was ascribed to a myocardial infarction.

in 1999 (BH – breath-hold, SC – scuba, ? – unknown)

Bouyancy vest	Contents gauge	Remaining air	Equipment Tested	Equipment Whose	Comments
No	n/a	n/a	n/a	Own	Second use of snorkel. Solo. Shallow water. Drowned.
No	n/a	n/a	n/a	Hired	Mild myocardial infarct 17 years ago. Appeared healthy. Acute myocardial infarction.
No	n/a	n/a	n/a	Borrowed weights and fins	Attempting deep dive. Hyperventilated. Unused to weight belt. Lost fin.
No	n/a	n/a	n/a	Hired	Childhood polio. Hypertension. Recent medical check. Acute myocardial infarction.
No	n/a	n/a	n/a	Hired	Last snorkelled four years before. Aortic valve replaced two years before. Surface swim separation. Probably acute cardiac arrhythmia.
No	n/a	n/a	n/a	Hired	Silent death in calm water. Hypertensive myocardial changes. Cardiac death.
Not stated	Not stated	Adequate	No fault	Hired	First open water dive with class. Rapid ascent after separation. CAGE.
Not stated	Not stated	None	No fault	Hired	Separation underwater. Drowned.
Partly inflated	Not stated	Adequate	No fault	Hired	No dives for four years. Recent refresher dive. Separation underwater. CAGE
Not stated	Not stated	Not stated	Not checked	Own	Possible underwater avalanche panic caused ascent. CAGE. Delayed death.
Not stated	Not stated	Adequate	Not stated	Hired	Sudden panic ascent. CAGE. Brain dead next day.

Comment

This myocardial infarction could have occurred anytime, anywhere, and was not predictable from his health history.

Summary

CONSIDERED HIMSELF HEALTHY; SNORKELLING IN CALM WATER BEFORE LUNCH; AFTER LUNCH SUDDEN CARDIAC DEATH IN CALM WATER; HISTORY OF TWO “MINOR” HEART ATTACKS 17 YEARS EARLIER; ACUTE MYOCARDIAL INFARCTION.

CASE BH 99/3

This youth was the son of one of the crew of the dive boat, and a guest rather than a paying passenger. There were two groups of scuba divers aboard, under the supervision of two divemasters, and a crew of three. The club divers managed their own affairs, with one divemaster organising the scuba divers, the other and the skipper keeping a surface lookout watch on the divers. In response to his mother’s request they also maintained a watch on the youth as he snorkelled. He appeared to be making ‘duck dives’. At one time the skipper judged that the youth was getting too distant from the boat for safe observation and asked his mother to tell him to come closer, which he did. He was seen to be wearing board shorts and a T-shirt, a mask and snorkel, with strap-on fins, borrowed from his mother, on his bare feet.

After some time spent making shallow dives he apparently told his mother that he intended to try to dive deeper, to beat his previous best of 17 metres' sea water (msw), and donned one of the weight belts lying on the deck close to the stern boarding board. His mother instructed him in how to release the belt. He asked about the depth and was told it was 22 msw. The skipper denied having any knowledge that he had donned a weight belt but had noticed that he hyperventilated to some degree before his descent. He had suggested that it was safer to have a buddy, and also that he had one arm raised as he ascended so as to know when to blow the water from his snorkel as he broke the surface. This advice was not followed.

The alarm was raised when a single fin floated to the surface close to the dive boat. One of the scuba divers, having a post-dive swim, looked down and saw a body lying face up on the sea bed 22 metres below. The divemaster who had been acting as safety lookout immediately donned the scuba set kept ready for any emergency and jumped into the water. He noted that the mask was in position, some 'facial squeeze' was present and the snorkel was out of his mouth. He released the weight belt, said to be five kilograms or less, and carefully brought him back to the surface. Once back on board the boat, CPR was commenced.

Autopsy findings

The autopsy confirmed that drowning was the cause of death, and a post-hyperventilation dilution hypoxia blackout was given as the reason. In the autopsy report it was mentioned that the brain was retained and not returned with the body, a procedural matter the subject of recent intense public interest following a New South Wales investigation into the management of bodies and body parts by forensic departments.

Inquest statements

At the subsequent inquest the divemaster stated he had initially thought the victim was one of the crew and was unaware anyone would be snorkelling. He also said that he had directly asked to be informed whenever the youth entered the water so as to know to look for him and that this was not done. There was some criticism concerning the absence of a reservoir bag on the OxyViva resuscitation equipment but this would not have affected the outcome as he was certainly dead when found. Although there was a statement in the government regulations that the emergency equipment should deliver 100% oxygen, expert opinion was presented that this was an impossible requirement.

There was much discussion concerning whether the dive-boat owner or the hirer was responsible for checking the safety equipment before a chartered dive boat left harbour. It was decided that the dive-group organiser was probably the one to have this legal responsibility. As the victim was a guest of a crew member it was decided, after some discussion, that this was not a 'workplace' death so did not require an official investigation. If he had been a member of the scuba diver group or had performed any crew duties this would have been required.

Comment

That his mother had to show him how to release the weight belt suggests that he had no experience of diving with one. Although there was no direct description of the sea conditions, the fact that he was diving without a wetsuit and could be seen from the surface 22 metres above would imply water conditions were good. It is evident that he was far from being an experienced breath-hold diver.

The loss of one fin, possibly because of a slack strap, would have compromised his ability to swim to the surface had he become aware of an urgent need to do so before blacking out. The fins were intended to be worn over bootees, and were not his own but borrowed from his mother. His clothing would produce drag and prevent his achieving a rapid descent or ascent, and therefore could have had some effect on the tragic course of events.

After this episode his mother could never bear to sail on the boat. She considered that she had a degree of responsibility for his death because she had failed to warn him of the risks of post-hyperventilation blackouts. However, her past scuba training had not left her with any awareness of this risk.

Summary

EXPERIENCED SNORKELLER; NOT USED TO DIVING WITH WEIGHT BELT; HYPERVENTILATED BEFORE DIVE; ATTEMPT TO EXCEED HIS PREVIOUS BEST DEPTH; BARE FEET; LOST STRAP-ON FIN; FAILED TO DITCH WEIGHTS; PROBABLE POST-HYPERVENTILATION BLACKOUT; DROWNING.

CASE BH 99/4

This man was a member of a group of 'senior citizens' from overseas taking a trip with the intention of making a reef walk. However, on their arrival it was decided that the tide was too high for this and they were offered the option of snorkelling as an alternative. They had previously been given advice regarding snorkelling. Six of them decided to snorkel. Like all of the other members of the group, he had completed a medical questionnaire. In this he stated there were no medical restrictions to his fitness to undertake the trip and noted that he was taking some medication for hypertension.

The snorkel group was taken in a rubber dinghy to a small lagoon about two metres deep, about 150 metres from the vessel. After snorkelling for about 15 minutes they were all called back to the dinghy and it was then noticed that one person, the deceased, was floating face down about 100 metres from the dinghy. The dinghy stopped a short distance away from him as it was returning to the cruise boat, and when its presence evoked no response a crew member jumped into the water and turned him face up. His mask and snorkel were noted to be correctly in position. He was quickly pulled into the dinghy and brought back to the cruise boat where it was decided there would be no purpose in attempting CPR as he was obviously dead.

Autopsy findings

At the autopsy a scar was noted over and anterior to his left shoulder and that there was some atrophy of the left arm muscles, findings relating to childhood polio. The left ventricular wall was hypertrophied and the mitral valve showed moderate deformity, while there was moderate coronary artery disease. The cause of death was acute myocardial infarction in association with hypertension.

Comment

The fact that he was found in the water between the dinghy and the cruise boat may indicate that he felt unwell and was swimming back to it for this reason. The post-polio atrophy of one arm would not have influenced this outcome.

Summary

APPEARED TO BE HEALTHY; TAKING MEDICATION FOR HYPERTENSION; SNORKELLING IN CALM WATER NEAR OTHERS; MODERATE CORONARY ATHEROMA; ACUTE MYOCARDIAL INFARCTION.

CASE BH 99/5

This man and his wife were staying at an island on the Barrier Reef when they saw a snorkel dive advertised as "being for those with snorkelling experience". Their actual experience was not stated but it was probably rather less than was intended in the notice, as the man had not snorkelled since 1995. He had had an aortic valve replaced in 1997. Since then he had undergone cardiac checks every five months. These had apparently been satisfactory and his wife was unaware of any recent ill health. Although she judged the water conditions to be too rough for them she said nothing as she knew that he would have gone without her if she had refused to go and she believed he would be safer if she came to buddy him. Otherwise, she knew, he would be a solo swimmer in a crowd of other snorkellers.

There were 20 people on the 11-metre dive boat, both snorkel and scuba divers. The snorkel divers had a safety lecture during the trip out to the anchorage at a 'bommie'. The skipper and deckhand remained on board as surface safety cover for the snorkellers, while another staff member accompanied the scuba group. After swimming for a time the wife touched her husband and indicated it was too rough and they should return to the boat. Their normal practice was to swim side by side but after they turned to start their return she lost sight of him because of the waves. She decided it was wiser to continue her return swim alone rather than try to locate him. The skipper observed him lagging behind her as they swam along the reef edge 50–60 metres from the boat as they began their return. They would have the advantage of the wind during their return. He noticed the man stop swimming and shout to his wife, who did not hear him and continued swimming. He therefore signalled to him 'Are you all right?' and received an 'OK' signal in return. The skipper was still not satisfied "as he did not seem comfortable" although showed no signs of distress or of struggling. He ordered the mooring to be cast off and motored to make a close check of his condition. The boat passed close to the victim's wife, although she did not notice it, and when they reached him they found he was now face down and unresponsive.

He was quickly brought aboard and expired air resuscitation commenced after checking his carotid pulse was present. His mask was in position, the snorkel attached but not in his mouth. The recall horn was sounded, a radio call was made for the resort's medical assistance to meet them on their return, and CPR was instituted.

Autopsy findings

The autopsy showed only minimal atherosclerotic changes in the major vessels, the prosthetic aortic valve in situ, apical adhesions to the right parietal pleura, and a 1 cm bulla on the postero-apical surface of the left lung. Vomit was present in the oesophagus and both lungs. There were also fractured ribs – parasternal right 2nd and 3rd, left 2nd to 5th, and left mid-clavicular 4th and 5th ribs. These resulted from the very desperate and vigorous resuscitation attempts. Both kidneys showed signs of infection, with pus present on the cut surfaces, and cortical scarring especially of the right kidney. The weight of the heart was 548 gm. Cardiac arrhythmia was given as cause of death.

Comment

Another senior citizen, this time with a mistaken belief that he was fit for anything. Just because ordinary exercise is within a person's effort tolerance it does not mean that harder work can be tolerated without problems. Buddies who are out of sight or who cannot see you are no help in an emergency.

Summary

LAST SNORKELLED IN 1995; AORTIC PROSTHESIS INSERTED 1997; EXCESS BELIEF IN HIS ABILITY TO COPE WITH THE WATER CONDITIONS; SURFACE SEPARATION FROM BUDDY IN ROUGH SEA; RENAL INFECTION; PATENT CORONARY ARTERIES; DEATH PROBABLY DUE TO ACUTE CARDIAC ARRHYTHMIA.

CASE BH 99/6

This man and his wife were members of a group travelling to visit the Barrier Reef. They received a talk on snorkelling and general safety matters translated into their language by their tour guide during their outward trip. This included a requirement to report any medical problems. On arrival at the cay the passengers were transferred to the beach and snorkelling equipment was distributed, with buoyancy vests offered to anyone who wished for one. The victim had brought his own gear as he was concerned about the hygiene of company equipment. However, he was reassured as to this company's practices and used the offered equipment. There was a designated snorkelling area watched over both from the vessel and by a crew member on the beach, who could radio for a replacement if he had to enter the water to assist a swimmer. The sea was calm and the weather fine.

The victim had swimming and snorkelling experience and no significant medical history, so while four passengers were receiving instruction in snorkel use and others waded in the water, he was among the three or four experienced snorkellers who headed off to view the highlights of the safety zone. His wife remained on the beach. He returned to her after a short time to leave his fins as they were annoying him and he usually wore none, then he returned to the water. She later noticed he was stationary, floating face down. She was not initially concerned as she assumed he was taking photos. He was about 20 metres from the beach, not swimming, and then started to float away from the shore. Next there was a shout from some people in another boat who were pointing to a floating body. The shore safety watcher immediately informed the dive boat and then took his tender to give assistance.

First to reach the victim were two people who had swum out from the beach. They rolled him face up and noted that his face was cyanosed and he was unconscious and not breathing. They were towed back to the beach holding onto the tender and there CPR was commenced after removing his false teeth. However, the facial change this created resulted in the pocket mask not sealing properly. They continued CPR, changing places, until the oxygen respirator arrived from the boat. They initially experienced problems from regurgitation of food and water after nearly every breath they gave him. He was transported back to the boat on a stretcher and resuscitation efforts were continued until advised to cease by an emergency doctor by radio from a hospital.

Autopsy findings

The autopsy showed the heart weighed 529 gms and there was up to 40% narrowing within the left anterior descending coronary artery. The left ventricle was 2.1 cm in thickness. The diagnosis was death due to hypertensive heart disease and coronary heart disease. His only medication was "Xatral" (alfuzosin hydrochloride) for his prostate.

Comment

Again the victim was a senior citizen. Many elderly people live unaware of their hypertension until they see the doctor about something else, such as prostate problems. Many over the age of 65 have difficulty accepting that their effort tolerance is no longer that of a fit 40-year-old.

Summary

APPARENTLY FIT AND ACTIVE MAN ON PROSTATE MEDICATION; SILENT DEATH SNORKELLING IN CALM WATER; UNDIAGNOSED HYPERTENSIVE MYOCARDIAL CHANGES; CARDIAC DEATH.

CASE SC 99/1

This death occurred during the first open water dive of a basic scuba course. The sea was calm, with only a slight swell and tidal current. The visibility was 5 to 8 metres. The dive boat landed the class on a beach then took some scuba divers to another location. The instructor chose to lead his class of four in a 'V' formation from the beach. The victim was the second student on the instructor's left. The party descended slowly and after 1 to 2 minutes, at about 2.5 to 3 msw, the victim was missing. The instructor immediately brought the three other divers to the surface and told them to look around for bubbles coming to the surface. The dive boat returned at this time and a surface search was made from it and another nearby boat.

The body was found sitting on the sea bed by the instructor during his underwater search, less than 20 metres from the shore, depth two metres, about 25 minutes after his absence was noticed. CPR was unavailing.

During the inquest the victim's sister, who was in the same scuba class, said that both of them had experienced problems with the class work because of language difficulties. They had required the instructor's help to pass the second exam of the course.

A child witness described seeing a distressed diver come to the surface, then rapidly submerge. The witness also mentioned seeing the "whole top part" of the diver's body, that he probably did not have the regulator in his mouth, and that there was a "pretty loud noise like he was taking a very big breath, like gasping" before he went straight back under the water.

Comment

The child witness's statement is very suggestive of cerebral arterial gas embolism (CAGE) but the autopsy report is not yet available (July 2005). Panic induced by losing sight of the other divers may have precipitated a dash for the surface and breath-holding made this dash fatal. Buddies, or instructors, who are out of sight or who cannot see you are no help in an emergency. Unfortunately to lead a dive an instructor needs to be in front and to watch over a group he needs to be behind it. As long as instructors take more than two students with them underwater, separation of the group can occur and separation may lead to incidents and death.

This death occurred during the first open water dive of a basic scuba course; it demonstrates the narrow safety margin between a safe or a fatal course of events.

Summary

LANGUAGE PROBLEM IMPAIRED TRAINING; FIRST OPEN WATER DIVE OF COURSE; ENTRY FROM BEACH; SHALLOW CALM WATER; SCUBA INSTRUCTOR LEADING FOUR STUDENTS; SEPARATION; WITNESS SAW DIVER COME TO SURFACE "LIKE A ROCKET"; CLINICAL VERDICT WAS PROBABLE CAGE.

CASE SC 99/2

This overseas visitor had been trained to dive 21 months earlier. Apparently the course provided only four dives in an indoor pool. She had not dived since then. She signed up at a dive shop for some guided dives under the direction of an instructor who was a compatriot of hers. There was to be a third member of the dive group, another compatriot of similarly limited diving experience (nine dives). She, however, had taken a short 'refresher' dive with the instructor a few days before this dive so was better prepared to make the open water dive. The victim's first open water experience was an uneventful morning dive in a small sheltered bay with good visibility and a variety of marine life. This bay was considered so safe that it was used for training by local dive schools.

The instructor said that he showed the area to them and described the dive plan before they kitted up. He stated he checked that they had correct weights, and assisted the victim to assemble her gear as she had largely forgotten what her course should have taught her. He included instruction on how to inflate the BCD. It is uncertain whether he reminded them of the buddy system or of the rule to ascend to the surface if separation occurred. It is clear that he was treating her like a pupil rather than a certified diver. They moved slowly to enable him to assess their skill levels during the first dive, with a maximum depth of 10 msw.

For the surface swim out from the beach, they were told to partly inflate their BCDs. During their first dive she experienced some problems equalising her ears so before their second dive the instructor made her practise equalising them five times. Their second dive was to be a little longer and deeper than the first. The plan was for him to lead, the other two to follow, but it is thought that the buddy was alongside him and the victim was behind them. On the first dive she had used less air than her more practised buddy.

Fresh cylinders were used for the second dive. She had no equalising problems on this dive. The instructor pointed out marine life on the reef, looked without success for a Weedy Sea Dragon, then checked their air. The victim still had 130–140 bar but the buddy was down to 100 bar, so the instructor decided to start their return to the beach. He believed that he had signalled his intent but the victim evidently failed to see it and separation occurred, though he claimed they had made eye contact. Visibility was 10 metres but when he looked back "in 30 seconds" she was not in sight. He brought the buddy to the surface and then searched the surface for signs of bubbles but saw none, so dived again to make an underwater search. This proved unsuccessful so he surfaced and brought the buddy back to the beach. He then made a further 30–40 minute underwater search till his air supply was exhausted. It was his hope that she had joined some other divers, but this was not the case.

An intensive search was instituted but was unsuccessful. This was concentrated on the area where the separation had occurred. She was found three days later by local divers who used two underwater scooters and a careful search pattern in an area further from the shore than the original search area. All her equipment was in place and her air cylinder was empty. She was said to be short-sighted but did not wear glasses for everyday activities so this was not considered to be a factor significant in her death.

Comment

What occurred can never be known but it is probable that when the victim found herself alone she panicked and did not think about such basic actions as ascending to the surface or dropping her weight belt, and then drowned when she ran out of air, still focused on trying to find the other two. It was only her second open water dive. As the coroner said, it is one thing to listen to what may have been spoken about in general terms 21 months before, but quite another to know what to do when panic comes after finding oneself alone underwater. Indeed, the instructor himself stated about his compatriots, "they are more used to being guided underwater rather than diving by themselves". Unfortunately he did not let this acute observation govern his actions in the management of these two divers. Overseas-trained divers have not necessarily been trained in, let alone have experienced, diving conditions similar to those they find in Australia, but this may not be taken into account when they present a certificate of training. Such was the situation here.

Summary

OVERSEAS TRAINED; SECOND OPEN WATER DIVE; TRIO GROUP LED BY INSTRUCTOR; SEPARATION; CALM WATER; FAILED TO DITCH WEIGHTS OR INFLATE BCD OR ASCEND TO SURFACE; MILD SHORT-SIGHTEDNESS; CULTURAL FACTORS SIGNIFICANT; DROWNED.

CASE SC 99/3

The victim and her husband had dived for many years in a range of locations. However, because they had not dived for about four years before this incident they took a refresher dive before coming to the resort island. Although she suffered some mild seasickness on the trip out to the island this had resolved by the next day when they joined 18 others for a guided dive. The instructor gave them a talk on the trip to the mooring. Here the four photographers in the group chose to dive independently while the remaining 14 divers continued with the instructor, who was acting as a divemaster.

This couple were aware they were likely to have ear equalisation problems so they spoke to the instructor and they were among the first to enter the water and descend. On the seabed, 10 to 15 metres down, they adjusted their buoyancy and joined the group around the instructor. After a short time the husband found he was experiencing a problem with water in his mask and turned away from his wife while clearing it. When he turned back he was unable to see her but presumed she was among the other divers. When the instructor next checked the group he noticed that one diver was missing and followed protocol by looking around for about two minutes, then rounded up the group and brought them slowly up the mooring line, making a safety stop for three minutes at five msw. Earlier in the dive one buddy pair had left the group after notifying him. When they reached the surface he saw another dive boat was now alongside his dive boat. When he came aboard he saw that CPR was being given to a diver. During the dive he had kept all of the group within about 10 metres of himself, visibility being about 15 metres.

The skipper of the other dive boat reported how they had seen a diver at the surface close to the reef edge, who had descended again. They later saw the deceased come to the surface gently, apparently face up. There was no movement and their first impression was that this was a turtle. There was no response to an 'Are you OK' signal so the decision was taken to go and investigate. She was about 40 metres off the reef edge, unresponsive, mask on, regulator floating free, with blue lips and dilated pupils, and her eyes looking cloudy or foggy. Her BCD had a little air in it but was not full. The weight belt was in place and one fin was off. CPR was commenced as soon as her backpack was taken off. Oxygen was given and a radio call made to alert the resort nurse. A trauma physician who was staying at the resort assisted the resuscitation efforts. Radio contact was made with a mainland medical emergency service before CPR was discontinued. A check of the contents gauge showed 120 bar pressure remained – the initial pressure had been 200–210 bar.

Autopsy findings

A CT scan was performed of the head, neck, chest and abdomen before the autopsy was commenced. This showed extensive intra-arterial gas throughout the cranium, neck, thorax, abdomen and pelvis. Pockets of gas were seen anteriorly within the chambers of the heart but there is no description of which chambers were involved. There was a moderate-sized left pneumothorax, and there was some calcification in the right lobe of the liver that may indicate a history of previous granuloma. The coronary vessels were widely patent and showed only mild atheroma, while histology of the lung showed alveolar spaces apparently distended, with occasional alveolar haemorrhage. Some alveolar spaces contained a small amount of gastric contents. Also mild nephrosclerosis and nephrocalcinosis were noted.

Her health history was of a mild, non-medicated hypertension, hormone replacement therapy, and vitamins. She had an annual health check and, like her husband, took regular exercise. The equipment check, which did not record the weight of the belt, revealed no significant faults. The regulator mouthpiece had excessive perishing and a hole, but there was no water entry when it was tested. The air contained no contamination. There was a comment that the equipment required some maintenance but was functional. She was wearing a prescription mask.

Comment

It is difficult to imagine a reason for this experienced, though 'rusty', diver to leave her buddy without warning, particularly as there were others close by, the visibility was good, water calm, she had plenty of air remaining, and her equipment was working correctly. No reason for her to have been 'spooked' has been identified, and even had she experienced a spray of water through the regulator this should not have caused her to panic. The skipper's report suggests she did not surface violently, and the BCD was apparently only partially inflated, which suggests she made a swimming ascent but omitted to breath regularly, or exhale adequately, during her ascent. The severity of the pulmonary barotraumas and of the CAGE was remarkable. The missing fin probably came off during her recovery. Once again, separation was the first step on the path to disaster.

Summary

TRAINED, EXPERIENCED DIVER; NO DIVES FOR FOUR YEARS; RECENT REFRESHER DIVE; WELL-ORGANISED DIVE; GOOD WATER CONDITIONS; UNEXPLAINED SUDDEN SEPARATION FROM BUDDY; SOME AIR IN BCD; PRESCRIPTION MASK; SOME HYPERTENSION; MASSIVE CAGE.

CASE SC 99/4

Although this incident occurred outside Australian territorial waters it is included as the victim was evacuated by air and died in Australia, so was investigated on behalf of the local coroner. He was an experienced diver who was making his 23rd annual live-aboard trip with friends of long standing. He and his buddy were at an unstated depth when they were enveloped in material from either an underwater avalanche or the collapse of the rock shelf above them. They apparently made an ascent together until about three metres from the surface, at which time the victim reportedly removed his mask and made a rapid ascent to the surface. He was unconscious when reached. CPR was quickly initiated aboard the yacht and this was continued until he was evacuated by air to Australia for specialist treatment. He died in hospital from a cardiac arrest.

Autopsy findings

The autopsy showed minimal atherosclerosis in his heart. He had had a left-sided thoracotomy some years before for a “non-malignant condition” and a few pleural adhesions were noted. Inflation of the lungs was performed and an air leak was demonstrated into the pulmonary circulation from the posterior aspect of the left lung. This led to the pathologist’s diagnosis of CAGE, which was supported by the typical history of a CAGE diving incident, though the period of treatment since the accident had removed the possibility of gross intravascular air being found.

Comment

Unfortunately there is no record of any examination of his equipment being performed, so there are no details as to whether he had adequate remaining air, inflated his BCD, dropped his weight belt, or was using his regulator during the final stage of his ascent.

The diver fitted the definition of a senior citizen in the State of Victoria, being over 60 years old. There was no evidence that he had been diving since his last annual diving holiday. Being involved in a rock fall could well have overwhelmed his years of experience.

Summary

EXPERIENCED DIVER; ENGULFED BY UNDERWATER AVALANCHE; ASCENT WITH BUDDY; SEPARATION; RAPID MASK-OFF ASCENT LAST THREE METRES; UNCONSCIOUS AT SURFACE; DIED IN HOSPITAL AFTER AIR EVACUATION; CAGE; TERMINAL ACUTE CARDIAC FAILURE.

CASE SC 99/5

The victim was an overseas visitor of limited experience who joined a three-day live-aboard trip to dive on the Barrier Reef. He had been trained two years previously. The boat carried a group of dive pupils with their two instructors, and another diver who had an Advanced Diver certificate. This man’s experience was about 30 dives greater than the victim’s. One of the instructors got them to fill out a form to detail their dive experience, and a liability-release form, then issued them their equipment. This instructor also gave them a talk covering good diving practices. Although the company manual stated that all divers should be taken on an assessment dive before they were allowed to dive unaccompanied by an instructor, this was not thought necessary as he had recently made a dive with the company and performed in a correct manner.

Their first dive was rapidly aborted when the victim’s personal mask leaked due to separation of the face plate. An instructor assisted their return. Following the return of the trainee divers the boat was driven to another area close to a reef wall and the skipper took the two trained divers in the outboard tender to a place where they could descend and drift back to the dive boat along the wall. The skipper noticed that the victim was having great difficulty in descending headfirst, so advised him to descend upright and hold the deflator hose above his head. He appeared to be normal in his demeanour and followed the advice successfully. The skipper told them he would remain and drift around as their surface supervisor. The visibility was good, 20 metres or so, and he remained still and watched their bubbles ascending. Then he noticed there were a lot more bubbles, rather like shaken soda water, and the victim shot up through the surface right to his waist. His mask was off his face and he made a sound like a shout, then flopped face down in the water. He was only about 10 metres from the tender so was rapidly reached and taken aboard. The buddy surfaced very soon afterwards.

The buddy first met the victim on the dive boat when the equipment was being handed out. He thought the victim appeared to be anxious about his mask, taking a second one as a spare. They were briefed by one of the diving instructors to follow behind the students for their first dive of the trip and reminded of the good diving practices they should follow. He thought the victim was still anxious as they started their first dive, as shown by his quick movements, heavy breathing, and difficulty at the surface until the instructor ascended and took him back to the dive tender because of the separation of the mask’s skirt from the face-plate frame. The buddy joined the instructor and continued with the dive.

After this dive, the boat was moved to another location and the next dive was arranged after checking that a sufficient surface interval had elapsed. The buddy was surprised that when he suggested they prepare for this dive the victim asked for time to have a few minutes' sleep, which he took to indicate nervousness, a need to collect himself. After they had checked each other's equipment they got into the tender with the skipper. The victim was slow to descend but did so after advice from the skipper of making a feet-first descent. The buddy kept a close watch on him as they descended and they exchanged frequent OK signals. They descended quickly to 18 msw then gradually swam back up to 14 msw, their planned dive depth. The victim showed his inexperience by jerky movements "like a diver in training". They swam along the reef wall for a few minutes, the buddy keeping him in constant view, though unable to establish eye contact. The victim continued to give the impression to his buddy that he was anxious, then he suddenly began to swim horizontally away from his buddy very fast. There was no apparent reason for his action. His buddy followed, assuming that he would look round and accept a 'slow down' signal. Suddenly he became vertical, began to fiddle with his mask, his rapid movements indicating extreme anxiety and his breathing rapid and heavy. He then started kicking hard towards the surface holding his mask. The buddy was able to watch his ascent, which was faster than his bubbles, and his recovery by the skipper. He was not able to see whether he breathed out during his ascent but saw him go limp before he reached the surface. He then made his own ascent. Frothy blood was coming from the victim's mouth, his eyes were open, and "he looked bad".

Once back on the dive boat, CPR was commenced. CAGE was diagnosed and a radio call for assistance was made. Instructions were received to go to a helicopter pontoon 13 miles away, which they did at maximum speed, and from there he was taken to a hospital that had a recompression chamber. At the hospital, bilateral intercostal catheters were inserted and a chest X-ray showed gas in the mediastinal, pericardial, and subcutaneous tissues across his chest. CT scan of his brain showed gross oedema and presence of some cerebral perfusion. Hyperbaric treatment to 18 metres with 100% oxygen proved unavailing and he remained deeply unconscious. He developed high-output renal failure, a suspected centrally mediated diabetes insipidus, and other metabolic derangements. Brain death was confirmed by two independent specialists the next day.

Autopsy findings

At autopsy pin-point air leaks were noted on inflation of the lungs and multiple scattered air blebs were present over the surfaces of both lungs. The diagnosis of CAGE was confirmed. Examination of the equipment showed it functioned adequately in a static situation and met the manufacturers' performance specifications. However, the regulator was noted to be in poor mechanical condition from lack of regular maintenance, and unhygienic due to the lack of, or poor, cleaning. It was not tested to establish how it would satisfy the demands of a panicking diver. The mask had some splits and holes in the skirt that allowed ingress of a small amount of water initially but more when the mask was moved or pressure was reduced by the wearer inhaling from it. Although the remaining air was not recorded there is every reason to believe the tank contained more than sufficient air had the victim remained still and regained his composure.

Comments

While the matter is not noted, it is probable the BCD was not inflated. Water inflow into the mask may have exacerbated the victim's anxiety level during the dive. Once panic occurs the diver is at extreme risk of dying even though well supplied with air and close to his buddy. Such was the case here.

Summary

TRAINED BUT INEXPERIENCED; LACKED CONFIDENCE; PROBABLE MASK PROBLEM WITH WATER ENTRY; POSSIBLY INADEQUATE AIR SUPPLY FOR A PANIC BREATHING SITUATION; PANIC ASCENT; FAILED TO DROP WEIGHT BELT; CLASSIC CAGE SYMPTOMS; BUDDY ACTIONS COMMENDABLE.

Discussion

The rationale for the existence of the medical sub-specialty of diving medicine is to reduce to a minimum morbidity and mortality among those who 'dive' or enter an environment of significantly changed ambient pressure or breathing medium. The basis of advice is theory soundly based on case studies and experiments. In the case of diving-related fatalities, the most complete and comprehensive body of information is the investigations into such fatalities made on behalf of coroners. This is particularly so in Australia where such data are available far more readily than in other countries. Such form the basis of this and previous reports.[1,2] However, one of the difficulties in properly assessing diving-related deaths is the time it takes to obtain all the various reports.

Examination of the data from cases in which a snorkel was being used confirms yet again the findings of previous reports that show clearly that hyperventilation to increase depth and duration of a dive can be fatal (BH 99/3). This is a lesson that appears to require successive generations of divers to learn anew. Case BH 99/1 is a reminder that a person inexperienced in the use of a snorkel can drown in water so shallow that they would have saved themselves by placing their feet on the sea bed and standing up. It possibly demonstrates the fatal 'tunnel vision' effect on the thought processes of a person faced with an unexpected problem while in the process of concentrating on trying to perform a new skill.

Four of the dead snorkellers were over 65 years old. Health problems are more frequent in older people. In the four senior citizens, a cardiac factor was the most probable critical factor. None of these persons regarded themselves as being unhealthy, and it is unlikely a routine medical check would have raised warnings of their risk of death. It may be necessary to regard such deaths as an unavoidable fact of life, though asking about health histories is certainly appropriate and of potential value. However, determination to snorkel or scuba dive has long been known to lead to suppression of the answers that would bar the person from such activities.

There are significant lessons to be learnt from the cases reviewed here for those who organise scuba dives involving inexperienced divers from overseas, or who teach persons in other than their first language. There is also the confirmation of the fact that an instructor leading others cannot perfectly monitor them constantly. This is sadly demonstrated in cases SC 99/1 and SC 99/2. It is of particular importance to be aware of the different expectations vested in the dive leader by some overseas cultures. Instructors have great responsibilities and it is difficult for them to adequately cover every eventuality, particularly where a dependent diver fails to follow reasonably expected responses to becoming separated. Perhaps it is time to encourage groups to have two safety divers, one the dive leader and the other the rearguard. Self-interest should ensure all those involved with inexperienced scuba divers are aware that proof of training is no guarantee of a diver's competence in an open water environment.

Conclusions

Once again the 1999 fatalities in Australia highlight both the avoidable risks of snorkelling and the risks to elderly, apparently fit, people in the age group where sudden death is an unavoidable reality. The efforts made by watchers and others to resuscitate the victims are commendable.

Four of the scuba divers died from CAGE. Only one of these was an inexperienced diver. One diver, in a class doing its first sea dive, died with an empty tank after losing the group.

A constant problem for dive-group leaders is having to both lead a group and simultaneously closely watch over its members. Leading requires being in front and watching over a group requires being behind it.

When welcoming visitors to the Great Barrier Reef there is the problem of adequately imparting vital safety information to those for whom English is not their first language. Some of the scuba divers have little, if any, experience and may expect to be nannied by their dive leaders. When planning dives these facts should be considered in order to increase the safety of those involved.

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The cost of hyperbaric therapy at the Prince of Wales Hospital, Sydney

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Key words
Hyperbaric oxygen, hyperbaric facilities, economics

Abstract

(Gomez-Castillo JD, Bennett MH. The cost of hyperbaric therapy at the Prince of Wales Hospital, Sydney. *SPUMS J*. 2005; 35: 194-8.)
We need formal economic analyses in the field of hyperbaric medicine. As the first step in a staged approach to full cost-effectiveness analysis for major indications, we present an analysis of the true cost of treatment and the cost of treatment per diagnosis in our unit. Following explicit definitions of cost, accounting cost objects, cost objectives and cost categories, we calculated all costs involving the treatment of patients during the financial year 2003–2004. Dollar costs were taken from a detailed examination of itemised spending provided through the hospital accounting system. Patients were classified into diagnostic groups and included both those who did and those who did not receive hyperbaric oxygen therapy (HBOT). The latter were mainly wound care patients. We then calculated the individual cost for each diagnosis. All costs are expressed in Australian dollars. We treated a total of 304 patients with 1,333 compression cycles using both monoplace and multiplace compression vessels. The total number of individual patient compressions was 3,446. The overall cost for the year of operation was $1,195,197. The average cost of therapy for each patient having HBOT was $4,159, while for those having only wound care the average cost was $2,832. The overall average cost to deliver one HBOT session for an individual patient was $325. These figures will assist us in accurately representing the likely costs of future therapy and in discussions with third-party payers. It is our intention to use these data to inform cost-effectiveness studies currently under way in our facility.

Introduction

Cost is a major factor in any rational assessment of the place of a therapy in practice. Marginally effective therapies with high delivery costs may be unacceptable to many medical systems, particularly in the developing world, while highly effective therapies that are also cheaper than the alternative treatment are likely to be enthusiastically adopted. Increasing healthcare expenditure is of significant concern to healthcare providers, administrators, politicians and the general public.

Despite emerging technologies, personnel and hospital costs usually constitute the bulk of expenditure in healthcare.[1] This is likely to be so with the provision of hyperbaric oxygen therapy (HBOT). While the health economics literature in general has grown over the last 10 years, many of the published articles are of low quality, and this appears to be particularly so in the area of diving and hyperbaric medicine. Poor economic evaluations are not only wasteful of scarce resources but also misleading.[2]

Although there are an increasing number of publications regarding the effectiveness of HBOT, there are very few publications available to assist resource allocation at the societal level. An extensive search for economic analyses of HBOT in fact generated only one article that met Drummond's criteria as a true economic evaluation.[3] Given worldwide health resource constraints and an increasing demand for economic information, economic analyses will become critical for future rational clinical use.[4]

Cost analyses are usually conducted to assist the appropriate allocation of funds and there are several well-described methods to assess the expenses related to a particular clinical condition or treatment. The four approaches most commonly described are cost-benefit analysis, cost-effectiveness analysis, cost-minimisation analysis, and cost-utility analysis.[5] While all these methods can provide specific and useful assessments, they are difficult to perform without competent advice on heath economics. Perhaps because of this, articles that purport to accurately quantify and compare costs of treatments frequently fall short of the mark.[6]

Recognising this problem, we have not attempted formal economic analysis with this paper and have not assessed the impact of therapy on outcome or utility. We have attempted only to accurately quantify costs, intending more formal economic analysis when further effectiveness data and the assistance of a health economist are available.

Methods

We calculated the financial cost of HBOT sessions and the total HBOT costs per diagnosis, defining the financial cost as the expenditure on goods and services purchased. Costs are thus described in terms of how much money has been paid for the resources used by the Department of Diving and Hyperbaric Medicine (DDHM) at the Prince of Wales

Hospital (POWH) in Sydney. We included the costs of occupying an appropriate bed when the individuals were formally admitted overnight. All estimations and calculations have been made in Australian dollars (AUSD) and for the financial year from 1 July 2003 to 30 June 2004.

First we identified all types of costs and classified them into three broad categories: capital, recurrent and other, as detailed in Table 1. Individual items were costed using financial statements generated at the POWH, resource usage records from the DDHM patient database and administrative records. Staff-time allocations were estimated from a consensus opinion among the staff working in the DDHM and included all activities undertaken including clinical, administrative and training duties. All data were entered into an electronic spreadsheet and decision tree model Treeage® (Treeage Software, Williamstown, MA).

Using this information, we then calculated the individual consumption of resources by carefully assigning units of time and specific resource allocation for the different diagnostic categories. The total cost for each diagnostic category thus represents the cost of producing all therapy administered in the DDHM for each particular diagnosis. The average cost could then be calculated per treatment and per diagnosis by dividing the total cost by the number of patients or the number of therapy sessions, as appropriate. This average cost was independent of which pressure vessel was used for any individual patient, and is therefore an estimate that represents our actual chamber usage rather than hypothesising a particular chamber for each diagnosis. This process is illustrated by the flow diagram in Figure 1, while the data collection processes are summarised in Figures 2 and 3. We did not attempt sensitivity analysis for any errors in cost assumptions. The overall total cost of operation for the DDHM included some patients not treated (clinic patients found not suitable, candidates examined for fitness to dive and wound-care only patients). These costs were excluded from the calculation of costs for each diagnostic category except where wound care was administered to patients having HBOT.

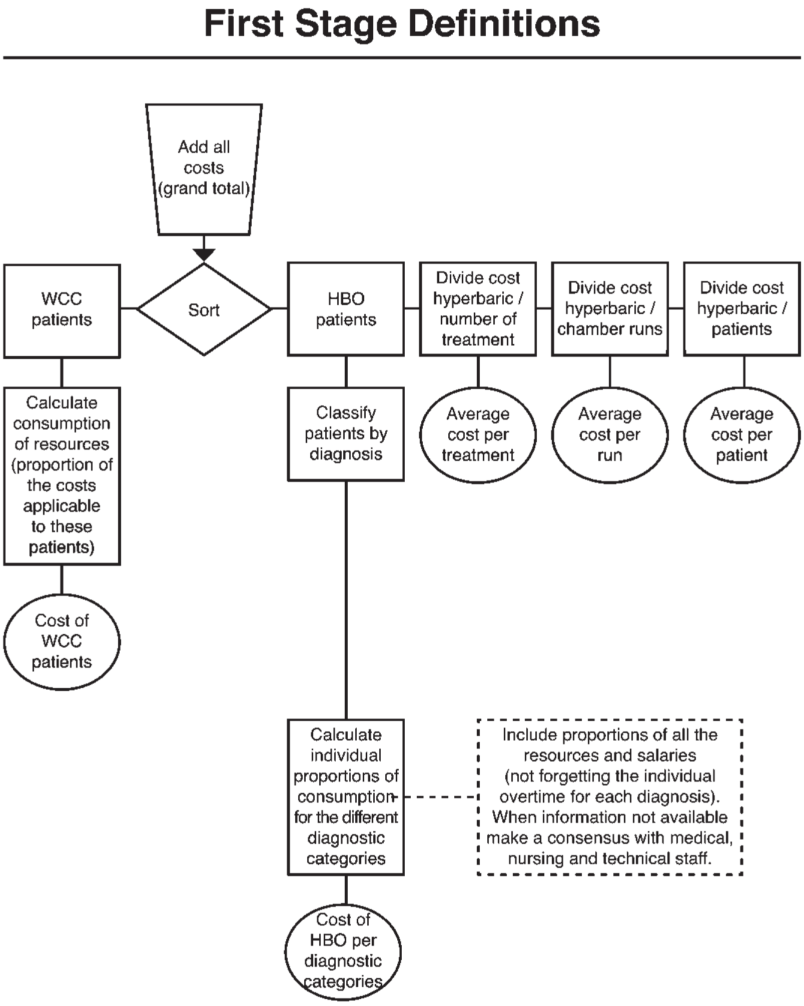
Table 1
Classification of costs by input

Capital costs	**Included items**
Chambers:	*monoplace, multiplace*
Equipment:	*hyperbaric systems, hospital systems, administrative (e.g., computers)*
Buildings:	*hyperbaric unit*
Recurrent costs	
Personnel:	*doctors, nurses, technicians*
Supplies:	*hyperbaric delivery system, medical consumables, administrative consumables*
Operation and maintenance:	*hyperbaric system, administrative, medical*
Buildings:	*operations and maintenance, utilities*
Other operating costs	
Financial administration and management	

Table 2
Costs for provision of service by diagnostic category. Total cost for a diagnosis in one year may include fractions of a completed individual due to patients with a partially completed course at the end of the review period. All figures have been rounded to nearest whole dollar and apparent arithmetic errors in the total cost column are due to using actual costs to calculate these figures. (ORN – osteoradionecrosis)

Diagnostic category	Average number of compressions per patient	Cost for a single compression (AUSD)	Total average cost of treatment course (AUSD)	Total cost to facility in one year (AUSD)
Prevention of ORN	37	304	11,248	274,119
Soft-tissue radiation injury	23	311	7,153	273,838
Chronic wounds	12	311	3,732	188,010
Osteoradionecrosis	15	304	4,560	133,569
Diving injuries	2	720	1,440	58,295
Acute ischaemic conditions, flaps and grafts	4	406	1,624	41,857
Other conditions	4	304	1,216	32,482
Chronic osteomyelitis	18	304	5,472	27,017
Acute necrotising infections	10	398	3,980	23,486
Other infections	7	354	2,478	23,369
Ophthalmological conditions	11	399	4,389	13,959
Toxic gas poisoning	2	396	792	10,284
Neurological conditions	23	406	9,338	9,338
Osteonecrosis	30	304	9,107	9,107
Wound clinic patients	—	—	2,832	76,467
Total				**1,195,197**

Figure 1
Flow diagram of methodology for calculating costs in this study
(WCC – wound care clinic; HBO – hyperbaric oxygen)



In addition to average costs, we also calculated the cost required to treat one additional patient for each of the diagnostic categories. Such costs took account of consumed resources only and assumed no additional capital or other fixed costs such as wages. The diagnosis classification we used was the one used by the POWH DDHM patient database, and this appears in Table 2. All costs were calculated using Treeage® and are presented rounded to the nearest whole dollar.

Results

In the financial year July 2003 to June 2004 we treated a total of 304 patients. Thirty-five of these were not compressed (27 wound clinic patients and eight others), leaving 269 patients who were compressed with 1,333 compression cycles. Of these cycles, 732 were in a monoplace chamber and 586 in our multiplace chamber, and the total number of individual patient compressions was 3,446. The total chamber compression time was 2,477 hours.

Excluding the eight patients who were neither compressed nor treated in the wound clinic, the overall cost for the year of operation was $1,195,197. The average cost of therapy for each patient having HBOT was $4,159, while for those having wound care only the average cost was $2,832. The overall average cost to deliver one HBOT session for an individual patient was $325. Table 2 shows the costs for each individual diagnosis using the same methodology as that for the overall costs, while Figure 4 shows the cost details by category for the compressed and wound clinic patients.

Excluding all fixed costs and making no attempt to differentiate costs for the use of monoplace or multiplace treatment, the incremental costs of an additional patient were $188 per treatment. This figure assumes an ability to expand treatment numbers without employing extra staff or increasing the number of chamber runs required. Detailed incremental costs by diagnostic category are presented in Table 3.

Figures 2 and 3. Summary of data collection and cost classification. Data collection is summarised on the left, and the right-hand figure shows different approaches to cost categories.

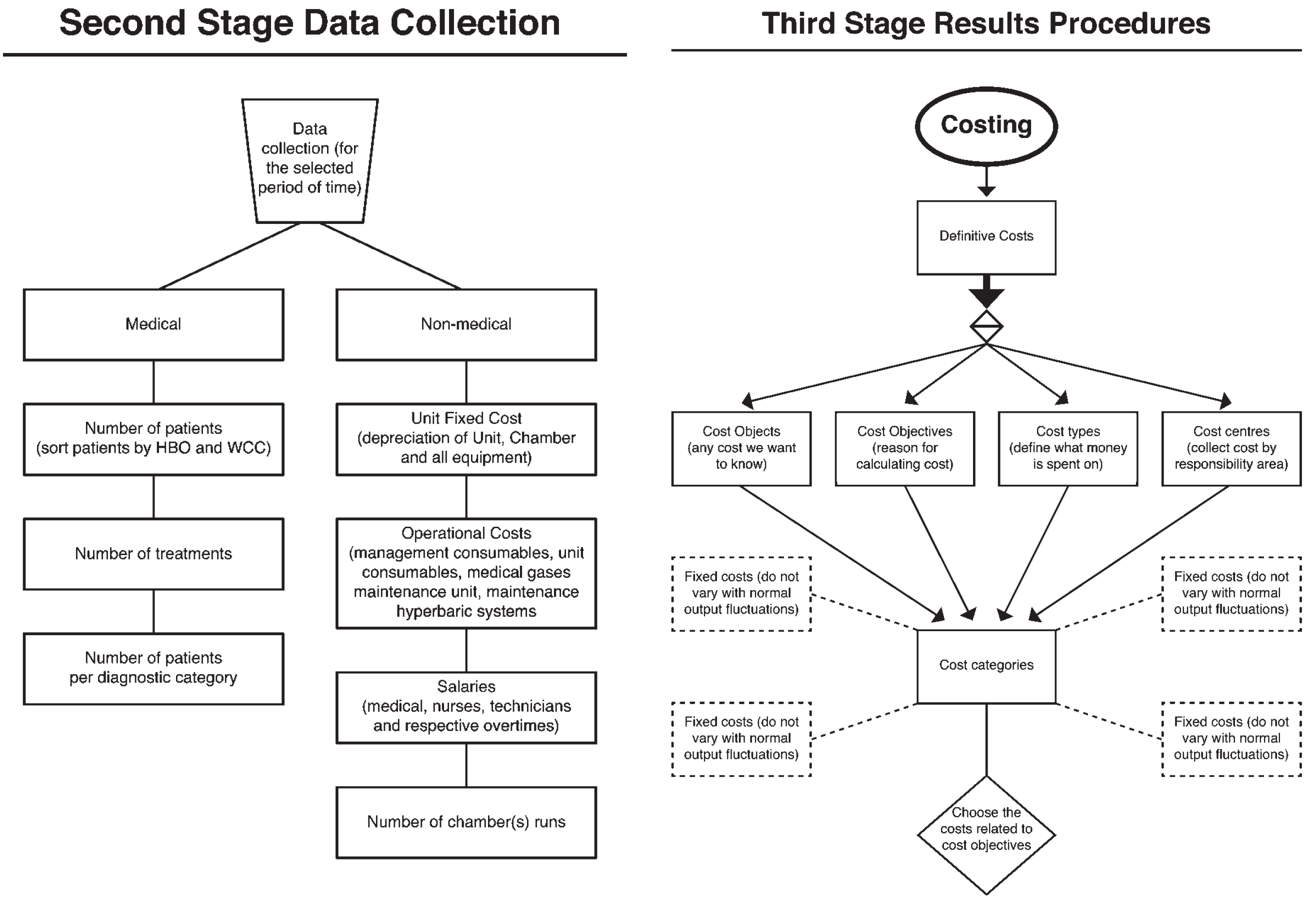


Figure 4. Costs for hyperbaric and wound care patients, financial year 2003–2004 (AUSD)

Total cost of Department operations for one year
$1,195,197

(n = 304; 8 patients neither wound clinic nor compressed)

Hyperbaric activity
$1,118,730 (n = 269)

Chamber depreciation	$50,000
Equipment depreciation	$15,120
Mono-place depreciation	$1,200
Unit depreciation	$67,500
Consumables	$40,452
Maintenance	$16,854
Management	$13,500
Medical gases	$10,000
Nurse overtime	$41,629
Technician overtime	$19,658
Salaries – doctors	$358,458
Salaries – management	$50,400
Salaries – nursing	$270,059
Salaries – technicians	$163,900

Wound care clinic
$76,467 (n = 27)

Equipment depreciation	$1,680
Unit depreciation	$7,500
Consumables	$4,495
Management	$1,500
Salaries – doctors	$18,866
Salaries – management	$5,600
Salaries – nursing	$36,826

Average cost per wound clinic patient
$2,832

Table 3
Incremental cost of one further patient by diagnostic category (ORN – osteoradionecrosis)

Diagnostic category	Incremental cost of additional patient (AUSD) per treatment
Prevention of ORN	177
Soft-tissue radiation injury	180
Chronic wounds	178
Osteoradionecrosis	177
Diving injuries	415
Acute ischaemic conditions	235
Others	176
Chronic osteomyelitis	177
Acute necrotising infections	229
Other infections	203
Ophthalmological conditions	229
Toxic gas poisoning	227
Neurological conditions	233

Discussion

With this cost study we have measured the cost of provision of care to patients in our unit, both overall and for individual diagnostic categories. These figures will assist us in accurately representing the likely costs of future therapy and in discussions with third-party payers.

Our figures are, of course, based on actual costs and should not be directly compared with hospital hyperbaric charges or Medicare expenditure. For example, our medical staff are all salaried specialist practitioners, and altering the mix of both seniority and employment contracts would alter our cost estimates.

Maximising the efficiency of healthcare delivery is dependent upon maximising benefit for the lowest possible cost. To estimate our efficiency at POWH, information on both resource use and health benefits of hyperbaric versus alternative therapies is needed. By estimating the relative benefits of HBOT versus alternative therapies in a series of Cochrane meta-analyses, we are working toward an estimate of cost benefit in a series of publications currently under preparation in our unit.

For example, in a Cochrane review of the randomised evidence for the effectiveness of HBOT for the treatment of diabetic feet,[7] meta-analysis suggests that the number needed to treat (NNT) to avoid one major leg amputation is four (95% CI 3 to 11). Using our cost data above, at POWH each chronic wound patient receiving HBOT costs on average $3,732. We can calculate, therefore, that our unit will spend on average $14,928 for each major amputation avoided if our results are consistent with those described in published randomised trials. If the assumptions made are valid, we can be 95% confident that the true cost lies between $11,196 and $41,052. The actual extra cost for HBOT in these patients will depend on health costs for treatment excluding HBOT, but including the costs associated with amputation and rehabilitation. It is possible that HBOT may actually save money in this context.

Our figures suggest that HBOT can be delivered at relatively modest cost. We now need to use these figures to inform an accurate analysis of cost versus effectiveness compared with alternative therapeutic strategies. Further analyses based on independent estimates of effectiveness are under way and will be reported in due course.

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Review article

Severity scoring in decompression illness

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Key words
Decompression sickness, decompression illness, severity, treatment sequelae, morbidity, review article

Abstract

(Mitchell S. Severity scoring in decompression illness. *SPUMS J*. 2005; 35: 199-205.)
Scoring systems for disease severity may be designed to predict outcome (prognostication), to facilitate clinical decision making or to stratify patients into subgroups of comparable severity to enable comparisons of therapeutic strategies. This review considers systems that have been proposed for scoring severity of decompression illness (DCI). Most attempts to score severity of DCI have focused on prognostication. One system has been designed to be used to stratify DCI severity in clinical trials, and to provide a linear index of severity that may be used to quantify recovery.

Statement on terminology

This paper adopts the editorial policy described by Francis and Mitchell with respect to the terminology of dysbaric disease.[1] Specifically, the term 'decompression sickness' (DCS) will explicitly refer to symptomatic evolution of bubbles from dissolved inert gas in blood and/or tissues, and the term 'arterial gas embolism' (AGE) will imply the introduction of bubbles to the pulmonary veins as a result of pulmonary barotrauma. The term 'decompression illness' (DCI) will be employed, as suggested by Francis and Smith,[2] to embrace the clinical presentations of both the above pathological processes.

Introduction

Scoring systems for severity of disease are applied in many medical disciplines, usually with one or more of the following goals:

- prediction of outcome
- support of clinical decision making
- stratification of patients into comparable severity subgroups to enable valid comparisons of facilities or therapeutic strategies.

Examples of such systems that have achieved wide acceptance in their respective disciplines include the Acute Physiology and Chronic Health Evaluation (APACHE) score in either of its iterations,[3] which is applied to predict mortality in intensive care patients, and the Glasgow Coma Score,[4] which is applied in the setting of brain injury for all of the above purposes.

Genesis of a scoring system for severity of disease usually involves a process with some or all of the following components.[5]

1 Patient selection. The patient population to which the system will be applied is defined.
2 Outcome selection. Most scoring systems are designed to allow prediction of a particular outcome, for example, the presence of symptoms at discharge from hospital, and this must be chosen and defined.
3 Predictor variable selection and data collection. Clinical factors considered likely to influence the chosen outcome(s) are identified, and relevant data pertaining to these variables in a patient population of known outcome are recorded.
4 Assembly of the model. Combinations of mathematical techniques (such as multivariate logistic regression) applied to the data collected at 3, and clinical judgement are used to derive weightings for the chosen variables in the scoring paradigm.
5 Transformation of the score into a probability for the outcome(s) of interest. Various approaches can be used to establish the prognostic implications of a particular score or score interval.
6 Validation of the model. Ideally, the prognostic power of the system is validated (predicted versus actual outcomes) in a separate group of patients who were not involved in the derivation of the system.

Despite the proposal of several systems for scoring severity of DCI,[6–10] some of which have been developed through a similar process to that outlined above, no method has achieved universal or even widespread acceptance. There are many difficulties in designing such a system, not least of which is a profound lack of prospectively gathered data that relate manifestations to outcome.[8] As a result, it becomes very difficult to objectively rank the protean manifestations of DCI in order of prognostic importance, and to derive appropriate weightings for their respective contributions to a severity score. Moreover, since the clinical spectrum of severity in DCI is so broad (it can range from feeling 'off colour' to paralysis, circulatory collapse and death), the derivation of a scoring system that can both embrace the entire spectrum of disease and be considered linearly related is a substantial challenge. Finally, the matter is further complicated by the existence of two pathophysiological processes (DCS and AGE) that are sometimes indistinguishable clinically but which have different natural histories. Not surprisingly, most of the proposed systems limit their scope to subsets of DCI patients (such as those with neurological disease), and some specifically exclude patients suspected of suffering AGE.

This paper will review the scoring systems that have been proposed to this point with discussion of their strengths and weaknesses. Possible future directions will be considered.

Extant scoring systems

DICK AND MASSEY 1985[6]

This appears to be the first attempt to ascribe a numerical score to indicate severity in DCS. The score is derived by adding two 'grades' chosen from descriptive scales of sensory and motor symptoms respectively. The weighting of the grades for the various manifestations appears to have been based on clinical experience rather than an objective process designed to determine their relative importance. The maximum grade in each scale is 5, giving a maximum possible severity grade of 10 (Table 1). This simple structure makes it quick and easy to apply. However, the system can be applied only to patients with neurological DCS, not those suffering from AGE, and takes no account of non-neurological manifestations. Moreover, the score descriptors (Table 1) are open to interpretation. "Weakness" and "paralysis" can overlap as can "paraesthesia" and "numbness", and thus there is a risk of inconsistent application.[7]

Not surprisingly, when this system was applied to a population of DCS patients, it was demonstrated that greater proportions of those with low grades exhibited either spontaneous recovery or complete relief with recompression than those with higher grades.[6] This was also observed by Ball (1993)[11] who utilised the Dick and Massey system in an investigation of the effect of severity and time to recompression on outcome in DCS.

The severity-versus-outcome data reported in these two studies are summarised in Table 2. Ball also used percentage changes in severity grade (referenced to the admission score) to track recovery during treatment and at discharge.[11]

BOND ET AL 1990[7]

This group compared treatment outcomes in divers treated with different initial recompression tables. They developed a descriptive system for categorising DCI severity in order to control for this parameter in their assessment of recompression efficacy. The severity categories (Table 3) were arbitrarily defined on the basis of the authors' experience. There was no attempt to validate the categories and, surprisingly, data presented in the original paper suggested that the categories were not very predictive of outcome defined as resolution or persistence of symptoms 24 hours after the last recompression treatment.

KELLEHER ET AL 1996[8]

This group accumulated 214 case reports of neurological DCI in standardised format from multiple hyperbaric units. No attempt was made to separate these cases into sub-diagnoses of DCS and AGE, and patients without neurological manifestations were excluded. Each case was classified according to: the modalities affected

Table 1
The neurologic decompression sickness severity scale proposed by Dick and Massey.[6] The scores for each scale are added to give a maximum possible score of 10

Sensory symptoms

Grade	Symptom	Extent
1	Paraesthesia	Single limb or area
2	Paraesthesias	Multiple regions
3	Numbness	Single region or limb
4	Numbness	Two regions or limbs
5	Numbness	Three or more limbs

Motor symptoms

Grade	Symptom	Extent
1	Weakness	Single limb or muscle group
2	Weakness	Multiple limbs or muscle groups
3	Paralysis	Single limb or muscle group
4	Paralysis	Two limbs
5	Paralysis	Three or more limbs

Table 2
Severity as graded by the Dick and Massey system[6] versus outcome as reported in two studies

Source	Severity	Complete relief/ total cases	%
Dick & Massey[6]	Mild (1–3)	24/24 (treated)	100
		10/11 (untreated)	91
	Moderate (4–6)	10/14	71
	Severe (7–10)	1/6	16
Ball[11]	Mild (1–3)	13/14	93
	Moderate (4–6)	4/11	36
	Severe (7–10)	2/24	8

Table 3
Severity 'categories' for DCI as proposed by Bond et al[7]

Code	Severity	Descriptors
0	No symptoms	Nil
1	DCS I (mild)	Pain, rash, itching
2	DCS II (mild/moderate)	Pain, numbness/tingling, restlessness, headache, skin – sensation, muscle twitch
3	DCS II (moderate)	Ringing ears, pain, fatigue, reflex change
4	DCS II (moderate/severe)	Weakness, numbness/tingling, breathing, nausea, vomiting, hearing loss, skin – sensation, personality change, walk – standing
5	DCS II (severe)	Visual disturbance, speech disturbance, weakness, paralysis, bladder, bowel
6	AGE	Semiconscious, unconscious, paralysis, convulsions

(consciousness, sensory, motor); the number of sites involved in any sensory or motor deficit; and the anatomical locations of the manifestations. Post-treatment outcomes were recorded. In particular, the focus in development of the subsequent predictive model was on outcomes after the first recompression treatment. A relationship between incomplete resolution following the first treatment and the pattern of pre-treatment sensory and/or motor manifestations was apparent, and this relationship was further described in terms of a linear logistic model. This model allowed calculation of predicted outcome (incomplete resolution after the first treatment) according to the pattern of sensory and motor manifestations as shown in Table 4. It should be noted that this is not a severity scoring system *per se* (no score is actually derived); rather, it is a manifestation-based model for predicting outcome after the first treatment.

BOUSSUGES ET AL 1996[9]

This group reviewed 96 cases of DCS treated at a single hospital over an eight-year period. Patients suffering from non-neurological DCS or suspected AGE were excluded. Univariate analyses examined the relationship between various parameters (characteristics of the dive, the evacuation and the clinical presentation) and adverse outcome defined as incomplete resolution at one month after treatment. Those parameters found to influence outcome were: progression of symptoms prior to recompression; the presence and degree of motor impairment; the presence of urinary function disturbance; and the presence of objective sensory disturbance. Interestingly, delay to treatment was not found to influence outcome (though this analysis was not adjusted for disease severity). Coefficients of importance were assigned to those parameters that appeared to have a significant influence on outcome. Repetitive diving was also included in the group of influential factors even though its influence was non-significant in the univariate analysis. The value of the assigned coefficients appears to have been influenced by the significance of the parameter in the univariate analysis, and by the 'experience' of the authors. The severity score is calculated by adding all applicable coefficients (Table 5) at presentation.

The system was validated in a population of divers treated at a separate institution. Sixty-six divers were scored at presentation, and their outcomes (complete or incomplete recovery at one month) were noted. The positive and negative predictive values (for the presence of any sequelae) for a score greater than 7 were 86% and 89% respectively (Table 6). Subsequently, Pitkin et al retrospectively applied this system to a further 217 cases of neurological DCI recorded on the Institute of Naval Medicine database for the years 1995–96.[12] In a similar analysis to that performed by Boussuges et al, they recorded outcomes in patients whose score was less than or equal to 7, and greater than 7. However, instead of classifying outcomes in terms of presence or absence of any sequelae, they used categories designated as "no or mild sequelae" and "severe sequelae". The validity of this approach in assessing the prognostic

Table 4
Observed and 'expected' (from application of the model) numbers of cases with incomplete resolution of any manifestations after first treatment in relation to initial sensory/motor manifestations[8]
(X = symptoms present)

Sensory		Motor		Total	Cases with incomplete resolution	
Arm	Leg	Arm	Leg		Actual n (%)	Expected n
X				56	10 (18)	10.3
	X			43	18 (42)	16.4
X	X			20	7 (35)	8.5
		X		12	1 (8)	1.6
			X	2	0 (0)	0.5
		X	X	2	0 (0)	0.5
X		X		10	3 (30)	1.6
	X		X	32	18 (56)	17.1
X			X	0		
	X	X		2	0 (0)	0.7
X	X	X		0		
X	X		X	2	1 (50)	1.2
X		X	X	2	1 (50)	0.5
	X	X	X	2	1 (50)	1.0
X	X	X	X	4	2 (50)	2.2

Table 5
Attribution of 'coefficients' of importance for use in calculating the Boussuges gravity score[9]
(severity score is calculated by summing all relevant coefficients for the patient)

Parameter	Descriptor	Coefficient or score 0	1	2	3	4	5	6
Repetitive dive	No	X						
	Yes			X				
Clinical course prior to HBO	Improvement	X						
	Stable				X			
	Deterioration						X	
Objective sensory disorder	No	X						
	Yes					X		
Motor impairment	No	X						
	Monoparesis, paraparesis, or tetraparesis					X		
	Paraplegia							X
	Hemiplegia				X			
Urinary disturbance	No	X						
	Yes						X	

power of the system is open to debate since the majority of patients with a score of 7 or less would actually have had to deteriorate during treatment to find themselves in the "severe sequelae" group. Not surprisingly, the negative predictive value of a score 7 or less for severe sequelae is 99%. In contrast, the positive predictive value of a score greater than 7 for severe sequelae is only 16% (Table 6). In comparing their results with those published by Boussuges, the authors appear to have overlooked these discrepancies in outcome group definitions.

Table 6
Prognostic value of the Boussuges scoring system as assessed by the original authors[9] and by Pitkin et al[12]

As assessed by the original authors[9]

Score	Sequelae	Recovery	Total
>7	18	3	21
≤7	5	40	45
Totals	23	43	66

sensitivity = 78%; specificity = 93%; positive predictive value = 86%; negative predictive value = 89%

As assessed by Pitkin et al[12]

Score	Severe sequelae	No/mild sequelae	Total
>7	16	71	87
≤7	1	129	130
Totals	17	200	217

sensitivity = 94%; specificity = 65%; positive predictive value = 18%; negative predictive value = 99%

MITCHELL ET AL 1998[10]

In the mid 1990s the Royal New Zealand Navy (RNZN) group planned a randomised trial of lignocaine as an adjuvant to recompression in DCI patients. For a number of compelling reasons,[13] an alternative trial was subsequently conducted in cardiac surgery patients.[14] However, the initial intention to involve divers raised issues of severity stratification, trial group homogeneity, and comparative outcome measurement. The last of these was a particularly vexing problem. The intention was to involve divers with serious neurological DCI, and since many such patients are left with residual symptoms despite maximal therapy, it was felt that complete versus incomplete recovery was too insensitive a measure of outcome for the purposes of the trial. For example, lignocaine might have provided greater degrees of recovery without necessarily altering the complete–incomplete recovery ratio between the respective trial groups. There was no system in existence which allowed scoring of DCI on a scale that implied linear separation of the various presentations according to their 'severity'. A new system was developed with the key goal being an ability to assess relative severity and recovery of the trial patients, rather than to facilitate prognosis.[10]

In application of the RNZN system, the first step is to score each of 22 possible manifestations of DCI on a scale of 0 (absent) to 3 (maximal). Structured guidelines on how to derive this score for each manifestation are specified. In the second step, the unweighted score for each manifestation is multiplied by conversion factors intended to reflect its relative importance, and the progression of the manifestation prior to treatment. The conversion for relative importance reflects the fact that some manifestations are less likely to resolve and more likely to result in long-term problems than others. Once each manifestation has been scored, and the score 'converted' to reflect its relative importance and progression, the individual manifestation scores are summed to give the patient's overall severity score. Thus, all manifestations are scored (not just neurological), and all contribute to the overall severity score, even though the relative contribution of minor, naturally evanescent symptoms would be quite small.

Since the overall severity score is assumed to lie on a linear continuum of relative severity, then re-scoring during recovery and subtracting the new score ("progress score") from the initial score ("admission score") provides a numerical index of recovery (or deterioration) that, in theory, can be used to compare relative recovery between patients. If a patient's progress score is 0 (that is, they have fully recovered), then their recovery score will be equal to their admission score.

The derivation of the importance of conversion factors was a complex process that is best appreciated by reference to the original paper.[10] There was (and still is) no database describing the outcome and quality-of-life implications of individual manifestations of DCI. It follows that three experienced diving physicians independently rated 22 manifestations of DCI on scales describing their respective specificity for DCI, their natural history if untreated, and their potential to cause incapacity in daily living if unresolved. This allowed generation of a numerical index of relative importance of the individual manifestations. Unfortunately, an objective validation of these essentially subjective rankings would be an extraordinarily difficult task.

Holley (2000)[15] conducted a validation study of the RNZN system. One hundred consecutive case files for divers treated for DCI at the RNZN hospital were retrospectively reviewed. Sufficient data were available for application of the system in 79 patients. Although it was not intended as a prognostic scoring system, Holley used threshold scores of ≤25 and >25 to conduct a similar analysis of positive and negative predictive values to those reported by Boussuges et al and Pitkin et al (Table 7).[9,12] The positive and negative predictive values were 77% and 89% respectively. In support of the assumption that scores were linearly related to severity (and in the absence of any other more appropriate marker of severity), Holley correlated the number of treatments required to reach complete resolution or plateau with the admission score ($r = 0.80$, $r^2 = 0.64$, Figure 1).

Table 7
Prognostic value of the RNZN scoring system as assessed by Holley[15]

Score	Sequelae	No sequelae	Total
>25	10	3	13
≤25	7	59	66
Totals	17	62	79

sensitivity = 58%; specificity = 95%; positive predictive value = 77%; negative predictive value = 89%

Discussion

Scoring systems for DCI severity are desirable for two purposes:

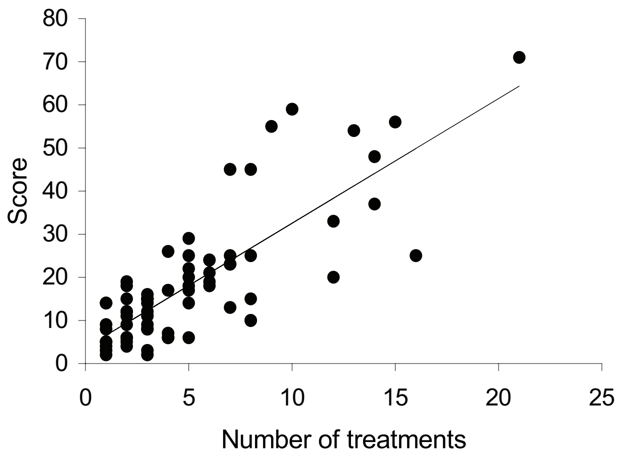
1 to prognosticate and guide clinical decision making
2 in the context of research, to measure severity and recovery in divers participating in trials of therapy.

A third goal might be a scoring system to facilitate DCI diagnosis, but this is unrelated to severity and is not considered further here.

PROGNOSTICATION AND CLINICAL DECISION MAKING

It is self-evident that a capacity for prognostication is useful for advising patients of their likely outcome. The expectations of badly injured divers are frequently in need of temperance, and outcome prediction based on objective data is always better than what might appear to the patient as a vague clinical impression. Prognostication might also prove highly valuable in clinical decision making. For example, a system that predicted outcomes for mildly injured divers in the absence of recompression would be invaluable in the management of remote DCI cases. Unfortunately, given the current fashion for recompressing all DCI patients no matter how trivial their disease, it is hard to see how such a system could be developed and validated objectively for contemporary populations of sport divers. A more realistic example of prognostic scoring in clinical decision making might include earlier withdrawal of repetitive recompression therapy and avoidance of delays in accessing

Figure 1
Correlation of RNZN scoring system admission score versus the number of recompressions required to achieve resolution or plateau in recovery[15]



rehabilitation in cases whose score indicates a poor prognosis even with extended courses of multiple recompressions. It is also conceivable that should superior efficacy for more aggressive recompression protocols ever be demonstrated, a severity scoring system might be useful in determining which patients should be allocated to such treatments.

To be useful in a busy clinical environment, a scoring system for prognostication and clinical decision making should be relatively simple and quick to apply. Several of the extant systems fit this description.[6,7,9] In particular, the system proposed by Boussuges et al is simple and quick, and it appears to perform well in prediction of outcome. However, patients with non-neurological disease cannot be scored using this system (nor one of the others that could be considered as 'quick and simple').[6] Non-neurological DCS may still result in sequelae and it follows that if prediction of outcome is the goal, then a separate or all embracing system will need to be developed. The Bond system does allow categorisation of all patients,[7] but we have no idea of the validity of the categories. The RNZN system can be used to score patients with most manifestations of DCS, and performs almost as well prognostically as the Boussuges system, yet over the entire range of disease (neurological and non-neurological).[10] However, it is not so simple and readily applied, and is probably better suited to the research situation (see below).

MEASUREMENT OF SEVERITY AND RECOVERY IN RESEARCH

A method of ensuring equivalence between study groups is vital in any study involving a disease as variable as DCI.[8,9] Even more important is a sensible measure of outcome. The use of incomplete versus complete recovery is hopelessly insensitive and potentially very misleading; for example, how does one compare a dense paraplegic who eventually walks out of hospital with a limp (incomplete recovery) with a patient with upper-limb sensory change who recovers completely. Both have neurological disease. The paraplegic has made a functionally more important but incomplete recovery, whilst the other patient has recovered completely. The use of percentage recovery as reported by Ball is similarly flawed since the recovery percentages take no account of the initial 'absolute' severity.

The RNZN system attempts to avoid these pitfalls by generating overall severity scores that are weighted to reflect the natural history and potential for functional handicap of the component manifestations. If it can be assumed that the scores are truly linearly related, then the changes in score during treatment provide a valid index of the size and significance of recovery that has occurred. However, despite the authors' attempts to objectify the allocation of importance weightings for the various manifestations of DCI, the process used must still be considered somewhat arbitrary. In addition, the system is cumbersome to apply, although an automated spreadsheet recently developed by James Francis has simplified matters considerably.

Future directions

Large databases of DCI patients whose manifestations and outcomes are carefully recorded are the key to developing scoring systems that both embrace non-neurological manifestations and more accurately predict outcome. However, even with such databases the task may not be easy. Ideally, discrete clinical DCI syndromes could be identified and the prognostic implications of these syndromes could be defined. However, although most clinicians probably perceive several 'typical' DCI presentations, it is noteworthy that principal component analysis of the DAN database (incorporating 2,822 case records) failed to identify any clear syndromes.[16]

At the present time, the Boussuges system probably represents the 'standard' in terms of prognostication, but is limited by being applicable only to those patients with neurological disease. The target should be a relatively simple algorithm similar to the Boussuges system, but which includes score components for important predictors of outcome in non-neurological disease also. Preferably, the validation process for such a system would examine its application (for prognostication) not only on initial assessment of the diver, but also at progressive stages of treatment.

For assessing severity and recovery, and for comparing these parameters between groups, a system designed to reflect true differences in significance of symptoms and to accurately reflect their progress is more appropriate, despite the almost inevitable increase in its complexity. At this time, the RNZN system probably represents the 'standard', but there is almost certainly room for improvement. In particular, a more objective determination of the relative importance of the various symptoms is almost certainly possible.

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Case reports

Respiratory decompression sickness in a recreational scuba diver

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Key words
Decompression illness, decompression sickness, respiratory, cardiovascular, case reports

Abstract

(Wilson CM, Sayer MDJ. Respiratory decompression sickness in a recreational scuba diver. *SPUMS J*. 2005; 35: 206-8.)
A case study is presented relating to the treatment of a recreational diver with suspected respiratory decompression sickness. The diver had performed a rapid ascent after running out of air at a depth of 15 metres and had immediately displayed all of the classic symptoms of respiratory decompression sickness, with severe chest pain, 'bubbling' in the chest, progression to pain on inspiration, development of a dry cough, blood in the sputum and development of dyspnoea. Eventual treatment was successful with complete resolution. However, the time from surfacing to treatment was almost 13 hours following difficulties in transferring the diver from a remote location. In this case, there was some reduction in the severity of the symptoms during transfer to a recompression facility with the delivery of normobaric oxygen and aggressive hydration.

Introduction

Respiratory decompression sickness has been well documented over the years both in diving and aviation medicine. Historically, this manifestation of decompression is known as 'the chokes'; other terms are pulmonary or cardiopulmonary decompression sickness and cardiorespiratory decompression sickness.[1–3] It is one of the rarer presentations of decompression sickness, having only 2.0% prevalence in 11,471 manifestations compiled from DAN data.[2]

Accounts of actual cases of respiratory decompression sickness are rare in the literature. The present report describes a case that was treated in 1996 at the Dunstaffnage Hyperbaric Unit near Oban on the west coast of Scotland. It also details the problems associated with patient transfer from remote locations.

Case report

A 60-year-old male recreational scuba diver was diving from the Island of Islay in the Inner Hebrides off the west coast of Scotland. Islay is renowned for its many and varied distilleries producing malt whiskies of great character.[4] He was not an experienced diver having been diving for only four years. He had a long-standing medical history of hypertension for which he was being adequately controlled with the angiotensin converting enzyme (ACE) inhibitor drug, enalapril 5 mg daily.

During his time in Islay he and his dive buddy, who was a doctor, had been diving to between 12 and 19 metres carrying out a total of six dives over a three-day period. His incident dive, the second of the day, was commenced at 1700 hr to 15 metres' sea water remaining there for 31 minutes. He unfortunately ran out of air at this point and made a rapid ascent which was uncontrolled during the last six metres to the surface. He immediately experienced severe anterior chest pain, pain in the back of the neck that radiated into the head described as being similar to a migraine and felt his thinking was lacking clarity. Within a few minutes of surfacing he described a "bubbling" feeling in his chest, which progressed to pain on inspiration. A cough developed and blood was noted in his sputum. He then became dyspnoeic and after a short time had difficulty in walking short distances.

It was felt that he required medical assistance and was taken at 1930 hr (*circa* two hours post dive) to the cottage hospital on Islay. Cottage hospitals in Scotland are in remote areas of sparse population and are run by the local general practitioners (GPs). At this point he could not walk the length of his trolley because of his dyspnoea and was noted to be hypoxic with a SpO_2 of 85% on air. A chest X-ray and electrocardiogram (ECG) appeared normal and he was commenced on oxygen, 4 $l.min^{-1}$ by Hudson mask.

Doctors in remote areas where diving is uncommon may have little or no working knowledge of diving problems but Scotland has an emergency telephone support service run from Aberdeen Royal Infirmary, where the UK National Health Service (NHS) has the only funded hyperbaric service in the British Isles. The advice from the consultant on call in Aberdeen was that this was very likely to be a diving-related problem and the patient should have high-flow oxygen, fluid resuscitation and be transferred to a recompression facility for urgent assessment and appropriate further management. The GP was requiring a great deal of persuasion to transfer the casualty but eventually organised a helicopter transfer by Search and Rescue (SAR) flight of the Royal Navy.[5]

The UK has a number of SAR bases around its coastline and in this case a helicopter was despatched from its base at Prestwick, just south of Glasgow, with the intention of transferring the diver from Islay (about 120 miles northwest of Prestwick) to the nearest recompression facility at Oban (about 50 miles north of Islay). At 2200 hr the helicopter was nearing the vicinity of Islay when it encountered heavy and persistent fog and visibility was so low as to make landing impossible. In the course of deciding on the next course of action the helicopter received notice of another medical emergency and so, as landing was not possible at Islay, the helicopter was redeployed elsewhere.

With the helicopter's departure, the GP decided to keep the patient on Islay. It took a great deal of time and persuasion by phone for the Aberdeen consultant to convince the GP that the diver did need to be transferred to an appropriate treatment facility at the earliest opportunity. It was eventually arranged for the 50-mile journey to be carried out by Royal National Lifeboat Institution (RNLI) lifeboat.[6] RNLI lifeboats in the UK are provided by charitable donations and are crewed by highly trained volunteers.

At 0100 hr the next day (over seven hours post dive) the Islay lifeboat left Islay with the GP and patient on board and began to travel north, while the RNLI lifeboat at Oban also launched to travel south. The Oban lifeboat carried a doctor with diving medical expertise and the intention was to rendezvous with the Islay lifeboat midway between Islay and Oban thus reducing the time either boat was off station. After transferring the patient to the Oban boat it was found that the initial expert management advice had not been followed by the GP in charge of him. He was changed from his 4 $l.min^{-1}$ flow of oxygen by Hudson mask to 100% by demand system, an intravenous access had to be established and an infusion with normal saline and aggressive fluid replacement commenced. Following this his dyspnoea improved over the remaining 90 minutes of the journey.

On arrival at the Oban Hospital at 0400 hr (over 10 hours post dive), the diver was still complaining of anterior chest discomfort but with less pain; he still had a severe cough. Full blood count, blood biochemistry, repeat chest X-ray and ECG were all performed and found to be normal.

Recompression was commenced at 0600 hr, some 12 plus hours post dive, on a Royal Navy treatment table 62 at the Dunstaffnage Hyperbaric Unit. The Unit is housed in the Dunstaffnage Marine Laboratory, hosted by the Scottish Association for Marine Science. The original recompression chamber at Dunstaffnage was installed in order to conduct scientific diving operations in compliance with the Diving at Work Regulations. However, subsequent installations have primarily been designed to provide a treatment service for the NHS as part of the recent Scottish Hyperbaric Registration Scheme.

The patient had complete resolution of his symptoms after two oxygen cycles at 18 metres. The table was continued without modification and he surfaced at 1045 hr. On surfacing he felt completely normal. He had no dyspnoea and was able to run up and down the hospital stairs. He had no chest pain and his cough had completely settled. A repeat chest X-ray and ECG were normal. Biochemistry showed a raised creatine phosphokinase (CPK) but was otherwise normal. It is routine practice in Scotland to admit patients to hospital for at least 24 hours following treatment in order to monitor for relapse and to observe the quality of recovery. Following his 24 hours of post-treatment observation, the patient remained well and was discharged.

Discussion

Respiratory decompression sickness is characterised by the triad of substernal chest pain, paroxysmal cough and dyspnoea.[1,2,7,8] This diagnosis was made in this case though pulmonary barotrauma and gas embolism were considered. The initial symptoms experienced by the patient were classic of this form of decompression sickness with severe chest pain, "bubbling" in the chest, progression to pain on inspiration, development of a dry cough, blood in the sputum and development of dyspnoea. The depth and duration of the incident dive had not been especially provocative but there had been a rapid ascent following a cessation in air supply.

Traditionally, cardiopulmonary involvement has been described following dives with a severe decompression stress, either where the dive profiles were highly provocative with omitted decompression or where decompression was long and arduous.[1,2] This can cause large quantities of gas emboli to pass into the pulmonary filtering system and overload it resulting in right ventricular failure and circulatory collapse.[7] This clinical manifestation is seen when about 10% of the pulmonary vasculature is involved.[7] The time to onset of symptoms can vary from a short delay to one of several hours after surfacing.[1,2] In any case of respiratory decompression sickness the symptoms can persist and progress causing adult respiratory distress syndrome, disseminated intravascular coagulation, central cyanosis, respiratory acidosis, pulmonary hypertension and falling cardiac output.[2] Respiratory and/or cardiac arrest can follow if the patient is not recompressed as a matter of urgency.[2]

Respiratory decompression sickness represents one of the lethal forms of decompression illness and recompression treatment should be pursued with some urgency.[2,9] Because of the remoteness of the dive location and the problems experienced in evacuating the patient, time to treatment in this case was almost 13 hours. The early management of this condition should be with high-flow oxygen and fluid resuscitation, not differing from that of the other forms of decompression sickness. It is unfortunate that the GP initially in charge of this case failed to follow the expert advice given to her, and was slow in progressing the urgent transfer despite great pressure from the Aberdeen consultant in telephone contact. The reason why this expert advice was not, or reluctantly, followed is unclear. However, there is no evidence of any progression in symptom intensity in this case during the delayed transfer and there was immediate improvement when the delivery of adequate normobaric oxygen and aggressive hydration was eventually instigated. In this case, recompression treatment consisted of a single unmodified Royal Navy table 62 with almost immediate and complete resolution.[10] Similarly good responses to treatment have been reported previously in cases of respiratory decompression sickness.[11] Although previous reports of respiratory or pulmonary decompression sickness had noted pulmonary oedema during lung scans,[3,12] all chest X-rays in the presented case were normal. The potential severity of respiratory decompression sickness cannot be ignored. However, in this case an unavoidable delay to treatment did not appear to produce progressive deterioration of symptoms or influence the eventual degree of resolution.

At the time of this incident the Oban lifeboat was carrying 100% oxygen by-demand equipment for an evaluation trial. After the success of this trial the equipment was rolled out to all lifeboats both inshore and offshore. Also following this incident written advice in the initial management of diving-related problems listing appropriate telephone numbers was widely distributed to all hospitals in Scotland.

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This case report was presented by Dr Wilson at the SPUMS Annual Scientific Meeting 2005 in The Maldives.

Acute pulmonary oedema in a hypertensive snorkel swimmer

F Michael Davis

Key words
Immersion, pulmonary oedema, snorkelling, beta blockade, case reports

Abstract

(Davis FM. Acute pulmonary oedema in a hypertensive snorkel swimmer. *SPUMS J*. 2005; 35: 209-10.)
A case is reported of a 52-year-old woman with known hypertension on medication, who developed acute pulmonary oedema whilst snorkelling in tropical waters. Subsequent management and investigations are described. No underlying myocardial disease was identified. This is presumed to be a case of immersion pulmonary oedema, contributed to by her medications, which included ß-blockers. Subsequently, a rare dopamine-secreting carotid body tumour, which was likely to have contributed to this event, was diagnosed and successfully resected.

Introduction

The sudden onset of acute left ventricular failure whilst swimming, snorkelling or scuba diving may have a variety of causes. Whilst myocardial ischaemia, particularly in the face of pre-existing cardiovascular pathology in the middle-aged or elderly, would be the first consideration in many cases, acute pulmonary oedema has also been reported in young, healthy individuals.[1–4] An apparent case of immersion pulmonary oedema in a snorkeller occurring in warm tropical waters is reported here.

Case report

An active, mildly obese 52-year-old female anaesthetist was vacationing in Queensland. She was a known hypertensive on nadolol 50 mg tds and diltiazem 280 mg daily, with only modest control. On the third day of a visit to an island on the Great Barrier Reef, she went snorkelling in calm, sunny conditions. She had snorkelled before, but not for some years, and was inexperienced. After about three-quarters of an hour she noticed some difficulty making headway, and she told her companion that she would swim to shore, about 200 m away, with the tide assisting her.

She describes what happened as follows.
"*I found my legs were very weak, which was worrying, but what started to preoccupy me was the presence of a lot of bubbly fluid in my chest. I thought I must have aspirated some sea water, but knew I hadn't. It took a very long time to get out of the water, and I was very breathless and bluer than I have ever seen anyone. Pink frothy stuff was coming out of my mouth. I had no chest pain…but felt weak.*

This is a resort island with a well-stocked first-aid clinic and a nurse. Unfortunately, the newly qualified nurse had no experience in acute medicine, she had never put in an intravenous (IV) line and she started to cry. I reassured her, and we obtained permission from a hospital junior doctor on the mainland to use morphine and frusemide, but the island's management would not allow me to put in my own IV. Half an hour later, by which time I was cross and exhausted, an elderly neurologist appeared who had not put in an IV for 25 years. I wasn't surprised, but welcomed him (through the oxygen mask and pink frothy sputum) with "Sit down and supervise this" and proceeded to insert my own IV. Morphine and frusemide were administered and I began to feel much better."

The snorkeller's condition having improved considerably, and after some discussion, the decision was made to evacuate her by boat to the mainland the following morning. The morning after that she was seen by a cardiologist and immediately admitted to the coronary care unit of a local private hospital. On admission, she appeared fatigued and dyspnoeic at rest. There were crepitations at both lung bases, a soft third heart sound and oxygen saturation on air was 93%. Echocardiography showed an area of infero-lateral left ventricular wall hypokinesis and mild mitral regurgitation. The only abnormality on electrocardiogram was peaked T-waves in the lateral chest leads.

Whilst in hospital, she had two episodes of anginal-type pain and a few brief episodes of palpitations, but cardiac iso-enzymes were not elevated, excluding an acute myocardial infarction, which had been the presumed diagnosis. She made steady progress and was discharged on the sixth day on aspirin, nadolol, diltiazem, frusemide and an ACE inhibitor. At this time, she was able to walk for more than an hour and a half without dyspnoea, and had no orthopnoea or palpitations. Blood pressure was normal and a 3/6 pan-systolic murmur was noted. The attending cardiologist stated in the discharge letter *"my impression is that there are certain pieces missing from this puzzle*."

Echocardiography two weeks later showed a left ventricular ejection fraction of 87% with no evidence of regional dysfunction or mitral regurgitation, the only abnormality being a mildly increased left ventricular mass index, consistent with her hypertension. A Bruce protocol exercise study was normal, with a heart rate of 89% of predicted maximum being achieved. Coronary angiography showed a dominant left main coronary artery of normal calibre and there were no significant flow-limiting coronary artery lesions.

However, the story does not end here. This woman's labile hypertension persisted, and a right submandibular lump was noted. Further investigations revealed elevated dopamine levels to nine times above normal. Nine months after the immersion incident, she underwent resection of a non-malignant right vagus paraganglionoma, confirmed to be dopamine secreting. Several cranial nerves were sacrificed during surgery and she underwent a prolonged recovery. Six years later she remains well, still in full-time anaesthesia practice.

Discussion

Immersion pulmonary oedema was first reported by Wilmshurst in eleven, middle-aged, hypertensive scuba divers in cold water.[1] The only feature of note in these divers was the development of a high peripheral vascular resistance response to forearm cold water (less than 12^{O}C) immersion. Subsequently, similar episodes in healthy young scuba divers, fin swimmers during long surface swims and in recreational snorkellers have been documented.[2–4] Several factors, such as overhydration, ischaemic heart disease and some drugs, particularly ß-blockers, are believed to be contributory. However, it may arise in an otherwise healthy individual with no apparent risk factors.

The pathophysiology of immersion-induced pulmonary oedema is not fully understood. Immersion and cold exposure cause peripheral vasoconstriction, with an increase in cardiac pre-load and after-load as blood volume is centralised and peripheral resistance increases. There is an increase in mean pulmonary artery pressure and pulmonary capillary wedge pressure. The engorgement of the pulmonary blood vessels may predispose to capillary stress failure. A more detailed discussion of the pathophysiology and the differential diagnosis of immersion pulmonary oedema has been presented by Mitchell.[5]

Immersion pulmonary oedema was not considered at any stage in the differential diagnosis in this patient, though the cardiologist concerned, who had no diving medical training or experience, clearly felt he was missing a key piece of the jigsaw. This appears to be a classic case, with the associated risk factors of hypertensive cardiovascular disease and use of ß-blocker medication in an inexperienced snorkeller, although it is very uncommon for this to occur in warm tropical waters.

Cases of Irukandji envenomation with chest pain, particularly if pulmonary oedema develops, may be misdiagnosed as acute myocardial infarction with developing heart failure.[6] This may be reinforced by a history of swimming (exertion), especially if the history of a mild sting is not elicited, or is forgotten by the victim. Elevated levels of troponins and/or CK-MB are taken as a measure of cardiac damage. In this patient cardiac iso-enzymes were never elevated, and Irukandji syndrome cannot be completely excluded from the differential diagnosis as she was snorkelling within the known geographical distribution of *Carukia barnesi*. However, the general absence of pain during the early post-immersion period makes this very unlikely.

This case of acute immersion pulmonary oedema is unusual in that a contributory pathology was subsequently identified.

Acknowledgments

Permission by the patient to report details of her experience and subsequent clinical course is greatly appreciated.

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SPUMS notices and news

South Pacific Underwater Medicine Society Diploma of Diving and Hyperbaric Medicine

Requirements for candidates

In order for the Diploma of Diving and Hyperbaric Medicine to be awarded by the Society, the candidate must comply with the following conditions:

1 The candidate must be medically qualified, and be a financial member of the Society of at least two years' standing.
2 The candidate must supply evidence of satisfactory completion of an examined two-week full-time course in Diving and Hyperbaric Medicine at an approved Hyperbaric Medicine Unit.
3 The candidate must have completed the equivalent (as determined by the Education Officer) of at least six months' full-time clinical training in an approved Hyperbaric Medicine Unit.
4 The candidate must submit a written proposal for research in a relevant area of underwater or hyperbaric medicine, and in a standard format, for approval by the Academic Board before commencing their research project.
5 The candidate must produce, to the satisfaction of the Academic Board, a written report on the approved research project, in the form of a scientific paper suitable for publication.

Additional information

The candidate must contact the Education Officer to advise of their intended candidacy, seek approval of their courses in Diving and Hyperbaric Medicine and training time in the intended Hyperbaric Medicine Unit, discuss the proposed subject matter of their research, and obtain instructions before submitting any written material or commencing a research project.

All research reports must clearly test a hypothesis. Original basic or clinical research is acceptable. Case series reports may be acceptable if thoroughly documented, subject to quantitative analysis, and the subject is extensively researched and discussed in detail. Reports of a single case are insufficient. Review articles may be acceptable if the world literature is thoroughly analysed and discussed, and the subject has not recently been similarly reviewed. Previously published material will not be considered.

It is expected that all research will be conducted in accordance with the joint NHMRC/AVCC statement and guidelines on research practice (available at http://www.health.gov.au/nhmrc/research/general/nhmrcavc.htm) or the equivalent requirement of the country in which the research is conducted. All research involving humans or animals must be accompanied by documented evidence of approval by an appropriate research ethics committee. It is expected that the research project and the written report will be primarily the work of the candidate.

The Academic Board reserves the right to modify any of these requirements from time to time. The Academic Board consists of:
Dr Chris Acott, Education Officer, Professor Des Gorman and Associate Professor Mike Davis.
All enquiries should be addressed to the Education Officer:
Dr Chris Acott,
30 Park Avenue
Rosslyn Park
South Australia 5072
Australia
E-mail: *<cacott@optusnet.com.au>*

Key words
Qualifications, underwater medicine, hyperbaric oxygen, research

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Minutes of the SPUMS Committee Meeting held in Melbourne on 31 July 2005

Opened: 1013 hr
Present: Drs C Acott (President), R Walker (Immediate Past-President), S Sharkey (Secretary), A Patterson (Treasurer), G Williams (Public Officer and Committee Member), D Vote (Committee Member)
Apologies: Drs M Davis (Editor), D Smart (ANZHMG Representative), C Lee (Committee Member)

1 Acceptance of previous minutes

1.1 Committee Meeting held Sunday 10 April 2005 (teleconference). Proposed Dr Acott, seconded Dr Walker, carried.

1.2 Informal Committee Meeting held Sunday 22 May 2005 (teleconference). Proposed Dr Walker, seconded Dr Vote, carried.

2 Matters arising from the minutes not covered in other agenda items

2.1 Administrator functions

The details of the contractual agreement/statement of works with Mr Goble need to be reviewed. The new website will impact on the required services. It was agreed that a formal statement of works needs to be established with regard to the services provided by the Administrator. The functions of the Administrator, Secretary and Treasurer will all need to be documented formally in the Statement of Purposes and Rules, but this should not delay the approval of the current edition being reviewed at this meeting. ACTION: Dr Acott to discuss the functions with Mr Goble. Dr Sharkey to investigate legal requirements for formalising this contractual relationship.

2.2 Election terms for Committee

The correct meaning of the three-year term as reflected in the Statement of Purposes and Rules was discussed. It was generally agreed that the wording was appropriate. Staggered appointments of committee members were proposed by Dr Acott – it was agreed that this would be ideal and should be managed as the situation requires in order to avoid loss of continuity within the Committee. ACTION: NFA.

2.3 2004 ASM Noumea final figures

It was not established whether the refunds to those who departed early have been reflected in the P&L statement for this meeting. ACTION: Dr Patterson to review.

2.4 2005 ASM

The travel agents provided a donation towards the gala dinner function noting the favourable exchange rate. Other issues relating to final figures are discussed at the Treasurer's report.

2.5 Letter of complaint

Letter from a patient regarding inappropriate behaviour of a diving doctor. Further to previous minutes medicolegal advice has been obtained by Dr Walker. On the basis of this advice the doctor was contacted by Dr Walker and the matter discussed. Further action is pending the outcome of action by the Medical Board.

3 Annual Scientific Meetings

3.1 2006 ASM. Pearl South Pacific Resort – Pacific Harbour, Fiji, 3–10 June

The Convenor (Dr Patterson) reported that the inspection has been completed. Resort is currently undergoing an upgrade which will be completed prior to the conference. Proposed programme: Welcome cocktail party 4 June; ASM 5–9 June; AGM Wednesday 7 June; Gala Dinner Friday 9 June. Child friendly. Proposed costings and inclusions were provided by Allways and reviewed by the Committee. Prices are considered reasonable. Registration fee yet to be determined.

The theme of the conference was discussed and agreed to be revision of basics principles with a series of workshops (including airway skills/equipment) and reviews of fitness-to-dive issues (asthma, diabetes, PFO, reverse dive profiles, breath-hold diving, pacemakers, immersion physiology, obesity, evolving profiles, safety). Title: "Something Old, Something New". CME points from RACGP and ANZCA being pursued.

3.2 2007 ASM

Proposed in New Zealand. Convenor Dr Davis.

3.3 2008 ASM

PNG has been suggested. Convenor Dr Acott, "Diving in the Tropics".

4 Treasurer's report

4.1 Financial statement attached. The Committee agreed financial position was healthy.

4.2 Treasurer reinforced the requirement for claims for reimbursement to be submitted in a timely manner and with complete and appropriate supporting documentation in order that they can be allocated transparently, appropriately and to the correct financial year. ACTION: All committee members.

4.3 The financial reports from the 2005 ASM contain inconsistencies that will require further clarification from the Convenor (Dr Meehan). ACTION: Dr Patterson to write to Dr Meehan and request clarification/justification of accounts.

4.4 The process with respect of reconciling bank records for deposits and credit-card payments needs review. The current process is open to frequent error and is cumbersome and time-consuming for the Treasurer. It is anticipated that the SPUMS website will assist in simplifying this process.

4.5 Inventory of property holding of SPUMS is required. There are several items that are now obsolete and should be available for purchase by the members. All equipment held by the past Secretary and the ASM-related equipment held by the Administrator needs to be sent to Sydney. ACTION: Dr Patterson/Sharkey.

5 Journal report (received by e-mail from Dr Davis)

5.1 Software upgrade request

PageMaker corrupted. Approval for upgrade agreed by the Committee. ACTION: Dr Davis.

5.2 Best Books free advertising space approved by the Committee. ACTION: Dr Davis.

5.3 Ross Wine letter

It was noted in correspondence from Dr Davis that no formal response from the President had been given to Ross Wine in relation to standards of medicals in Queensland. Dr Walker had previously considered the issue and concluded that it was not necessary for her to provide a response but will discuss the issue further with Dr Davis. ACTION: Dr Walker.

5.4 Remuneration of Editor was considered by the Committee. The Committee agreed to increase remuneration to NZ$1,400 per month with effect from January 2006.

5.5 Contracting of editorial services

At the request of Dr Davis it was agreed by the Committee that the services of the current Editorial Assistant (Sarah Webb) were valuable and would continue at the suggested rate of NZ$31 per hour.

5.6 It was noted that the office transition had been completed and the Treasurer confirmed that the accounts of termination payment had been received and were satisfactory.

5.7 Database of papers has been created but not completed. For review by the Committee at the next meeting.

5.8 Ongoing difficulties with slowness of contributions to the Journal was noted and discussed.

5.9 Name change for the Journal will commence in 2006 with volume 36. Embase consequences yet to be determined.

5.10 CD of presentation for 2005 meeting was blank. Dr Acott has advised that Dr Bennett is able to provide electronic copies of the presentations which will be forwarded to Dr Davis.

5.11 Deadline for the ASM brochure for Snap Printing is Monday 12 September.

5.12 EUBS/SPUMS journal amalgamation

E-mailed proposal from Dr Mueller was discussed. The Committee considered that the proposal was not in the best interests of SPUMS based on the detail provided to date. A more detailed proposal would need to be considered. It was suggested that EUBS could consider a representative at the next SPUMS ASM and also that some other form of link between the societies may be of some benefit. ACTION: Dr Acott will formally respond to Dr Mueller.

6 Education Officer's report

Four (4) Diplomas have been awarded. Discussion ensued regarding the continuing frustration from Diploma candidates seeking to get their papers published in journals other than the *SPUMS Journal*. The need to encourage submissions for the *SPUMS Journal* was reinforced to committee members.

7 Correspondence

7.1 E-mail from Dr Davis reinforced recent communication regarding the need for amendments to the Purposes and Rules to be promulgated through one process via the Secretary. This was agreed.

7.2 Letter from previous Secretary (Dr Meehan)

Issues have been dealt with previously and will be communicated directly by Dr Sharkey. ACTION: Dr Sharkey.

7.3 Letter forwarded by Dr Meehan from Queensland Police requesting report for inquest into a diving death. Dr Acott agreed to take on this issue and will respond to the letter. ACTION: Dr Acott.

8 Other business

8.1 SPUMS/ EUBS journals combining

Refer para 5.12.

8.2 Website update

An update on progress of the new SPUMS website was provided by Dr Walker. The delayed June issue of the *SPUMS Journal* will provide information for members regarding the website. The website is being established with SQUIZ. Features include online database, online membership and registration transaction facilities, secure gateway, online amendment by members, electronic membership reporting, regular updating of information, bulk e-mailing of correspondence, search engine, secure members' area, e-journal capable. Establishing the secure transaction facility has been a rate-limiting step recently and is now complete. The website will be able to be managed by SPUMS (long-term delegation of this function to be resolved, Dr Walker will manage in the initial phase). Expect to go 'live' in the next few weeks.

8.3 SPUMS Purposes and Rules

The final draft version was reviewed by committee meetings. It was agreed that further updates will be required in the future. ACTION: Dr Williams will forward typographical errors to Dr Davis. Dr Walker to add to the website.

8.4 Consumer affairs

ACTION: Dr Williams to seek written confirmation of approval for short delay of AGM outside the rules. Dr Williams to forward the revised approved Statement of Purposes and Rules to Dr Acott.

8.5 Status of overseas representatives

It was agreed that due to inactive nature of their involvement in recent years their positions should be deleted from the Journal unless otherwise requested. International involvement is gained through other means in the Society. ACTION: Dr Sharkey to notify Dr Davis of request to remove names.

8.6 Continued contracting of Editorial Assistant

Refer para 5.5.

8.7 Remuneration of SPUMS Journal Editor

Refer para 5.4.

8.8 Diplomates database

Dr Acott has a list of Diploma holders. It was noted that this should be on the membership database.

8.9 New membership categories

8.9.1 Incentives for recruitment of membership were discussed. A proposal to offer new members two years' membership for one year's annual fee was suggested if they attended that year's ASM. It was generally agreed that this proposal had merit and did not conflict with Society Rules. ACTION: Dr Patterson.

8.9.2 Retired membership

A couple of members had written requesting consideration of retired fees. It has been agreed that it is appropriate for retired doctors to pay an Associate Membership fee. Additional consideration was requested for retired members to pay reduced ASM fees and retain voting rights. Reduced ASM fees were not considered appropriate given the costing structure for the ASM. This issue would require a change to the Society's Statement of Purposes and Rules and will need to be considered at the next AGM. ACTION: Dr Walker to draft proposal for AGM.

8.9.3 Student membership

Similar consideration was given to a separate category for students. It was concluded that students should be Associate Members.

8.10 SPUMS liability insurance

This has been renewed and is considered essential by the Committee.

8.11 Issues of secretarial handover

Covered in other agenda items.

8.12 Australian Standards representative for AS 4005.1

It was noted that a responsibility of the previous Secretary was to act as SPUMS representative on the AS 4005.1

Committee. It was agreed that this role is most appropriately performed by a member of the Committee who naturally has more complete visibility of current SPUMS policy. ACTION: Dr Sharkey to seek advice from Dr Meehan re when the next meeting is due and to facilitate the nomination of an appropriate representative on this committee for SPUMS.

9 Next meeting
Teleconference, Sunday 9 October 2005, 0900 hr (Sydney time).

Closed: 1530 hr

Minutes of the combined AGM of the Diving and Hyperbaric Medicine Special Interest Group and the ANZHMG teleconference, Thursday 18 August 2005

Opened: 0900 hr

1 Present
Margaret Walker (Chair, Tas), Bob Wong (WA), David Wilkinson (SA), David Smart (Tas), Barbara Trytko (NSW), Bob Long (Qld), Brian Spain (NT), Mike Bennett (NSW), Mike Davis (New Zealand), Glen Hawkins (NSW), Ian Millar (Vic), Heather McDonald (New Zealand)
In attendance: Ms Juliette Mullumby

2 Apologies
Harry Oxer, Roslyn Lloyd-Williams, Mark Fajgman, Ian Seppelt, David Cooper, Ian Unsworth

3 Minutes of 2004 Annual General Meeting
Recommendation by Drs M Davis and B Trytko that the minutes be accepted as a true and accurate record of the meeting. Carried.

4 Business arising
It was noted that matters arising from the previous minutes would all be covered on the current agenda.

5 Address by Chair of ANZHMG
Dr D Smart noted that it had been a relatively politics-free year for the ANZHMG. He noted that following the last AGM, the group had spoken to a senior advisor in the Health Department which resulted in the extended funding of Medicare item 13015 for a further three years under section 3C.
Dr B Spain joined the meeting at this point.
Dr Smart reported that the extended funding would expire on 31 October 2007 by which time a report on the Problem Wound Study would need to be available. Dr Smart urged all units to contribute to the study and highlighted that contributing even a small number of cases helped to ensure that it was a comprehensive study of Australian and New Zealand hyperbaric units.
Dr Bob Long joined the meeting at this point.
Dr Smart noted that the ANZHMG will continue to undertake a medico-political role on behalf of hyperbaric units and to represent Directors of Units in Australia and New Zealand.

6 Timing of AGM
The Chair noted that in 2004 the SIG and ANZHMG held its first combined Annual General Meeting.
Dr I Millar believed that it was incredibly important to have separation between the standards and the political group. He suggested that visible separation through individual AGMs was important in facilitating this separation.
From 2006 it was agreed to hold separate AGMs for ANZHMG and the SIG but to hold both during the HTNA Meeting.
Dr B Trytko suggested forwarding registration brochures for future HTNA meetings to the SIG membership to increase the numbers of anaesthetists in attendance.
It was determined to increase communication between the SIG and its membership by producing an electronic newsletter twice a year. The Chair noted that a SIG report has been placed in the *SPUMS Journal* and it was agreed to also place the article in the ANZCA Bulletin.

7 MSAC Report
There was nothing highlighted for discussion under this item.

8 Hyperbaric problem wound database
Dr G Hawkins noted that he had written a database to hold the required information and offered to share it with other departments if requested. He expressed his wish to gather the data collated so far in order to compile an interim report.
Dr M Davis reported that New Zealand units would be unable to forward the collated data until the completion of the twelve months as that was a requirement set out in the ethics approval given to the project.
Dr H McDonald noted that Oxygen Therapy Ltd, Auckland, have included drop-down tables in their database and a security option that ensures all fields are completed before the record is saved or can be exited.
All units were encouraged to continue collating data in order to have a comprehensive databank.

9 HORTIS
The Chair reported that at Royal Hobart Hospital they were about to recruit their first patient to this trial.
Dr Long indicated that they had been inundated with calls about participation in the trial following an advertisement placed in the local paper.

10 ANZHMG/SIG list of indications for HBO_2
Dr Long reported that he is currently compiling a database and seeking ethics approval for a prospective trial of hyperbaric oxygen in the treatment of femoral head necrosis.

It was agreed to put a statement in the *SPUMS Journal* to the effect that there were no changes to the previously published list and referring in full to that publication.

11 Introductory Course in Diving and Hyperbaric Medicine

Discussion covered the possibility of moving the administration of the course to the College with the control of the course remaining with the ANZHMG. It was noted that the College does not allow proceeds from a course to pay for the facilitators to travel to the course. It was therefore agreed not to request the College to undertake the administration of the course. Dr M Bennett stated that he was happy to continue to run the course through the Prince of Wales Hospital, with the support of visiting lecturers from other states.

Dr M Bennett noted that the course would be held in the first two weeks of March in 2006. Dr Hawkins undertook to send an advertisement of the course to SPUMS for inclusion in their September edition.

12 Address by Chair of SIG

The Chair noted that the SIG had 171 registered members, which was considered particularly pleasing.

The Chair congratulated Dr Mike Davis on receiving the Charles W Schilling Award for his contribution of an outstanding nature to teaching, to the support of the goals of the Undersea and Hyperbaric Medical Society in educating the diving community and the public with communications about science and practice of diving medicine and related fields. She also recognised Dr David Smart who received the Craig Hoffman Award for significant contributions to diving safety at the recent Annual Scientific Meeting of the Undersea Hyperbaric Medicine Society.

It was recognised that Drs Carl Edmonds, Peter McCartney and John Williamson have been awarded ANZCA Citations for their contributions to diving and hyperbaric medicine.

Three facilities have now been accredited for training in diving and hyperbaric medicine and it was noted that two further facilities are currently undertaking the accreditation process.

It was noted that an annual fee for certificate holders of $100 was established but that no subscriptions have been sent out. Ms Mullumby undertook to follow this up with the College Finance Department.

Dr I Millar, who had been nominated by the SIG as an observer on the European Diving Technology Committee, reported that he had not received any reply to his nomination but that he had been invited to attend their meeting in Spain.

13 SIG business

The Chair noted that the SIG will be presenting a 90-minute session at the 2006 ANZCA ASM on non-diving conditions treated with hyperbaric medicine.

14 ANZCA SIG Certificate

It was reported by the Chair that the SIG had been asked by the Certificates Committee to discuss whether the prerequisite requirements for the Certificate needed to be reconsidered, particularly that of the SPUMS Diploma. It was considered inappropriate by the Certificates Committee to include a Diploma issued by another organisation as a prerequisite to a College Certificate without any College representation on the SPUMS Academic Board.

Those present acknowledged that a person should not be made to join one organisation in order to obtain a certificate from a different organisation. It was suggested that an alternative should be approved. A research project of a similar standard or approval of another diploma such as the one currently being developed in Auckland were considered possible alternatives.

There was general agreement that the College needed to have the ability to allow people to complete the requirements through its own administration system. It was agreed to allow a more open approach to meeting the prerequisites.

Recommendation from the Chair that candidates be eligible to sit the ANZCA examination in Diving and Hyperbaric Medicine after 12 months' full-time equivalent training in an approved unit. Carried.

The Chair reported that ANZCA is in the process of seeking College representation on the SPUMS Academic Board. It was agreed that the Chair would write a letter to SPUMS outlining the reasons for the request for consideration at the SPUMS October meeting.

Dr M Bennett argued that the College should retain the SPUMS Diploma and noted that the current arrangements benefited both organisations enormously. He suggested that the representative role could be filled by one of the current anaesthetic representatives.

Dr B Trytko left the meeting at this point.

It was agreed to consider this issue further once the SIG has heard back from SPUMS.

15 ANZCA – SIG exams

It was noted that this item had previously been discussed.

16 ANZCA citations

The Chair reported that one citation was in the approval process.

17 Hyperbaric facility accreditation

It was reported that Fremantle, Prince of Wales and Royal Hobart Hospitals had all been accredited. Other units who were thinking of applying for accreditation were encouraged to do so.

18 Minimum qualification to conduct AS2299 diving medicals

Dr M Davis reported that a refresher process is now being offered in New Zealand where there is no formal certification of doctors involved in diving medicals.

Dr D Wilkinson reported that the coroner in South Australia issued some directions via the Medical Board to all doctors with the strong recommendation that no diving medicals should be carried out by a doctor without some specialised training.

19 Australian Standards issue
It was highlighted that this issue would develop further with the decision to be made by the Recreational Committee and Occupational Diving Committee in September on whether Australia should recognise or align itself with the International Standards Organisation's *Standards on Recreational Diving*.
It was noted that a Film and Photographic Occupational Divers Standard will be promulgated in the coming few months. A standard is being developed for Occupational Diving Supervisors.

20 SPUMS Journal
It was noted that the Journal was going along well. Dr Davis was congratulated on the improvements he had made to the publication.

21 Minimum data set
It was noted that this issue had been covered elsewhere during discussion.

22 HTNA issues
It was agreed that the promotion of this meeting needed to be communicated to the medical community earlier. It was suggested that in future the meeting should be scheduled to avoid the European meeting which is frequently held in the second or third week of September.

23 Other business
The Chair noted that the SIG would be organising a session at the ANZCA meeting.
Drs Smart and Wilkinson are to attend the HTNA AGM to facilitate communication between the two groups.
With no further business the Chair thanked those present for participating and closed the meeting.

Closed: 1050 hr

Dr David Wilkinson
Hon Secretary, ANZHMG

Dr Margaret Walker
Chair, D&HM SIG

Professor Des Gorman appointed Head of the School of Medicine of the University of Auckland

Professor Des Gorman has been appointed as Head of the School of Medicine (a position analogous to what many universities would call the Dean of Medicine) at the University of Auckland's Faculty of Medical and Health Sciences, becoming in the process the first alumnus to head up one of the five schools the Faculty represents.

Des is of Ngapuhi descent and graduated with a BSc and MBChB from The University of Auckland in 1978, going on to complete his PhD at the University of Sydney while he was serving with the Royal Australian Navy. During this time he emerged as Dux of the Royal Navy Submarine School Officers' Course and was named Royal Australian Navy Officer of the Year. During his time with the RAN he trained as a Clearance Diving Officer (US Navy equivalent – Master Diver).

Des has retained an active interest in the Hyperbaric Unit at the Royal Adelaide Hospital, which he established with the support of the National Safety Council of Australia 20 years ago. He is a consultant to that hospital, as he is to the Royal New Zealand Navy (RNZN), RAN, Royal Navy of Oman, and other government and industry organisations. On returning to New Zealand in 1989, Des was Director of Medical Services for the RNZN until 1995, at which time he joined the staff of the Faculty of Medical and Health Sciences, the University of Auckland, and from 2000 has held a professorial Chair in Medicine.

Professor Gorman was President of SPUMS from 1990 to 1996, and was the Society's ASM Guest Speaker in 1986 and 2003. He has contributed regularly to the Society's journal and is a member of the Academic Board.

During his academic career Professor Gorman has had 218 papers published internationally and has made 36 keynote presentations to major international conferences, most in his specialist field of diving and hyperbaric medicine. His drive and determination resulted in one of the first university-based academic qualifications in diving and hyperbaric medicine in the English-speaking world, with establishment in 2004 of the Postgraduate Diploma in Medical Science in this subject at the University of Auckland.

"*It is a great thrill to be appointed to head up this school, which played such an important role in my career,*" Professor Gorman said. "*I am delighted to have the opportunity to really make a difference where I call home, and to do this through helping some really excellent young people as they gain the grounding for their own medical careers.*"

The Society wishes Professor Gorman every success in his new position, which he took up in October.

David Smart MD

Dr David Smart's thesis "*Expired carbon monoxide as a marker of CO poisoning and its application in determining treatment end-points*" has been accepted by the University of Tasmania, Australia, for the degree of Doctor of Medicine. He will be awarded his doctorate on 14 December 2005.

Apology

The Editor apologises that Drew Richardson was not listed in the previous issue of the *SPUMS Journal* amongst recent SPUMS recipients of Undersea and Hyperbaric Medical Society Awards. He received the Craig Hoffman Memorial Award in 2000.

SPUMS Award for HTNA ASM Paper 2005

The SPUMS Award for the best presentation by a member at the Hyperbaric Technicians and Nurses Association Annual Scientific Meeting in Melbourne, August 2005, was awarded to two recipients:

Helen Mullins, Department of Diving and Hyperbaric Medicine, Fremantle Hospital
A review of visual acuity changes in patients receiving more than 20 treatments

Anne Sydes, The Wesley Centre for Hyperbaric Medicine, Brisbane
A case series of pyoderma gangrenosum

Each received a book voucher.

Commodore Robyn Walker with Vice Admiral Chris Ritchie on her recent appointment

SPUMS diplomates 2005

The following diploma theses have recently been accepted:

Stephanie McInnes, Department of Diving and Hyperbaric Medicine, The Prince of Wales Hospital, Sydney
The incidence of decompression illness in forward versus reverse multilevel diving profiles
(paper submitted to *Undersea & Hyperbaric Medicine*)

Stefan Neff, Hyperbaric Medicine Unit, Royal Adelaide Hospital
Decompression illness in hyperbaric nursing staff

Karen J Walker, Hyperbaric Medicine Unit, The Alfred Hospital, Melbourne
The performance and safety of a pleural drainage unit (Oasis Dry Suction 3600 chest drain) under hyperbaric conditions

Daryn Wolfers, Department of Diving and Hyperbaric Medicine, The Prince of Wales Hospital, Sydney
Performance of two capnographs under hyperbaric oxygen conditions
(paper submitted to *Undersea & Hyperbaric Medicine*)

Congratulations to all diplomates.

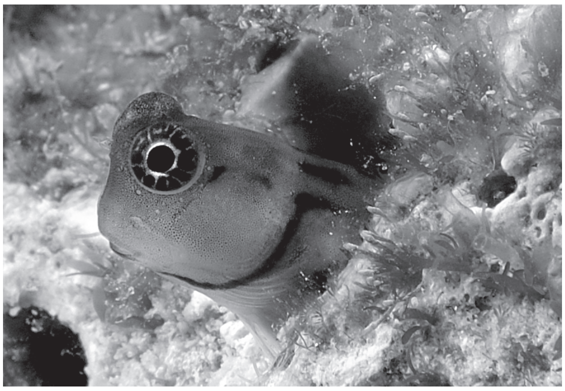
David Doolette, PhD

David, for many years the Society's Education Officer and also a guest speaker at the 2004 ASM, has recently moved from Adelaide, where he was a research physiologist in the Department of Anaesthesia and Intensive Care, to the USA. He has taken up research appointments with both the US Navy Experimental Diving Unit (NEDU) in Panama City, Florida, and Duke University Medical Center, Durham, North Carolina. He will be working on real-world applications of research into the nature of decompression sickness for both the US Navy and Diver's Alert Network, in the latter role in close association with Dr Richard Vann.

Resignation of Dr Patterson as Treasurer

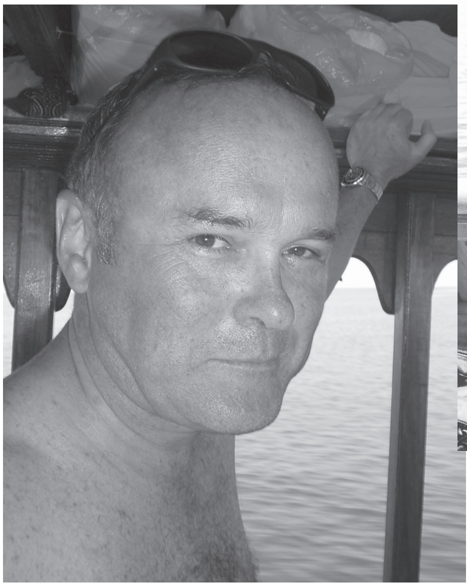
It is with considerable regret that the Society has accepted the resignation of Dr Andrew Patterson from the position of Treasurer and from the Executive Committee as from the end of 2005 (SPUMS financial year). He served in this role for two years, bringing considerable discipline to the financial affairs of SPUMS. Guy Williams will take over as Acting Treasurer from January until the Annual General Meeting in June 2006, when elections will be held for a new Treasurer.

Bug-eyed with disbelief at what the speaker said!



Registrants schooling to the meeting after diving

Michael Lang, Guest Speaker



Fiona Sharp

Martin Sayer

SPUMS ASM 2005
Coca Palms Resort
The Maldives

Photos courtesy, Martin Sayer and Karen Richardson

The Editor still searching for original material for the Journal

David Wilkinson

The world as it is

Accreditation of Hyperbaric Technical Officer (HTO) training in Australia

Dale O'Halloran

Key words
Hyperbaric facilities, training, qualifications, standards, policy, general interest

Abstract

(O'Halloran D. Accreditation of Hyperbaric Technical Officer (HTO) training in Australia. *SPUMS J*. 2005; 35: 219-224.)
Introduction: In 2000, the Hyperbaric Technicians and Nurses Association (HTNA) established a Training Committee of two registered nurses and two technical officers to address training and accreditation issues within the Association. For technical training the priority was to establish a career pathway and further education for Hyperbaric Technical Officers (HTOs). This process has been broken into four phases with known goals and outcomes.
Goals:
- Amend the prerequisite requirements for HTO training in the Hyperbaric Oxygen Therapy Facilities Industry Guidelines (HOTFIG) and the Draft Australian Standard (SF-46).*
- Design and accredit the framework of training for the Certificate IV and Diploma in Hyperbaric Technology to Australian National Training Authority (ANTA) standards.
- Find and assist a suitable registered training organisation (RTO) to implement the Certificate IV in Hyperbaric Technology.
- Find and assist a suitable RTO to implement the Diploma in Hyperbaric Technology.

Outcomes: HOTFIG was amended in February 2002; these changes now appear in the new Australian Standard AS 4774.2–2002. ANTA has approved the framework of training for the Certificate IV and Diploma in Hyperbaric Technology. Royal Adelaide Hospital (RAH), an RTO, commenced delivery of the Certificate IV in Hyperbaric Technology in July 2005. Once HTOs have completed the Certificate IV, RAH will commence delivery of the Diploma in Hyperbaric Technology. Future goals include guidelines for continuing education and an analysis of the training requirements for monoplace chambers.

Introduction

During the 2000 Hyperbaric Technicians and Nurses Association (HTNA) Annual General Meeting, members agreed to establish a committee to identify and develop education strategies for hyperbaric registered nurses and hyperbaric technical officers (HTOs) in Australia. The HTNA Training Committee, consisting of two nurses (Christy Pirone and Chris Mitchell) and two HTOs (David King and Dale O'Halloran), was established and its initial recommendations presented the following year. This paper will focus on these and subsequent developments for HTOs to the present time.

Goals for accredited training of HTOs

The HTNA Training Committee identified that the training for HTOs should:
- provide a career pathway
- be nationally accredited
- be affordable and
- be consistent with AS 4774.2–2002.[1 *]

This has been tackled in four phases.

- Phase 1 included the analysis of current training requirements and standards, definition of prerequisites, and identification of registered training organisations (RTOs) interested in delivering training, and was completed by May 2002.
- Phase 2 was completed in October 2002 and dealt with the design and accreditation of the framework of training.
- Phase 3 was the development of training resources and delivery of the Certificate IV of Hyperbaric Technology and was completed in July 2005.
- Phase 4 is the development of training resources and delivery of the Diploma of Hyperbaric Technology. The diploma package is likely to be delivered in 2006.

* Footnote: SF-46 is a Committee formed by Standards Australia to represent the interests of the following groups during the compilation of Australian Standard 4774.2–2002: Australian and New Zealand Hyperbaric Medicine Group (a sub-committee of the South Pacific Underwater Medicine Society); Australian and New Zealand College of Anaesthetists; Australian Industry Group; Australian Medical Association; Hyperbaric Engineering Industry Forum; Hyperbaric Technicians and Nurses Association; Institution of Engineers Australia and WorkCover New South Wales.

PHASE 1

Phase 1 involved analysis of current training requirements and standards, definition of prerequisites and identification of RTOs interested in delivering training. Following the review process, recommendations for HTO training were tabled at the 2001 HTNA Annual General Meeting held in Fremantle. These recommendations included a proposal to align prerequisite qualifications with courses accredited both in Australia and internationally, and the analysis and development of an accredited HTO course.

The analysis phase of the HTO course identified that no accredited training curriculum existed for HTOs. Existing *ad hoc* HTO training available at individual hyperbaric facilities in Australia varied immensely. The Hyperbaric Oxygen Therapy Facilities Industry Guidelines document (HOTFIG),[2] published by the HTNA in 1998, was of limited use as a training document, and was subject to inconsistent levels of compliance within hyperbaric facilities in Australia. Clearly, an accredited course was required as it would establish a consistent standard of training, career pathways and measurable work competencies and skills.

Overview of the analysis of skill sets

Three professional groups that operate in Australia and New Zealand were identified as having expertise in the operation of recompression chambers (RCCs) and the supervision and training of chamber operators and supervisors. These were:

- occupational divers
- commercial divers and life support technicians (LSTs)
- clearance divers (CDs).

Occupational divers

The Australian Diver Accreditation Scheme (ADAS) is the national occupational diver certification scheme. ADAS offers accreditation to divers who have been assessed by an ADAS diving training establishment as meeting the competency requirements of one of the relevant four parts of Australian Standard 2815.[3–6] This accreditation is valid only whilst diving operations are being undertaken in accordance with relevant legislation and operational standards, and whilst the diver is in possession of a current AS 2299 medical certificate certifying him/her fit to dive.[7]

AS 2815.3–1992 Training and certification of occupational divers – Air diving to 50 m contains components for the training of diving supervisors, including the supervision of the operation of RCCs.[5] There was and still is no current ADAS-accredited stand-alone RCC supervisor's course; however, ADAS do provide an RCC operator's course.

Commercial divers and life support technicians

The International Marine Contractors Association (IMCA) is the leading international body for the accreditation of training organisations that train offshore divers and support staff. IMCA has a training scheme for divers and non-divers (e.g., nurses) to become LSTs for onshore hyperbaric facilities. The pathway to becoming an LST is to complete an Assistant Life Support Technician course (14 days), which is offered in Tasmania. On completion of this course, approximately 3800 hours operating/supervising a hyperbaric chamber under the supervision of an IMCA-endorsed LST must be completed, after which a theoretical examination is taken.

Clearance divers

During the training of advanced CDs (petty officer and above), both monoplace/monolock and multiplace/multilock chambers are utilised for omitted decompression and therapeutic recompression. Advanced CDs supervise basic CDs (able and leading seamen) who operate the RCCs during these procedures. Basic CDs' knowledge and skills are comparable to those of the IMCA ALST and ADAS chamber operators.

Due to the particular skill sets gained in obtaining one of the above qualifications, and the lack of any similar level of training available in Australia, possession of one of these qualifications was identified as a prerequisite to undertaking a Certificate IV in Hyperbaric Technology. Adopting this 'prerequisite' policy enabled a significant reduction in the Certificate IV training time, thereby significantly reducing costs. Additionally, without the prerequisite requirement, the development of a full Certificate IV training package was considered not to be financially viable or practical for training providers given the limited numbers of jobs available in this profession in Australia.

Therefore, selection criteria were adopted into AS 4774.2–2002,[1] such that the candidate shall comply with one of the following prerequisites:

- be qualified as a life support technician (LST) and certified by the IMCA
- have as a minimum an ADAS Part 3 certificate of competency for diving supervisors, or
- if from a military background, have attained the minimum rank of Petty Officer Clearance Diver.

Running concurrently with the HTNA review was an Australian National Training Authority (ANTA) initiated and funded project for Community Services and Health Training Australia Ltd (CSHTA) to provide a training package for all health technicians across Australia. A training package of this type is considered the framework for uniform national training standards, must be endorsed by industry and applies to the vocational education sector. These types of packages consist of competency standards, qualification names and levels, and assessment guidelines.

As the HTNA is the industry body for Hyperbaric Technicians and Nurses in Australia and New Zealand, the newly formed HTNA Training Committee became the principal consultant to CSHTA in developing HTO training in Australia. The initial meeting between all parties was held in 2001 at the Wesley Centre for Hyperbaric Medicine in Brisbane, Queensland, and was attended by HTOs from the Alfred Hospital, Royal Australian Navy and the Wesley. During this meeting the syllabus structure and timelines for the project were formalised.

PHASE 2 – DESIGN AND ACCREDIT FRAMEWORK OF TRAINING

Certificate IV in Hyperbaric Technology

This qualification covers workers who maintain the safe function and operation of the hyperbaric chamber and related equipment during patient treatments and testing procedures. Common occupational titles may include Hyperbaric Technician, Hyperbaric Technical Officer, and Hyperbaric Technical Officer Grade One. The prerequisites set out in AS 4774.2–2002 were outlined above. The rules for this training package require 12 units to be completed, of which eight are compulsory (Table 1).

Diploma in Hyperbaric Technology

This qualification covers workers who manage, supervise and operate a hyperbaric therapy system and assume responsibility for the safe operation of the compression chamber. Common occupational titles may include but are not limited to Technical Facility Manager, Senior Hyperbaric Technical Officer, Hyperbaric Technical Officer Grade Two, or Hyperbaric System Maintenance Manager.

Desirable prerequisite courses are:

- The American Society of Testing Materials' Fire Hazards in Oxygen Systems and Oxygen Systems Course
- The American Society of Testing Materials' Operation and Maintenance (Oxygen) Course.
- Certificate IV in Hyperbaric Technology is a prerequisite for this qualification.

The rules for this training package require 10 units to be completed, of which six are compulsory (Table 2).

PHASE 3 – DEVELOPMENT OF TRAINING RESOURCES AND DELIVERY OF THE CERTIFICATE IV OF HYPERBARIC TECHNOLOGY

Due to the small number of hyperbaric facilities in Australia, low rates of HTO employment led to low interest from RTOs willing to deliver both the Certificate IV and Diploma in Hyperbaric Technology. The Royal Adelaide Hospital was the only RTO that has made a commitment to deliver these packages, and the Certificate IV in Hyperbaric Technology is now available from there. The majority of the course will be delivered by distance education with RCC modules delivered locally by HTOs who are accredited workplace trainers and assessors. Existing HTOs will be able to apply for credit transfers and recognised prior learning credits against the Certificate IV course commensurate with their existing qualifications and experience.

PHASE 4 – DEVELOPMENT OF TRAINING RESOURCES AND DELIVERY OF THE DIPLOMA OF HYPERBARIC TECHNOLOGY

The Royal Adelaide Hospital has undertaken to deliver the Diploma of Hyperbaric Technology. Technical officers of the HTNA Training Committee are developing the Diploma competencies that are hyperbaric specific and expect the first course will be delivered in 2006.

Future initiatives and reviews for HTO education

CSHTA are currently reviewing the Certificate IV and Diploma in Hyperbaric Technology as part of the national review of all health technician packages. We intend to ask Standards Australia to replace Appendix E of AS 4774.2–2002 with the nationally accredited training syllabus for the Certificate IV and Diploma of Hyperbaric Technology. An industry-based continuing education system for HTOs should also be developed in 2006.

Discussion

With the introduction of the HTNA Training Committee came the first formalised approach to standardising HTO training on a national and international basis with a view to accreditation of the training package by a third party. At this point the priority was for HTO training, not chamber operator or monoplace training.

Prior to the establishment of the HTNA Training Committee, hyperbaric facilities conducted HTO training in an *ad hoc* fashion. This was due to several factors: training was required to employ new staff, it was not offered at a national level, and the experience and knowledge of the trainers in each facility was obtained from employment in either clinical, military or commercial recompression chambers. This in-house training had several flaws: it was not accredited with any professional group, trainers' accreditation varied from facility to facility, and third-party peer review of the training package was not evident.

The first step in this process was to review the training requirements of HOTFIG. This became emotive as individuals viewed the process suspiciously as to its effect on future employment, and employers were concerned about governmental employment restrictions and training delays. During this first phase it became apparent that there was a belief that existing HTOs were using this review as a 'closed shop' mechanism by increasing the skill level required for commencement of HTO training.

In HOTFIG an HTO was stated to be responsible for the safe operation of the hyperbaric chamber and the safety of all occupants. Selection criteria and prerequisites as detailed in HOTFIG were inappropriate as an HTO does not only

Table 1
Certificate IV in Hyperbaric Technology

Compulsory units

HLTHIR2A	Contribute to organisational effectiveness in the health industry
HLTIN1A	Comply with infection control policy and procedures
HLTHSE1A	Follow occupational health and safety policies, procedures and programmes
HLTHSE4A	Follow safe manual handling procedures
HLTHY1A	Prepare multiplace hyperbaric chamber
HLTHY2A	Operate multiplace hyperbaric chamber
HLTHY3A	Conduct post-compression routines
HLTHY4A	Implement emergency procedures for hyperbaric chamber

Elective units

A minimum of two units must be selected from the following:

BSBCMN302A	Organise personal work priorities
BSBFLM402A	Show leadership in the workplace
BSBFLM403A	Manage effective workplace relationships
BSBCMN405A	Analyse and present research information
BSBCMN301A	Deliver and monitor a service to customers
BSBCMN412A	Promote innovation and change
BSBMED201A	Use basic medical terminology
HLTAMBPD1A	Manage personal stressors in the work environment
HLTSTE1A	Clean reusable medical devices
PRMCL18A	Clean a unit or location to achieve a low bacterial condition
HLTHIR3A	Work effectively with culturally diverse patients, clients, customers and co-workers
HLTHIR4A	Work effectively in a cross-cultural context with Aboriginal and Torres Strait Islander colleagues, clients and organisations

Two units may also be selected from the following:

- Health training package units at the Certificate IV level
- Other national training package units available at the Certificate IV level

operate the chamber but he/she also supervises the safety processes of chamber operation.[2] HOTFIG prerequisites varied from operator level (no supervisory training in chamber operation) to LST who operates and supervises a saturation diving system.[2] To allow for a non-diver becoming an LST, non-divers would be required to complete the IMCA-accredited LST training package. In the case of military divers the pre-requisite of Chief Petty Officer (CPO) rank was not qualified by the category (job) of Clearance Diver (CD) nor was it specified that the lower rank of Petty Officer (CD) has the same supervisory training

Table 2
Diploma in Hyperbaric Technology

Compulsory units

HLTHIR2A	Contribute to organisational effectiveness in the health industry
HLTIN3A	Implement and monitor infection control policy and procedures
HLTHSE3A	Establish, maintain and elevate the organisation's occupational health and safety system
HLTHY5A	Manage the maintenance of hyperbaric systems
HLTHY6A	Identify and respond to risks associated with hyperbaric therapy
BSZ404A	Train small groups

Elective units

A minimum of three units must be selected from the following:

HLTHIR6A	Implement and monitor compliance with legal and ethical requirements
BSBFLM501A	Manage personal work priorities and professional development
BSBFLM502A	Provide leadership in the workplace
BSBFLM503A	Establish effective workplace relationships
BSBFLM504A	Facilitate work teams
BSBFLM505A	Manage operational plan
BSBFLM506A	Manage workplace information systems
BSBFLM509A	Promote continuous improvement
BSBCMN405A	Analyse and present research information
BSZ401A*	Plan assessment
BSZ402A*	Conduct assessment
BSZ403A*	Review assessment
HLTHIR3A	Work effectively with culturally diverse patients, clients, customers and co-workers
HLTHIR4A	Work effectively in a cross-cultural context with Aboriginal and Torres Strait Islander colleagues, clients and organisations

*If one of these units is selected then all three must be selected

One unit may also be selected from the following:

- Health training package units available at the Certificate IV and Diploma levels
- Other national training package units available at Certificate IV and Diploma levels

in recompression chambers. For ADAS divers the current prerequisites did not recognise that the dive-site supervisor was responsible for the supervision and safe operation of the RCC.

After lengthy debate, the decision was made to change the prerequisite requirements to one of a supervisory level and have these decisions reflected in the new Australian Standard

AS 4774.2–2002, which would become the foundation for the yet-to-be-developed Certificate IV in Hyperbaric Technology. With these prerequisites in place, a suitable training course could be developed for experienced chamber supervisors in a clinical setting.

Four avenues of training were then investigated which could provide accredited training for the HTO. They were: a professional certificate from Adelaide University; ADAS certification; development of an HTNA-endorsed HTO course; or to assist ANTA to develop a health technicians training package for HTOs.

A professional certificate did not provide the introduction and intermediate levels of training, but may be considered at a later date. At the time, it was hoped that ADAS might develop and provide the HTO training but after brief discussions with ADAS, it became apparent that it did not fall under their charter of commercial/occupational diver training and ADAS had higher priorities for training demands. As for HTNA developing and providing accredited training, this was not considered feasible due to the effort required to become a registered training organisation (RTO) and deliver the training. The obvious choice became apparent when an ANTA initiative provided the funding and resources for the analysis and development of a nationally accredited training package for health technicians that included HTOs.

The initial scoping meeting for the ANTA project for HTO training was held at the Wesley Centre for Hyperbaric Medicine, Brisbane, with representation from the HTNA, the Alfred Hospital, the Royal Australian Navy and CSHTA. From this meeting two employment groups of HTOs were identified, the first group being casual/permanent employees with the sole responsibility of the supervision and operation of a hyperbaric system, and the second group being others responsible for various levels of management of a hyperbaric system.

As the majority of HTOs in the first group have limited patient contact in the workplace and come from an employment background with limited health-industry exposure, the core competencies that were deemed appropriate were medical terminology, infection control, manual handling and occupational health and safety (OH&S). For the second group managing and maintaining the OH&S system and hyperbaric system maintenance were identified as core competencies. Additionally compulsory and elective units of competency for all health-training packages would be included in the final packages. After this initial meeting, the remainder of the development was conducted by correspondence and telephone. Two levels of training were eventually endorse: the Certificate IV and Diploma in Hyperbaric Technology. Both of these courses would be delivered by distance learning, face-to-face training and chamber modules in a local hyperbaric facility.

Another hurdle was to solicit an RTO willing to deliver both training packages. Problems associated with the delivery of these packages were directly related to the low numbers expected to enrol in the course and the courses' financial viability. The projected low enrolment numbers are related to the low attrition rate of HTOs amongst the hyperbaric facilities in Australia and New Zealand. Two RTOs were approached, the Wesley Hospital and Royal Adelaide Hospital (RAH). RAH took up the challenge and have commenced delivery of the Certificate IV in Hyperbaric Technology.

To facilitate and encourage existing HTOs to complete the Certificate IV, a process was established to provide an industry competency certificate (HTNA HTO Grade 1) that could be used during the process of recognition of prior learning (RPL), with a goal of reducing the number of units of competency requiring completion. This process ('grandfathering') required HTOs to have two years' experience, completed 50 treatment cycles and a statutory declaration from their employer. At the Christchurch 2002 HTNA Conference, 75 applications were received with 42 HTOs being grandfathered. As of August 2005 only one HTO has applied to commence the Certificate IV course. This low number can be attributed to HTOs throughout Australia preparing individual RPL applications to be submitted with the initial course application.

Acknowledgments

David King HTO, The Wesley Centre for Hyperbaric Medicine, Brisbane; Teresa Farrell RN, Consultant CSHTA; Dave Passmore Warrant Officer CD, Royal Australian Navy; Dwayne Cananzi HTO, The Alfred Hospital, Melbourne and Steve Goble HTO, Royal Adelaide Hospital, Adelaide.

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5 Australian Standard 2815.3–1992. *Training and certification of occupational divers – Air diving to 50 meters*. Sydney: Standards Australia International Ltd; 1992.

6 Australian Standard 2815.4–1992. *Training and*

certification of occupational divers – Bell diving. Sydney: Standards Australia International Ltd; 1992.
7 AS/NZ 2299.1–1999. *Occupational diving operations – Standard operational practice*. Sydney: Standards Australia International Ltd; 1999.

For this work, Dale O'Halloran was the recipient of the 2002 SPUMS Prize for the best presentation by a member of the HTNA at their Annual Scientific Meeting in Christchurch.

Dale O'Halloran is a hyperbaric technical officer at the Wesley Centre for Hyperbaric Medicine in Brisbane.

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Obituary

Ted Eldred 1920–2005

Ted Eldred, the inventor of the single hose scuba regulator, died at his home in Yarck, Victoria, on Friday 26 August.

Ted began diving before World War 2 using rebreathers. His inventive mind set about making and improving rebreathers and, after the War, he commenced manufacturing them for sale. With the invention of the Aqualung, Ted turned his attention to open circuit compressed air systems and soon designed his first two stage, single hose regulator. This scuba system, like his rebreathers, he named Porpoise. In partnership with Maurice Batterham he commenced the Breathing Appliance Company to manufacture Porpoise diving equipment.

Over a period of 10 years Ted developed his single hose regulators until they were acknowledged as the most efficient and safest scuba system in the world. The single hose, two stage design also meant that Ted could develop an efficient surface supplied (hookah) system. Having separated the first and second stages of the open circuit demand valve diving system, Ted now spent many years improving it. He developed a balanced first stage regulator, so the available air to the diver did not drop as the air in the scuba tank was used. He developed the purge valve on the second stage regulator and continually improved its design until it was capable of delivering up to 300 litres of air per minute; unheard-of performance from diving equipment of that period.

Ted never had the money to patent his diving inventions. Under increasing financial pressure, the Breathing Appliance Company was sold to Le Spirotechnique in the 1960s and Ted's designs went around the world to replace the Cousteau–Gagnan Aqualung. Ted never received the financial reward or the public recognition for changing the way we dive today.

Ted Eldred's experience in diving, his engineering skills and his brilliant design of the single hose regulator, followed by a decade of development and improvement forever improved the ease and safety with which we dive.

Ted was very involved in the 1950s with the School of Underwater Diving and Swimming in Melbourne.

The Historial Diving Society SEAP perpetuates Ted's name through the annual Ted Eldred Award.

Extracts taken from the Tribute by Jeff Maynard published in the Historical Diving Society SEAP's Newsletter, September 2005

Australian designed and manufactured Porpoise Universal, Royal Australian Navy model
(photo courtesy of Stephen K Taylor)

The diving doctor's diary

A fishy tale from Port Vila (with a sting in the tail)

Richard Harris

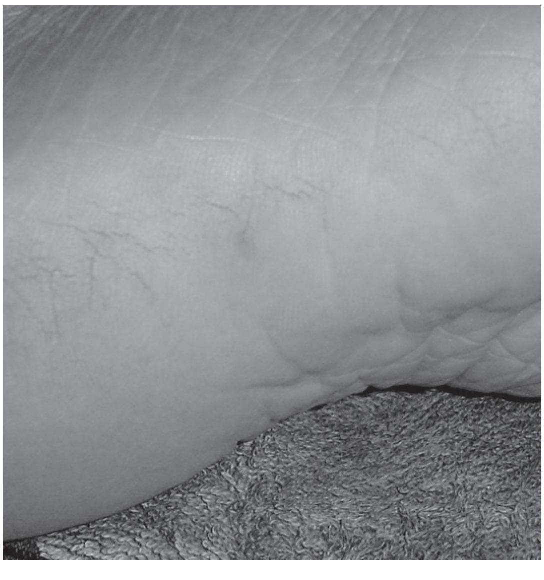
Key words
Envenomation, marine animals, case reports

Technical diving is dangerous. I'll tell you why. There is a local drop off in Port Vila, Vanuatu, that I have been exploring, taking some video footage of the really interesting corals that live there. The reef starts at about 50 m and drops to 180 m. It is a great site.

The last time I dived there, I was getting kitted up and when I put my bootie on I felt a mild pain in my left big toe. It got worse until eventually I had to take my boot off. A large centipede crawled out, leaped overboard and swam off before I had a chance to kill it. That was three weeks ago and the toe is still slightly tender.

The next time I dived the site, I met a couple of mates at 6.30 am at the beach where I have my small boat moored. I swam out to get the boat, then loaded it up with all our gear. We were just about to set off from the beach when I trod on something sharp. It didn't hurt too much but I could see a small bleeding cut on the side of my heel (Figure 1). It felt a bit odd and I wondered if I had stood on a sea urchin. I grabbed my mask and peered into the water to see a bearded ghoul (*Inimicus caledonicus*) on the sand.[1] The wound was starting to ache a bit now, so I thought we better stick around for a while before embarking on a deep dive, in case the pain got worse.

Figure 1
The innocuous-looking injury from this scorpionfish sting is barely visible on the author's instep



Within five minutes I was in severe pain in my heel and up the side of my leg; it felt like a big thorn was driving into my foot. I asked the villagers there to bring some hot water and I put my foot into it. This seemed not to help at all and soon I was beside myself with the pain. The locals all came to look at the white man in pain, and started discussing how they never walk out at low tide and how if I ever wished to borrow their canoe to get my boat I was welcome. Not wishing to appear impolite, I tried to seem grateful for the offer whilst I urged my mate to unload the gear out of the boat, put the boat back on the mooring and get me home a.s.a.p. Meanwhile the locals had moved on to how one of their friends got nine holes in his foot from the same fish (I had only one hole) and "he was a big strong man but he cried for hours". They discussed local leaf remedies and one disappeared into the bush to find the correct plant. Another offered to urinate on my foot. I had more faith in local anaesthesia (or even amputation by now) so, with assistance, got into the car and my buddy drove me home.

A friend from the hospital (who was in the middle of a bout of malaria so wasn't feeling too chipper himself) met me at my house armed with a bagful of local anaesthetic and morphine. I had continued the hot-water treatment but the pain was extraordinary – 8 out of 10. I was sweating and hyperventilating so my head was starting to spin.

I explained how to perform a sural nerve block on my ankle with the local anaesthetic (Ropivacaine 1% 10 mls), and he injected the area. I barely felt the needle. Within a few minutes I felt the numbness creeping down my foot until it reached the affected area...BLISS! The transformation that came over me was nothing short of miraculous. I still felt a bit rough, but 1000% better than before. Well enough to get the books out and study my nemesis!

That afternoon I felt a bit nauseated and washed out, probably just coming down from the burst of adrenaline. The local anaesthetic wore off about 15 hours later; fortunately the venom wore off some time earlier. For the next few days I just felt like I had a very deep bruise in the foot, with some very minor local swelling. Not much to show for all that pain! Ah...life in paradise.

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Letters to the Editor

Dive computer profile analyses

Dear Editor,

We were very interested to read the recent article by Sayer et al on the analysis of dive computer profiles and calculation of nitrogen loading indices for divers with decompression illness (DCI).[1] We found the concept of using nitrogen loading to quantify the necessary duration of recompression therapy to be a novel idea.

We believe, however, that their methodology and analysis created several biases that may have prematurely led to the rejection of their hypothesis. The first issue is that there were no criteria or a case definition for the diagnosis of DCI used in the study. This issue is encountered in many studies involving DCI, and allows for the inclusion of an unknown number of false-positive cases. False-positive cases (i.e., non-cases of decompression sickness) are not likely to respond to recompression therapy and therefore may receive multiple treatments. Since most dives are exposures with low nitrogen loading, most of the non-cases will also have low nitrogen loading, and therefore a systematic error in favour of the null hypothesis has been introduced. Currently, there is no universally accepted case definition for the diagnosis of decompression sickness (DCS) or arterial gas embolism (AGE). A set of criteria for the diagnosis of DCS and AGE was recently presented in Tokyo, Japan.[2] The use of an objective, validated, highly specific case definition for DCS would largely eliminate the false positives from the data set and reduce the bias in favour of the null hypothesis.

Another bias that may have contributed to the authors' failure to validate their hypothesis was that they did not consider the effects of time to treatment. Patients with prolonged delays between symptom onset and initial treatment have a lower likelihood for rapid recovery. These patients may also require multiple recompression treatments. As stated previously, these cases (like most of the cases in the series) will likely have a low nitrogen load. Yet despite this low calculated nitrogen burden, these patients would likely receive more recompression treatments, thus again creating a systematic bias in favour of the null hypothesis.

Finally, we feel an additional bias is introduced because patients with DCS and AGE were grouped together in the study. The authors use the term decompression illness (i.e., DCS and AGE) to describe their cases. However, AGE is not related to nitrogen loading. As AGE cases can require multiple recompression treatments, once again, this creates a systematic bias favouring the null hypothesis.

We were disappointed to read the authors' conclusions that their model did not perform as expected. However, it still seems their hypothesis has significant merit and may have been rejected prematurely. Perhaps by applying a validated, highly specific case definition of DCS, eliminating cases of AGE, and setting a cut off for time to treatment, results may be obtained that support the authors' original hypothesis. We feel the principles of the authors' hypothesis are sound, and would be excited to see additional work in this area.

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Key words
Decompression illness, computers diving, nitrogen, models, treatment, letters (to the Editor)

Reply:

Dear Editor,

I welcome the opportunity to respond to the very valid and reasoned issues raised by Medak et al in relation to the recent study on analysing the dive computer profiles from divers with actual or suspected decompression sickness.[1]

Although the study started with the premise that cumulative nitrogen loading from the incident and preceding dives could have influenced the type and/or duration of subsequent treatments, it became very obvious that this would not be possible for a number of reasons that I detail below. Therefore, the real value of the study is that it presented a methodology for comparing multi-level computer-controlled dive profiles with empirically-tested square-wave decompression tables. It is clear that this is of value only where the incidents are occurring as a result of a series of repetitive 'incident-free' dives, where it may be difficult for the treating physician to demonstrate to the patient the possible reasons for the eventual treatment or treatments (i.e., that the dives may have been close to or exceeded recognised decompression limits). Where the study was limited, in this respect, is that cumulative nitrogen loading is a very blunt tool for evaluating these profiles. On-loading alone will always overestimate the effect of deep diving, as it ignores the benefits of staged decompression, and it will always underestimate the effects of rapid ascents, where on-loading ceases promptly. Preliminary results from an ongoing study have been reported elsewhere,[2] whereby the nitrogen partial pressures from the incident profiles are modelled with three tissue compartments and with an ambient-to-compartment pressure component. This new approach of computing probabilistic decompression sickness (pDCS) should correct the limitations of the initial analyses within the context of presenting valid and comparable values for each type of profile.

It is accepted that the initial analyses ignored a lot of the clinical data available for the profiles that were examined. This is being addressed in the ongoing study employing probabilistic modelling. As well as comparing pDCS values against the eventual diagnosis, the ongoing study also takes into account the condition of the patient on presentation, the condition on discharge compared with that of presentation and the progression of symptoms. Although time to treatment will be considered, with the possibility of introducing a cut-off time, there is probably little merit in making any prolonged investigation of this feature with such a relatively low sample number. In any case, time to treatment is a multi-factorial dynamic in the management of diving casualties and, therefore, it is too simplistic for Medak et al to make any generic statements on the effect of delayed treatment and likelihood of recovery. Without wishing to get too tied up with what is a highly complex issue, any effects of delay on the eventual treatment will always be influenced by the minimum time delay for divers presenting with the most severe types of illness (i.e., the proximity of the treating facility to the patient catchment) as well as the severity of that illness. It is further complicated by the fact that the severity of illness may dictate the time to treatment through the instantaneous recognition of very obvious and measurable symptoms compared with a diver with minor, self-assessed symptoms. However, I accept that time to treatment itself may not be a very reliable indicator of the severity of presentation across different presenting groups and I agree, therefore, with Medak et al that further study should differentiate between cases of DCS and AGE.

It is reassuring to learn that Medak et al find merit in the general approach to investigating this interesting data set. I can assure them that additional work in this area is continuing and that their comments on the initial study will help influence that ongoing study. It will continue to be of interest to make quantitative assessments of the effects that specific profiles may have on eventual patient treatment and outcome. This is, after all, one of the few areas of medicine where the treating physician is presented with an actual record of the events that caused the patient's illness. In addition, well-classified profiles from incidents of actual DCS that are collated by treating facilities could produce a data depository for use by developers of future decompression models.

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Time to change the Annual Scientific Meetings (ASMs)

Dear Editor,

I have just been reading the September 2005 issue of the *SPUMS Journal* and came across the 10 April Executive Committee Meeting minutes, specifically regarding the ASMs and the recent poor attendance.

Just to add my two cents' worth, I agree that it is time to bring the Annual Scientific Meeting onshore, make it a more serious academic event and attach a separate dive trip. I have attended only the one ASM, in Fiji 2000, and I found it expensive, a poor dive trip because of having to cater for such numbers, a poor family trip because of the lectures in the afternoon and a poor academic meeting because the diving and socialising detracted from the meeting. I was too sleepy to concentrate on the talks, no doubt due to my 'bubble load'!

Make it onshore, make it a quality meeting and I for one would attend regularly. As it stands, I would rather do my diving without getting lectured in the afternoon.

Can you canvas the membership on this?

Dr Richard "Harry" Harris
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PMB 9013, Pt Vila, Vanuatu

Key words
Medical society, meetings, letters (to the Editor)

Editor's reply:

I thank Dr Harris for his thoughts on the Society's ASMs. Their 'traditional' form of many years has been debated at Executive meetings on frequent occasions, whilst a survey of members some years ago gave minimal feedback! There was a lack of interest in 'onshore' meetings in the past, but times have changed. With the new website, another survey of members' views is being seriously considered.

The day-to-day structure, combining diving with a four-hour meeting, is dictated largely by Australian members' wishes to have the meeting fully tax-deductible; changing this would add to the cost. Despite my age, personally I find I cope well with this, provided I largely avoid the 'socialising' (a euphemism for late-night drinking?). This format is much the same as the winter ski conferences so popular in medical continuing education. Many colleagues and I prefer a meeting broken into discrete chunks, rather than sitting in a conference room all day for several days. Organising scientific meetings *is* expensive if you want good guest speakers and a well-organised trip, there is simply no way around this.

I am concerned at the comments on the scientific content of the meeting. The guest speaker at the 2000 ASM was David Elliott, always excellent, which is why we have invited him so often. Others included Des Gorman, Simon Mitchell, Robyn Walker, Paul Thomas, David Taylor, Mike Bennett, Malcolm Le May, Drew Richardson and Rees Jones. There were some good case-based discussions and a vigorous debate on fitness standards for diving. I have to disagree with Dr Harris on this. On one thing we do agree, the diving was mediocre that year, partly due to severe coral bleaching.

What SPUMS needs is ideas and solutions and for members to present their research at our Society meetings, not to publish elsewhere. I look forward to Dr Harris's continued active participation in SPUMS in the future.

Diving-related fatalities resource

The coronial documents relating to diving fatalities in Australian waters up to and including 1998 have been deposited by Dr Douglas Walker for safe keeping in the National Library of Australia, Canberra. Accession number for the collection is: MS ACC 03/38.

These documents have been the basis for the series of reports previously printed in this Journal as Project Stickybeak. They are available free of charge to *bona fide* researchers attending the library in person, subject to an agreement regarding anonymity.

It is hoped that other researchers will similarly securely deposit documents relating to diving incidents when they have no further immediate need of them. Such documents can contain data of great value for subsequent research.

The poetry doctor

Have fun

I'd like to write a prescription
That's never had bad side effects
To help stress of any description
To all races, classes and sex.

It's totally free with no fault.
It's simple for it will just say,
"Take life with a big pinch of salt
One, two, three, four times a day."

For our lives are bustling with hustle,
Underpaid, overworked, overtaxed,
That stimulates spasm of muscle
Which is cured by being relaxed.

Yet I see tension headaches and chest pain,
Irritable bowel with diarrhoea,
Asthma, hypertension and migraine
Which out of the blue do appear.

These people all suffer from tension
Causing spasm that grips and deforms.
These symptoms enhance apprehension
So a downward spiral will form.

My prescription has numerous potions,
Any fun that will so entertain
Or humour dissolved in a lotion
To inject in a jocular vein.

For to laugh releases the pressure,
Defusing the strain and the stress,
Making us feel much fresher,
Untying the knots and duress.

So have fun on a daily basis,
Don't be so serious and grim.
Have some daily "Red Faces",
Act on a whisper or whim.

Be more spontaneous and hasty
Let gravity come to a halt.
Make your life far more tasty
By taking a big pinch of salt.

Christmas is a great opportunity to escape the seriousness of academia, research, teaching or clinical consultation and spend some quality time with family and friends, have fun and frivolity, relax and renew. Take this prescription home and take the full course over the holiday. Failure to complete the course may create a resistant strain (and stress).

John Parker
<www.thepoetrydoctor.com>

Book review

The ECHM Collection, Volume 2

484 pages, hardback
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The *ECHM Collection Volume 2* continues the fine concept and formatting established in the first volume. The ECHM series is a collection of the consensus meetings of the European Committee for Hyperbaric Medicine (ECHM). The current volume covers the 2000 to 2003 meetings, with the judge's final consensus report of the fourth meeting (1998) on "HBO in the treatment of the diabetic foot", which was omitted from the first volume.

The volume begins with the end report of the 4th ECHM congress and is followed by three sections based on the main topics of the concensus meetings:

- Section 2: New indications in hyperbaric oxygen therapy. Malta, 2000.
- Section 3: Hyperbaric oxygen therapy in the treatment of radio-induced lesions in normal tissues. Lisbon, 2001.
- Section 4: Prevention of dysbaric injuries in diving and hyperbaric work. Geneva, 2003.

The second section contains an interesting assessment of several pathologies in which hyperbaric oxygen therapy (HBOT) has been used for treatment, grouped as follows:

- new indications in infectious diseases
- new indications in oncology
- new indications in neurology
- other new indications.

The "New indications in infectious diseases" component mainly looks at conditions in which there is an obvious background to the efficacy of HBOT. It includes intracranial abscesses and anaerobic pleuro-pulmonary infections. Unfortunately, it is not a particularly broad review of the topic and consists mainly of a brief review of the mechanisms and then a report of a case series in each author's facility. The section on oncology looks at HBOT in radio-sensitisation of neuroblastomas and late radiation enterocolitis, which are covered well and a better generalised argument for and against the use of HBOT is presented. The reviews on new indications in neurology cover cerebral palsy and stroke. Both look at the evidence well and explain clearly the problems in performing studies with these particular groups of patients with regards to getting appropriate unbiased outcome data. In the review of stroke, Marroni laments that there probably is a place for HBOT but because of the flawed methodological processes of the studies thus far no definitive statement can be made. There are promising case series for other indications (Crohn's disease, sickle cell disease and retinitis pigmentosa) that may show that HBOT is beneficial in these conditions but further evidence is required.

Section 3 is a much more revealing read. It works in the classical sense of a consensus meeting with a literature review, a basic studies review, clinical studies, then a jury report and consensus review and finally, and quite appropriately, a statement on the direction that future research should take.

The initial meeting is set up for a jury to answer six questions in an evidence-based medicine format. The opening review by Dr David Pasquier is one of the better ones that I have come across. It concentrates particularly on irradiated tissues of the head and neck, pelvis and CNS/peripheral nerves. He very comprehensively goes through all the evidence for the development and then treatment of these often debilitating side effects. The section on head and neck is extremely well done and the author obviously has a firm knowledge of both radiation oncology and treatment modalities for head and neck tumours and delayed radiation problems. The evidence for beneficial effects with other soft tissues with radiation-induced problems is a little less extensive. This is reflected in the shorter sections on these conditions, but nevertheless they are covered well.

The next monograph, on HBOT in radionecrosis, is less helpful. It consists of several tables of summaries of papers that have been published in radionecrosis and HBOT use. The main problem is that the selection of some of the papers seems somewhat 'un-vetted' with papers with sample sizes of one and two patients sitting alongside papers with more appropriate sample sizes. Reviewing these papers in a more structured manner would have helped to establish numbers needed to treat, and better statistical analysis would make each paper's contribution more relevant in the overall context of the other papers.

The following chapters provide some good data on the incidence of late radiation tissue damage as well as the pathophysiology behind the damage. They then look at the effects of HBOT on the damaged tissue with a particular emphasis on osteoradionecrosis and the potential effects of HBOT on the successful insertion of dental implants.

Part three of this section looks at soft-tissue radionecrosis. There seems to be a lot of repetition here with incidence statistics and the nature of treatments already covered in earlier papers, but this is the nature of the consensus format and putting these papers together with individual reviewers. The monograph by Feldmeier on the concern that HBOT may cause cancer development or growth is another piece of well-constructed work well worth reading.

The sixth consensus meeting is presented in Section 4 of the collection. It concentrates on the "Prevention of dysbaric injuries in diving and hyperbaric work". As with most of the consensus meetings there is an established set of five questions, which a jury answers based on presentations of the literature and known research. The first part of this section looks at the value of medical examinations for both recreational and commercial diving professionals. Tetzlaff presents an insightful monograph on the difference between compressed-air work and compressed-air diving. This raises the point as to whether compressed-air workers should be assessed in a different way to commercial divers and showed me personally how limited is the knowledge in this highly complex area of occupational assessment.

The next segment of this section looks at safety management in five different compressed-gas environments:

- professional divers
- compressed-air (non-diving) professionals
- scientific divers
- recreational divers
- hyperbaric therapy attendants.

Each section is presented by a professional safety expert in each of the disciplines and shows the very different concerns that occur with each type of compressed-gas environment.

The next two parts look at decompression modelling and the effects of decompression models on real-life situations. The final part looks at compressed-air workers (caissons and hyperbaric chambers) and whether they need specific safety procedures due to the difference in bubble formation theory compared with commercial divers. All of these arguments are presented clearly and coherently with a good jury summary at the end.

My overall opinion of this volume is that there is a much more clinical hyperbaric emphasis than the first volume, which mirrors the general trend away from diving into more clinical hyperbaric practice throughout the world. The fifth consensus meeting is the gem in this volume, looking at the effects of radiotherapy on the body and the potential benefits (and points at which there is no benefit) of HBOT.

As with the earlier volume, this is an academic book and not for the general reader interested in the field. By their nature, these collections are always going to be slightly out of date. This volume is a significant improvement on the first with better and clearer aims and a more rigorous application of evidence-based medicine in its evaluations. As for the first volume, my only criticism is that the lack of an index and the section division of the page numbers make it a little harder to navigate this book than it should be. A pleasing feature is an improvement in the graphs and diagrams compared with Volume 1, which are now clear and add to the text appropriately.

All in all, a valuable addition to any hyperbaric unit library with a pleasing European emphasis on the state of play of hyperbaric medicine.

Glen Hawkins
Hyperbaric Fellow, Prince of Wales Hospital, Sydney

Key words
Medical society, meetings, diving, decompression illness, safety, treatment, osteoradionecrosis, hyperbaric oxygen, book reviews

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The world as it might be

Drinking and diving, perhaps more is better?

Alf Brubakk and Michael Bennett

Introduction

We have previously shown that there is an inverse relationship between surface tension in serum and bubble formation.[1] We have also shown that exercise performed 20 hours before a dive will significantly reduce bubble formation both in the rat and in man.[2,3] We have further shown that this effect is related to nitric oxide (NO) production.[4] It is known that ethanol is able to up-regulate NO production,[5] and that binge drinking is associated with an increase in NO metabolites.[6]

Aim

To determine if ethanol, which both reduces surface tension and increases NO production, in sufficient quantities would prevent bubble formation following a dive and thus give scientific credence to the common practice of serious drinking the day before the dive.

Methods

For this study, a group of Norwegian and Australian divers were selected due to their known affinity for serious drinking. Twenty divers of both sexes (12 men and 8 women) aged 25–40 years (mean 31 ± 7 years) participated in the drinking group (DD) while a matched group of 18 divers (10 men and 8 women) who never used alcohol (SD) served as controls. The divers did not eat or drink prior to the test. A blood sample for measuring haematocrit and surface tension was obtained before the test. The DD group drank whiskey (Laphroaig™ Single Malt, 10 years old) using the protocols outlined by Wilson et al,[7] while the SD group drank similar quantities of a hypertonic salt solution to obtain the same level of dehydration. After 90 minutes of drinking another blood sample was obtained.

The divers were then compressed in pairs (SD/DD) to 280 kPa at a rate of 100 kPa.min-1, breathing air. After 80 minutes at depth, they were decompressed at a rate of 100 $kPa.min^{-1}$ following the USN diving procedure. On arrival at the surface, both divers were placed in a supine position and were monitored for a period of 90 minutes using cardiac ultrasound. Gas bubbles were seen as bright spots (painful to the eyes of one investigator) in the images and were evaluated using the method of Eftedal and Brubakk.[8] After lengthy discussion the protocol was approved by the ethical committee (Figure 1).

Figure 1
The Ethics Committee in Trondheim get their first look at the experimental protocol

Results

Recruitment for the control group was very slow because of difficulties finding volunteers who satisfied the inclusion criteria; this was not the case in the DD group. There were no significant differences in the haematocrit and surface tension in the two groups prior to the dive (data not shown).

The DD group became reasonably drunk (Figure 2), as is documented by the fact that their blood alcohol level was 1.4 ± 0.3 $oo.oo^{-1}$. Following the dive, surface tension was increased by 8.2% in the DD group vs 3.1% in the SD group; this difference was significant. The DD group had a median bubble grade of 3, vs 1.5 in the SD group.

ARRESTS

There were two arrests in the DD group following an incident at a local bar after the dive. One volunteer was convicted of performing a lewd act at the bar despite his reasonable explanation that he was only trying to manually inflate the barmaid's buoyancy control device; an example of the perceptual distortion noted in this group (Figure 3).

DECOMPRESSION ILLNESS

One volunteer in group SD was treated for Type I decompression sickness four hours after completing the test profile. All volunteers in the DD group complained of headaches and nausea on day 1 post dive.

PREGNANCY

There were no unwanted pregnancies recorded from either group.

Figure 2
Escorted DD subject

Figure 3
Some divers in group DD reported various perceptional distortions

Conclusions

This study has demonstrated that alcohol in sufficient quantities will indeed reduce bubble formation. Nevertheless, it is questionable whether it will increase diving safety. The empirical dive procedures used by many experienced divers and that have also been demonstrated at numerous conferences, for example SPUMS ASMs, appear to have a scientific basis. However, the results of this study should be considered only in parallel with the seminal paper on technical drinking by Wilson et al.[7] Once again, the cumulative effects of bar pressure cannot be understated, and the need for medical personnel to be present needs reaffirmation. There may also be negative social consequences if this regimen is widely promulgated. Any adoption of the experimental approach should be considered only after a comprehensive, large, multi-centre, randomised trial. Obviously only one group will be blind.

Acknowledgments

The whisky was generously donated by a benefactor whose identity we have promised not to divulge. This study was definitely not supported by SPUMS, EUBS or UHMS.

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Alf Brubakk, Department of Circulation and Medical Imaging, Norwegian University of Science and Technology, Trondheim, Norway
Michael Bennett, Hyperbaric Medicine Unit, Prince of Wales Hospital, Sydney, Australia

Mike and Alf demonstrate once again their inability to take life too seriously and wish all *SPUMS Journal* readers "***en riktig god jul med håp om at denne artikkelen kan gi inspirasjon til mange "sikre" dykketurer i 2006.***"

SPUMS

Annual Scientific Meeting 2006

3rd – 10th June 2006

The Pearl South Pacific
Pacific Harbour, Fiji

www.thepearlsouthpacific.com

"Something Old, Something New ..."

Convenor: Dr Chris Acott

c/-: 30 Park Avenue
Rosslyn Park SA 5072
AUSTRALIA

Ph: +61 41 2618417

Em: cacott@optusnet.com.au

REGISTER NOW FOR WHAT WILL BE A FIRST-CLASS MEETING

SPUMS ANNUAL SCIENTIFIC MEETING 2007

Preliminary Announcement

Dates: 16 to 22 April 2007
Venue: Oceans Resort, Tutukaka, Northland, New Zealand

Co-convenors: Mike Davis and Simon Mitchell

Preliminary Theme
From mountain high to ocean deep
The physiological challenges of extreme environments

Further information will appear in the June 2006 issue of the Journal

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ELEVENTH ANNUAL ADVANCED HYPERBARIC MEDICINE SYMPOSIUM

Dates: 23 to 25 March 2006
Venue: Columbia, Ohio

An internationally respected faculty will represent basic science, clinical research, evidence-based medicine and 'best practice' disciplines. We look forward to welcoming you to Columbia in March!

For additional information:
Dick Clarke, President
National Baromedical Services,
5 Richland Medical Park, Columbia, SC 29203, USA
Phone: +1-803-434-7101
Fax: +1-803-434-4354
Website: <www.baromedical.com/hbo2006>

UNDERSEA and HYPERBARIC MEDICAL SOCIETY
Annual Scientific Meeting 2006

Dates: 22 to 24 June 2006
Venue: Hilton in the Walt Disney World Resort
Orlando, Florida
For additional information:
Lisa Wasdin
c/o Undersea and Hyperbaric Medical Society
PO Box 1020, Dunkirk, Maryland 20754, USA
Phone: +1-410-257-6606 extn 104
Fax: +1-410-257-6617
E-mail: <lisa@uhms.org>

AUSTRALIA AND NEW ZEALAND HYPERBARIC MEDICINE GROUP OF SPUMS

Introductory Course in Diving and Hyperbaric Medicine

Dates: 27 February to 10 March 2006
Venue: Prince of Wales Hospital, Sydney, Australia

Course content includes:
- History of hyperbaric oxygen
- Physics and physiology of compression
- Accepted indications of hyperbaric oxygen (including necrotising infections, acute CO poisoning, osteoradionecrosis and problem wound healing)
- Wound assessment including transcutaneous oximetry
- Visit to HMAS Penguin
- Marine envenomation
- Practical sessions including assessment of fitness to dive

Contact for information: Ms Gabrielle Janik, Course Administrator
Phone: +61-(0)2-9382-3880
Fax: +61-(0)2-9382-3882
E-mail: <janikg@sesahs.nsw.gov.au>

EUROPEAN UNDERWATER AND BAROMEDICAL SOCIETY

32nd Annual Scientific Meeting 2006

Dates: 23 to 26 August 2006
Venue: Radison SAS Hotel Norge, Bergen, Norway

Scientific Secretary: Prof Einar Thorsen, Haukeland University Hospital, Bergen

For additional information contact:
FJELL OG FJORD KONFERANSER AS
E-mail: <silje@fjellogfjord-konferanser.no>
Website: <www.eubs.org>

Emile Gagnan and the Aqua-Lung 1948–58
Historical Diver Magazine. Winter 2005; 13(1): No. 42.

This issue of the Historical Diving Society's magazine is devoted almost entirely to an interesting and detailed account, written by Phil Nuytens, of Emile Gagnan's largely unrecognised engineering contributions to the development of the Aqua-Lung. It includes much previously unpublished detail and an illustrated listing of early Aqua-Lung regulators.
Contact: <bob@hyperbarichealth.com>

THE UNIVERSITY OF AUCKLAND
FACULTY OF MEDICAL AND HEALTH SCIENCES

Master of Medical Science
Postgraduate Diploma in Medical Science
Diving and Hyperbaric Medicine

Enquiries from registered medical practitioners are now being accepted for 2006 for the Masters and Postgraduate Diploma programmes in diving and hyperbaric medicine.
Faculty: Des Gorman, Michael Davis (Course Director), Simon Mitchell, Chris Acott, Kathleen Callaghan, William Baber and Drew Richardson.
Overview: These are distance-learning programmes, available internationally without a resident component in Auckland. However, attendance at a recognised short course in diving medicine is a prerequisite. Graduates will be able to practise effective clinical diving medicine in a primary care setting or to embark on clinical practice within a hyperbaric medicine environment.

The course titles for the Diploma programme are:
- Physiology and medicine of diving (obligatory)
- Health surveillance of divers and hyperbaric workers
- Hyperbaric medicine
- Clinical diving and hyperbaric practice (based at a recognised host hyperbaric unit)
- Research essay in diving or hyperbaric medicine
- Research project in diving or hyperbaric medicine

Information on Masters programmes available on request.

For further information, including fees, please contact the Course Coordinator: Jessica Rorich
Phone: +64-(0)9-373-7599, extn 88489
Fax: +64-(0)9-308-2379
E-mail: <j.rorich@auckland.ac.nz>
Web: <http://www.health.auckland.ac.nz/study/postgrad/subjects/Diving_and_Hyperbaric_Medicine.html>

Full information on courses and admission regulations is available in the University of Auckland Calendar or online <http://www.auckland.ac.nz>

ANZ COLLEGE OF ANAESTHETISTS ANNUAL SCIENTIFIC MEETING
Preliminary Notice

Date: 13 to 17 May 2006
Venue: Adelaide Convention Centre, South Australia
Hyperbaric Special Interest Group session
- Iatrogenic cerebral arterial gas embolism
- Cost analysis of HBOT

For further information contact:
Dr Margaret Walker <margaret.walker@dhhs.tas.gov.au>

ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE COURSES 2006

Medical Officers Course

June/July 2006

Basic	26/06/06	to	30/06/06
Advanced	03/07/06	to	07/07/06

October/November 2006

Basic	23/10/06	to	27/10/06
Advanced	30/10/06	to	03/11/06

DMT Full Course

February/March 2006 3 weeks, 13/02/06 to 03/03/06
October 2006 3 weeks, 9/10/06 to 27/10/06

DMT Refresher Course

To be announced

For further information or to enrol contact:
The Director, Hyperbaric Medicine Unit
Royal Adelaide Hospital, North Terrace
South Australia 5000 or
Phone: +61-(0)8-8222-5116
Fax: +61-(0)8-8232-4207
E-mail: <Lmirabel@mail.rah.sa.gov.au>

ROYAL AUSTRALIAN NAVY MEDICAL OFFICERS' UNDERWATER MEDICINE COURSE 2006

Dates: 06 to 17 February 2006
Venue: HMAS Penguin, Sydney

The Medical Officers' Underwater Medicine Course seeks to provide the medical practitioner with an understanding of the range of potential medical problems faced by divers. Considerable emphasis is placed on the contraindications to diving and the diving medical, together with the pathophysiology, diagnosis and management of the more common diving-related illnesses.

Cost: $1833.00 (tbc)

For information and application forms contact:
The Officer in Charge, Submarine & Underwater Medicine Unit, HMAS PENGUIN,
Middle Head Rd, Mosman, 2088 NSW, Australia
Phone: +61-(0)2-9960-0572
Fax: +61-(0)2-9960-4435
E-mail: <Sarah.Sharkey@defence.gov.au>

Instructions to authors

(**revised June 2005**)

The *SPUMS Journal* welcomes contributions (including letters to the Editor) on all aspects of diving and hyperbaric medicine. Manuscripts must be offered exclusively to the *SPUMS Journal*, unless clearly authenticated copyright exemption accompanies the manuscript. All manuscripts, including SPUMS Diploma theses, will be subject to peer review. Accepted contributions will be subject to editing.

Contributions should be sent to:
The Editor, SPUMS Journal,
C/o Hyperbaric Medicine Unit, Christchurch Hospital,
Private Bag 4710, Christchurch, New Zealand.
E-mail: <spumsj@cdhb.govt.nz>

Requirements for manuscripts

Documents should be submitted electronically on disk or as attachments to e-mail. The preferred format is Word 97 for Windows. Paper submissions will also be accepted. All articles should include a **title page**, giving the title of the paper and the full names and qualifications of the authors, and the positions they held when doing the work being reported. Identify one author as correspondent, with their full postal address, telephone and fax numbers, and e-mail address supplied. The text should be subdivided into the following sections: an **Abstract** of no more than 250 words, **Introduction**, **Methods**, **Results**, **Discussion**, **Acknowledgements** and **References**. Acknowledgments should be brief. References should be in the format shown below. Legends for tables and figures should appear at the end of the text file after the references.

The text should be double-spaced, using both upper and lower case. Headings should conform to the current format in the *SPUMS Journal*. All pages should be numbered. Underlining should not be used. Measurements are to be in SI units (mmHg are acceptable for blood pressure measurements) and normal ranges should be included.

The preferred length for original articles is 3,000 words or less. Inclusion of more than five authors requires justification as does more than 30 references per major article. Case reports should not exceed 1,500 words, with a maximum of 10 references. Abstracts are also required for all case reports and review papers. Letters to the Editor should not exceed 500 words (including references, which should be limited to five per letter). Legends for figures and tables should generally be less than 40 words in length.

Illustrations, figures and tables should not be embedded in the wordprocessor document, only their position indicated. No captions or symbol definitions should appear in the body of the table or image.

Tables are to be in Word for Windows, tab-separated text rather than using the columns/tables option or other software and each saved as a separate file. They should be double-spaced and each in a separate file. No vertical or horizontal borders are to be used.

Illustrations and figures should be in separate files in TIFF or BMP format. Our firewall has a maximum size of 5 Mb for incoming files or messages with attachments.

Photographs should be glossy, black-and-white or colour. Posting high-quality hard copies of all illustrations is a sensible back-up for electronic files. Colour is available only when it is essential and may be at the authors' expense. Indicate magnification for photomicrographs.

Abbreviations may be used once they have been shown in brackets after the complete expression, e.g., decompression illness (DCI) can thereafter be referred to as DCI.

References

The Journal reference style is the 'Vancouver' style *(Uniform requirements for manuscripts submitted to biomedical journals*, updated July 2003. Web site for details: <http://www.icmje.org/index.html>). In this system references appear in the text as superscript numbers at the end of the sentence and after the full stop.[1,2] The references are numbered in order of quoting. Index Medicus abbreviations for journal names are to be used (<http://www.nlm.nih.gov/tsd/serials/lji.html>). Examples are given below:

1 Freeman P, Edmonds C. Inner ear barotrauma. *Arch Otolaryngol.* 1972; 95: 556-63.
2 Hunter SE, Farmer JC. Ear and sinus problems in diving. In: Bove AA, editor. *Bove and Davis' Diving Medicine*, 4th ed. Philadelphia: Saunders; 2003. p. 431-59.

There should be a space after the semi-colon and after the colon, and a full stop after the journal and the page numbers. Titles of quoted books and journals should be in italics. Accuracy of the references is the responsibility of authors.

Any manuscript not complying with these requirements will be returned to the author before it will be considered for publication in the *SPUMS Journal*.

Consent

Studies on human subjects must comply with the Helsinki Declaration of 1975 and those using animals must comply with National Health and Medical Research Council Guidelines or their equivalent. A statement affirming Ethics Committee (Institutional Review Board) approval should be included in the text. A copy of that approval should be available if requested.

Copyright

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DIVER EMERGENCY SERVICES PHONE NUMBERS

AUSTRALIA
1-800-088-200 (in Australia)
+61-8-8212-9242 (International)
The toll-free number 1-800-088-200 can only be used in Australia

NEW ZEALAND
0800-4-DES111 or 09-445-8454 (in New Zealand)
+64-9-445-8454 (International)
The toll-free number 0800-4-DES111 can only be used in New Zealand

The DES numbers are generously supported by DAN-SEAP

PROJECT STICKYBEAK

This project is an ongoing investigation seeking to document all types and severities of diving-related accidents. Information, all of which is treated as being **CONFIDENTIAL** in regards to identifying details, is utilised in reports and case reports on non-fatal cases. Such reports can be freely used by any interested person or organisation to increase diving safety through better awareness of critical factors.

Information may be sent (in confidence) to:
Dr D Walker
PO Box 120, Narrabeen, NSW 2101, Australia.

DIVING INCIDENT MONITORING STUDY (DIMS)

DIMS is an ongoing study of diving incidents. An incident is any error or occurrence which could, or did, reduce the safety margin for a diver on a particular dive. Please report anonymously any incident occurring in your dive party. Most incidents cause no harm but reporting them will give valuable information about which incidents are common and which tend to lead to diver injury. Using this information to alter diver behaviour will make diving safer.

Diving Incident Report Forms (Recreational or Cave and Technical)
can be downloaded from the DAN-SEAP website: <www.danseap.org>
They should be returned to:
DIMS, 30 Park Ave, Rosslyn Park, South Australia 5072, Australia.

PROJECT PROTEUS

The aim of this investigation is to establish a database of divers who dive or have dived with any medical contra-indications to diving. At present it is known that some asthmatics dive and that some insulin-dependent diabetics dive. What is not known is how many. How many with these conditions die is known. But how many dive safely with these conditions is not. Nor is the incidence of diving accidents in these groups known.
This project is under the direction of Dr Douglas Walker and Dr Mike Bennett. The investigation has been approved by the Ethics Committee of the Prince of Wales Hospital, Randwick, approval number 01/047.

If you are in such a group please make contact. All information will be treated as CONFIDENTIAL. No identifying details will appear in any report derived from the database.

Write to: Project Proteus
PO Box 120, Narrabeen, NSW 2101, Australia.
E-mail: <diverhealth@hotmail.com>

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