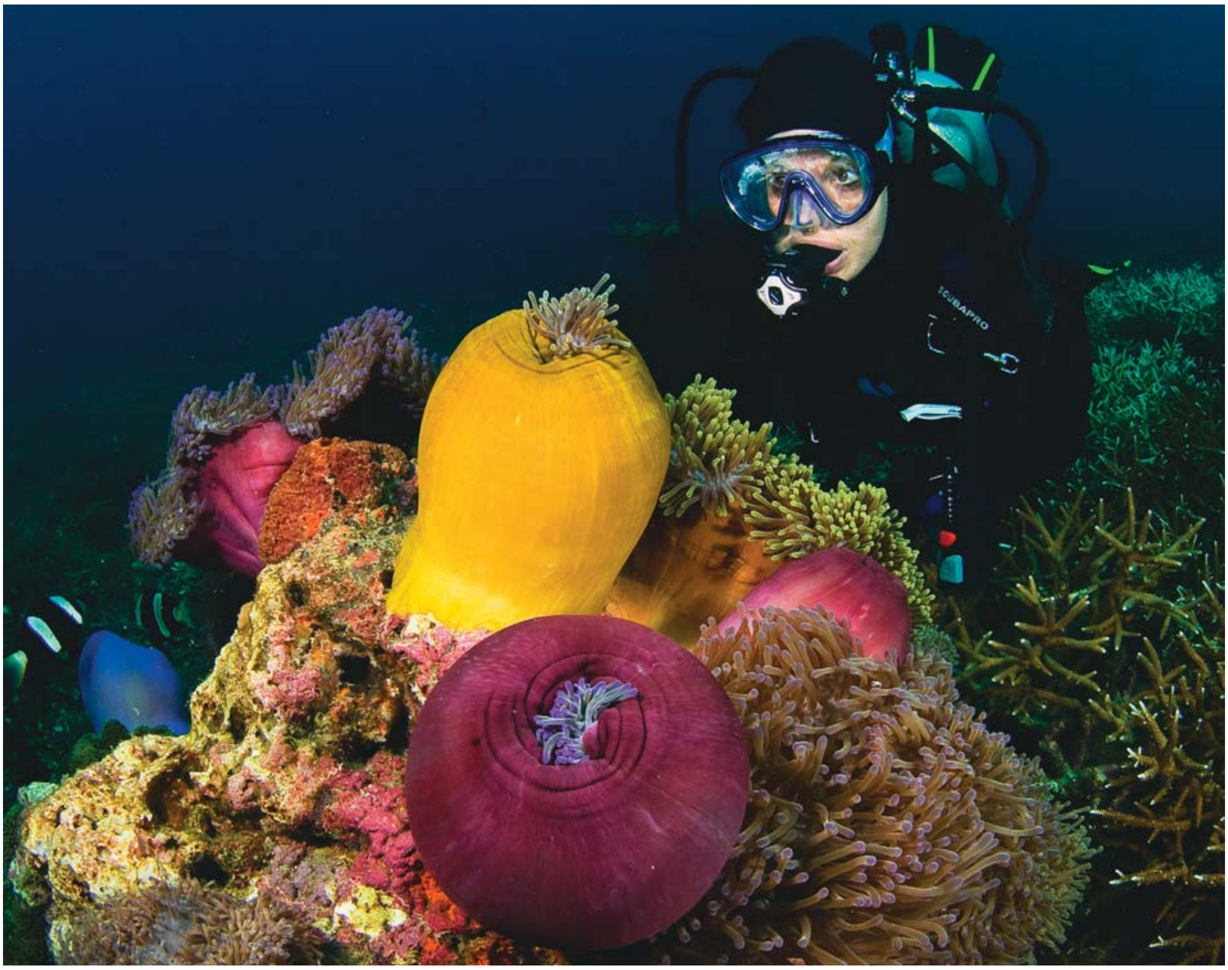
Diving and Hyperbaric Medicine

The Journal of the South Pacific Underwater Medicine Society (Incorporated in Victoria) A0020660B and the European Underwater and Baromedical Society

Volume 40 No. 3 September 2010



'Fit to dive' – what does it mean?

Questionnaires or full medicals – does it matter?

The revised SPUMS diving medical is launched

Nitrox does reduce fatigue compared to air

Australian diving fatalities 2005

ISSN 1833 - 3516
ABN 29 299 823 713

Print Post Approved
PP 331758/0015

PURPOSES OF THE SOCIETIES

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 and to convene members of each Society annually at a scientific conference

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY

MEMBERSHIP

For details of the different types of SPUMS membership and further information on the Society, or to complete a membership application, go to the Society's **website:**
<www.spums.org.au>

The official address for SPUMS is:
c/o Australian and New Zealand College of Anaesthetists,
630 St Kilda Road, Melbourne,
Victoria 3004, Australia

EUROPEAN UNDERWATER AND BAROMEDICAL SOCIETY

MEMBERSHIP

For further information on EUBS and to complete a membership application go to the Society's **website**:
<www.eubs.org>

DIVING and HYPERBARIC MEDICINE
The Journal of SPUMS and EUBS
<www.dhmjournal.com>

Editor and Publisher:
Michael Davis <editor@dhmjournal.com>
c/- Hyperbaric Medicine Unit
Christchurch Hospital, Private Bag 4710
Christchurch, New Zealand
Phone: +64-(0)3-364-0045 or (0)3-329-6857
Fax: +64-(0)3-364-0817 or (0)3-329-6810
European Editor:
Peter Müller <peter.mueller@eubs.org>

The Editor's offering

This issue focuses on the medical assessment of sport divers and on diving fatalities, to a proportion of which medical problems contribute. As the contents were being assembled, the British diving magazine, *Diver*, reported on the first six UK fatalities for 2010. One victim was aged 41, and the others between 54 and 67 years old. Most were experienced divers who "*got into difficulties*", or some similar phrase, at depth, during ascent or on the surface. The reports are, at this stage, flimsy, but medical problems were mentioned in a couple, and one wonders just how much fitness, in its broadest sense, had an impact on events.

The UK Maritime and Coastguard Agency recently published their 2009 diving report, comprising 212 diving incidents, including 14 fatalities. More than a third of the divers involved were over 50 years old, and 38 (18%) incidents may have arisen from underlying medical conditions. The British Sub-Aqua Club reports 16% of UK divers are aged over 50, but in recent years have contributed over half the fatalities. The data from Diver Alert Network (DAN) members also show a marked age-related increase in mortality for both sexes.[1] The over-50s constituted 31% of the fatalities between 2000 and 2006; deaths associated with cardiac incidents being 12.9 times more likely in this group compared to those under 50 years old.

So, should older divers hang up their fins? A Florida dive operator summed it up succinctly "*They're certified divers, they have a right to dive.* [The dive operator] *cannot nor should not be responsible for the health of divers. It is an extreme sport.*" This is reinforced by Joel Dovenbarger at DAN, who comments that "*the responsibility for maintaining personal health remains with the individual, as well as the reassessment of fitness after illness, injury, or the effects of aging*." Also, the trend for increasing fatality rates amongst older participants is not confined to diving, but is seen in a variety of other sporting activities, and may simply reflect an increased participation in sport by the elderly.

At a recent DAN workshop (unpublished), how best to screen older divers for cardiovascular risk was debated, but no easy answers were found. One can have a normal stress echocardiogram and still have important underlying coronary artery disease. In the occupational diving context, a 2004 Health and Safety Executive workshop concluded that "*no single 'ideal' exercise test exists which can measure aerobic and physical demands of diving...*"[2]

This needs to be balanced against the fact that many divers, not just the elderly, do not exercise regularly or adequately to maintain scuba diving fitness, whatever that term might encompass. And here is the conundrum: what is the appropriate level of fitness for a recreational scuba diver? Is it the same for a dry-suited technical diver doing a deep wreck dive in cold water as it is for a tourist in Thailand on a shallow coral reef, in warm, calm, crystal-clear tropical waters? Do both need to be prepared for an extreme emergency underwater? Do the dive training agencies place sufficient emphasis on physical fitness as an important component of diving safety in their training programmes? Does an entry-level diving medical assessment contribute usefully to this in any way whatsoever? Many questions, and as many answers as there are divers and diving physicians! The central issue here is 'diving fitness' rather than medical 'fitness to dive'.

The new ISO standard for recreational diving is about to be adopted in Australia. This essentially adopts the Recreational Scuba Training Council health questionnaire. The Australian Standard 4005.1-2002 has now lapsed and will not be reviewed, mainly because the recreational diving industry sees no need for it and will not fund a review, preferring to adopt the ISO standard. However, the health requirements of the ISO recreational diving standard are lower than those that applied with AS4005.1. They are also well short of the internally controversial position taken by SPUMS, as outlined by Bennett in his editorial in this issue, that **all** prospective scuba divers should have a medical interview and physical examination prior to commencing scuba diving.[3]

At another extreme, coroners throughout Australia and New Zealand have been calling for stricter standards for diving medical screening and in Queensland, of course, medical examination of the recreational diver is on the statute book. Some see a potential for legislative control being imposed on sport diving, rather than the sensible voluntary system that has existed up till now in Australasia.

Thus, we face a confused situation, from an increasingly permissive milieu, backed by only modest epidemiology, to legislative control as in Queensland. Where the answer finally lies remains to be seen, but at least all parties appear to accept that some form of medical screening is essential. This writer, for now, still holds to the worth of a risk-management-based medical interview for all entry-level divers.

References

1 Denoble PJ, Pollock NW, Vaithiyanathan P, Caruso JL, Dovenbarger JA, Vann RD. Scuba injury death rate among insured DAN members. *Diving and Hyperbaric Medicine*. 2008;38:182-8.
2 Evans G, Smith J. *HSE workshop on exercise testing for divers*, HSL2004/10. Sheffield: Health & Safety Laboratory; 2004.
3 Bennett M. The SPUMS diving medical. *Diving and Hyperbaric Medicine*. 2010;40:150-1.

Michael Davis

The front-page photo was taken by Dr Simon Mitchell at Redang, Malaysia. The SPUMS Secretary, Sarah Lockley, admires several large, colourful anemones, probably ***Heteractis magnifica***.

Original articles

Evaluation of critical flicker fusion frequency and perceived fatigue in divers after air and enriched air nitrox diving

Pierre Lafère, Costantino Balestra, Walter Hemelryck, Nicola Donda, Ahmed Sakr, Adel Taher, Sandro Marroni and Peter Germonpré

Key words
Scuba diving, air, enriched air – nitrox, nitrogen narcosis, inert gas narcosis, performance, visual analog scale

Abstract
(Lafère P, Balestra C, Hemelryck W, Donda N, Sakr A, Taher A, Marroni S, Germonpré P. Evaluation of critical flicker fusion frequency and perceived fatigue in divers after air and enriched air nitrox diving. *Diving and Hyperbaric Medicine*. 2010;40(3):114-8.)

Introduction: Many divers report less fatigue following dives breathing enriched air nitrox (EANx) compared with breathing air. A reduction of post-dive fatigue with EANx would suggest a pathological origin, possibly the presence of asymptomatic nitrogen bubbles in the body after a dive.

Method: We studied fatigue in 219 healthy divers performing either an air (n = 121) or EANx32 (oxygen 32%, nitrogen 68%; n = 98) dive to 21.2 ± 4 metres' sea water for 43.3 ± 8.6 minutes in tropical open-water conditions. Divers were assessed pre-dive and 30–60 minutes after surfacing using a visual analog scale (VAS) of fatigue and critical flicker fusion frequency (CFFF).

Results: The two groups were comparable in sex ratio, age and diving experience. The change in perceived fatigue level after a single dive was significantly lower when EANx was breathed compared to air dives (VAS; $P < 0.001$). Compared to pre-dive, CFFF decreased by 6% in the air group ($P < 0.01$) but increased by 4% in the EANx group ($P < 0.05$). The post-dive difference between the two groups was highly significant ($P < 0.001$).

Conclusions: Three hypotheses should be considered to explain the difference in post-dive fatigue and alertness between the air and EANx groups: a nitrogen effect, an oxygen effect and a bubble effect. These involve complex phenomena in the functional modifications of the nervous system in hyperbaric environments according to the type of gas used for the dive, and more research will be required to elucidate them.

Introduction

Within recreational scuba diving, air is the most commonly used breathing gas, but since its introduction to the diving community in 1985, the use of enriched air nitrox (EANx: any gas combination of oxygen and nitrogen where the oxygen fraction is greater than 21%) has become widespread. In some diving centres it is now almost impossible to obtain an 'air-only' fill.

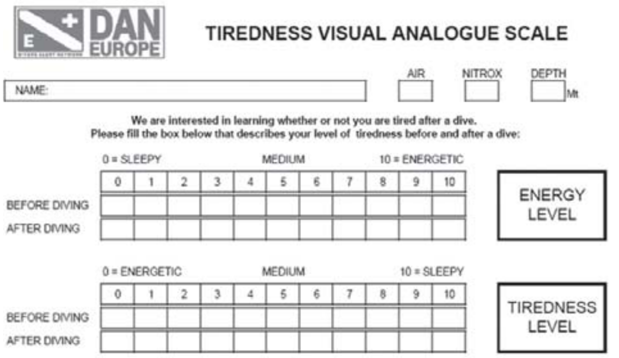
Because of the reduced nitrogen fraction, the main advantage of EANx diving lies in longer bottom times without additional decompression requirements, compared to an air dive at the same depth. The diving community also attributes several other, unproven benefits to EANx use, such as lower gas consumption (due to the higher percentage of oxygen in the mix) and reduced severity of any barotrauma (improved circulation due to high blood oxygenation and lower nitrogen level, implying fewer nitrogen bubbles). The reduced level of nitrogen has also been claimed to reduce feelings of tiredness or fatigue following a dive.[1]

Although multifactorial, fatigue may be an important symptom as it can be a manifestation of decompression stress or decompression sickness (DCS).[2,3] A reduction of post-dive fatigue by the use of EANx would suggest a pathological origin for this fatigue, ascribed to the presence of asymptomatic nitrogen bubbles in the body after a dive.[4] For the time being, there are only anecdotal reports of reduced fatigue with EANx, while one controlled study with simulated (dry chamber) dives showed no measurable difference in fatigue, attention levels or ability to concentrate.[5,6] An objective, in-the-field measurement tool is thus needed to verify this assertion and evaluate the neuropsychometric effects, if any, of diving with air or EANx. We report a field study using a visual analog scale (VAS) of fatigue and a critical flicker fusion frequency (CFFF) test in a large group of divers.

Methods

After ethical approval and written informed consent, 301 healthy divers (97 female, 204 male) volunteered for this study, which was carried out at Sharm-El-Sheikh, Egypt, over a two-month period. All volunteers were certified divers and assessed fit to dive prior to entry into the study. Because of the measurement method used (see below), divers with visual impairment were excluded unless they used their

Figure 1
Visual analog scale presented twice in opposite directions: one evaluates the 'energy level' (from sleepy/0 to energetic/10), the other evaluates the 'tiredness level' (from energetic/0 to sleepy/10)



correction lenses during the test. Divers using medications such as steroids, benzodiazepines, barbiturates, or any other psychoactive drugs were also excluded.

Participants were asked not to drink any alcohol- or caffeine-containing beverages before and after the dive. Each subject performed a single dive at least 12 hours after any previous dives, breathing either air or EANx32 (32% oxygen, 68% nitrogen). No diving restrictions were imposed except for a maximum depth of 30 metres' sea water (msw), required by local Egyptian law. All divers performed a multi-level dive, in the nitrox group ranging from 14 to 29 msw, with a total immersion time between 32 and 69 minutes, and in the air group between 12 and 28 msw, with a total immersion time between 31 and 71 minutes.

Decompression was made according to each diver's personal dive computer. When diving with EANx, the dive computer was set for an EANx32 mix. Although many different dive computers were used, dive profiles were similar and decompression was most often limited to a single safety stop of 5 minutes at 5 msw.

Fatigue was assessed before and 30–60 minutes after the dive using a 100 mm visual analog scale (VAS). In order to test the attention and comprehension of the diver, the same scale was presented twice but in opposite directions: one asked to evaluate the 'energy level' (from sleepy/0 to energetic/10), the second asked to evaluate the 'tiredness level' (from energetic/0 to sleepy/10) (Figure1). After the first evaluation, 71 divers were excluded because of lack of coherence in the results, possibly due to difficulties in comprehension, language problems or complacency in doing the test.

Alertness was tested using critical flicker fusion frequency (CFFF), defined as "*the frequency to which a stimulus of intermittent light seems to be completely stable to the observer*".[7,8] The device used was designed and built by Human Breathing Technology (HBT Technology, Trieste, Italy), specifically for this project and future underwater use. In brief, the waterproof device consists of a rotating ring, surrounding a short cylindrical housing of 8 cm diameter containing the numeric (digital) frequency indicator. Attached to this waterproof housing is a flexible cable, to whose end is attached a single blue LED (Light Emitting Diode – 8000 K) enclosed in a smaller cylindrical container (so as to shield it from stray light and reflections). While the subject to be tested is looking straight at the LED at a distance of 50 cm, the investigator turns the dial slowly clockwise in order to increase (fuse) the flicker frequency. When the test subject indicates that no more flickering is perceived, the value is noted by the investigator. As there are no markings on the dial, nor a visible 'starting position', the test subject has no indication whatsoever of the actual flicker frequency of the LED. This test was repeated three times from flickering to fusion, and the mean value was noted as the CFFF. When the three results differed more than 5% from one another, the result was rejected as aberrant. Another 11 divers were excluded for aberrant results leaving a total of 219 divers for analysis.

Standard statistical analysis was performed, including means and standard deviations, and ANOVA for repeated measures to test the between- and within-subjects effect after Kolmogorov-Smirnov test for normality of distribution. The researchers who analysed the data were blinded to the condition of the diver (air or EANx). GraphPad Prism version 5.00 for Windows (GraphPad Software, San Diego, California, USA) was used on a personal computer. Taking the initial value as 100%, procentual variations were calculated for each parameter (VAS, CFFF), allowing an appreciation of the magnitude of change rather than the absolute values. A probability of <0.05 was considered statistically significant.

Results

Divers' demographic and dive data are presented in Table 1. With regard to the dive performed, the EANx group had, on average, slightly deeper and longer dives than the air group ($P > 0.05$, one way ANOVA).

Table 1
Divers' demographics with diving experience and dive parameters (all subjects), SD in parenthesis

Demographics	**Air** (n = 121)	**EANx** (n = 98)
Sex ratio (♂/♀)	77/44	68/30
Age (years)	44.9 (11.8)	44.7 (11.1)
Diving experience		
Total years	8.2 (6.2)	6.2 (5.5)
Total logged dives	352 (347)	322 (524)
Depth (msw)	20.4 (4.3)	21.9 (3.8)
Dive duration (min)	42.5 (7.9)	44.2 (9.3)

Figure 2
Procentual variation of the visual analog scale of perceived fatigue (*P* **< 0.01, ns - not significant)**

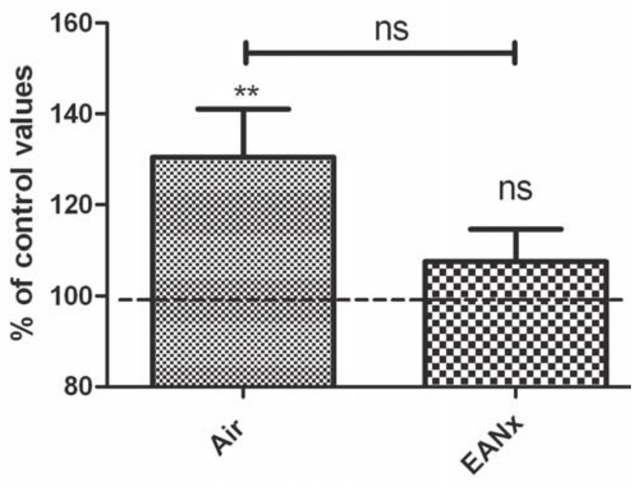


Figure 3
Procentual variation of critical flicker fusion frequency (* *P* **< 0.001;** *P* **< 0.01; *** *P* **< 0.05)**

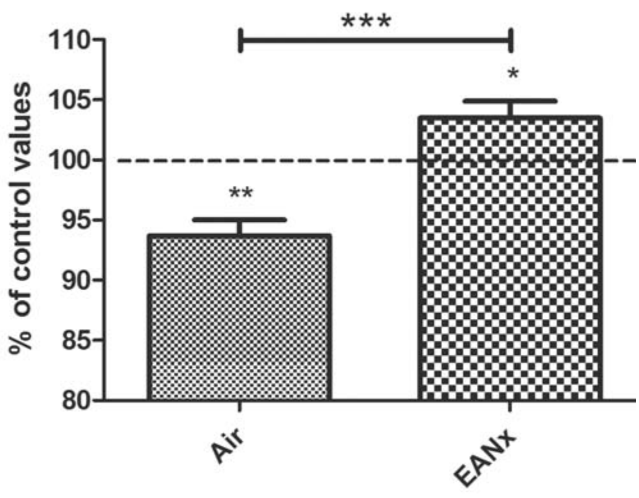


Figure 2 shows the results of the VAS evaluation. It can be seen that the perceived fatigue is significantly higher after the air dives compared to pre-dive ($P < 0.001$, two-tailed paired t test, t = 1.872). On the other hand, the difference between pre- and post-dive breathing EANx was not significant. Figure 3 shows the results of the CFFF, in which the difference was significant. It was decreased 6% in the air group but increased 4% in the EANx group post-dive. ($P < 0.01$ and $P < 0.05$ respectively). The difference between the two groups was highly significant ($P < 0.001$, one-way ANOVA).

Discussion

As the visual analog scale is a widely used and validated measure of subjective sensation, such as pain and fatigue, it should be the ideal tool for quantifying and comparing divers' self-reported fatigue.[9,10] This method has been used in two previous studies that have, however, produced conflicting results.

In the first study, a simulated dry dive in a hyperbaric chamber was performed, controlled for depth, bottom time, decompression rate, temperature and physical exertion.[6] Subjects were blinded as to their breathing gas (EANx or air) and after the dive reported no subjective difference in fatigue. However, even with the air dive, fatigue did not increase at all, casting doubt on the extent to which the simulated dive reflected 'real-life' diving. As fatigue is commonly reported following recreational underwater diving, the authors agreed the simulated dives probably differed in many respects to actual underwater diving; thus they and others expressed a need for reliable in-the-field measurement.[6,11,12]

In the only previous field measurements reported, a major bias is likely, since the EANx divers had shorter total immersion and decompression times than the air dives with which they were compared.[5] As energy expenditure increases due to physical exertion and thermoregulation, we may hypothesize that (perceived) fatigue could be higher after a longer dive than after a shorter one.

For our study, divers from both groups performed their dives at the same dive sites at the same time and, thus, had similar diving conditions in terms of visibility, current and water temperature. Weather variations related to the study time span (two months) may have occurred, but were not documented. Although there is no statistically significant difference between the two groups, the absolute values of the diving parameters are unfavourable for the EANx group, who had slightly deeper and longer dives (EANx group 21.93 ± 3.8 msw, 44.17 ± 9.33minutes; air group 20.4 ± 4.3 msw, 42.48 ± 7.89 minutes). Therefore, the increased post-dive fatigue seen in the EANx group cannot be attributed to the conditions in which the experiment was performed.

To increase the reliability of the VAS evaluation, each diver was tested twice with reversed scales. Only if the scores on both scales were coherent, was the result considered valid. In 71 divers the scores were not coherent. According to the VAS, the EANx dives do not seem to provoke any post-dive increase in perceived fatigue. On the other hand, after air dives, perceived post-dive fatigue increased significantly. This result seems to support the subjective claims of EANx divers, but would need to be confirmed by a more objective and reproducible measurement than the VAS.

Although CFFF depends on several factors, such as the spectral composition of the light source, its average brightness, size, and retinal position, it is also a brief, easy and economical measure of vigilance.[9,13] Indeed, some authors have emphasised the advantages of CFFF assessment as an objective, quantitative and important method for measuring alertness and arousal.[14–16] CFFF measurements have been shown to be highly reproducible.[17] When executed in standard conditions, the CFFF test thus makes it possible to determine in a longitudinal way the evolution of the degree of fatigue and cortical arousal in test subjects.

CFFF has been used in deep saturation diving.[18] In that study, CFFF variations were grossly parallel to EEG modifications and probably revealed neuropsychological impairment (including fatigue) that was not apparent from subjective reports. In our study, the diver was blinded to the actual results. Analysis of the changes in CFFF response shows a marked difference between the air and EANx groups, with improvement of alertness with EANx and impairment with air breathing. These differences in response were highly significant statistically.

In order to explain the difference in post-dive fatigue and alertness between the air and EANx groups, three hypotheses should be considered: a nitrogen effect, an oxygen effect and a bubble effect.

Nitrogen: Nitrogen gas is known to have a degree of anaesthetic potency, related to its lipid solubility (Meyer-Overton rule), possibly due to interaction at the lipid bi-layer of neuronal membranes, altering their function.[19] While this theory is an oversimplification, it could explain why more nitrogen could lead to more fatigue. Recent studies have shown impaired psychomotor processing during air exposures from 204 to 408 kPa suggesting that nitrogen narcosis occurs even at relatively shallow depths.[15,16] No comparisons with EANx diving have been made.

Oxygen: During the EANx dive, the inspired PO_2 was 103 ± 45 kPa. Normobaric hyperoxia has been shown to facilitate nerve conduction, probably due to oxidative stress.[20] Several potential mechanisms, which will not be discussed here, have been proposed to explain this. The consequence of these is inhibition of inhibitory cerebral pathways, which could account for the enhanced cerebral arousal measured by the CFFF. Although tempting, this assumption must take into account that air divers also had an elevated PO_2 (64 ± 29 kPa), so the time spent at depth is probably too short to explain the difference observed.

Bubbles: Decompression schedules that have a high K-value (K = rate of decompression/partial pressure of inspired oxygen) generate more decompression stress.[21] Given the fact that, in our study, decompression rates were the same, the use of EANx would likely have produced a less 'stressful' decompression. Since a recent thermodynamic analysis suggests that bubbles are the bi-stable hydrophobic gates responsible for the on-off transitions of single-channel currents, we may also hypothesize a bubble effect.[22]

The complexity of these phenomena, which we have only touched upon briefly here, make it, as yet, impossible to draw any conclusions as to the various factors contributing to fatigue after a dive.

Conclusions

We have shown that, in a large group of divers, perceived fatigue after a single dive, as evaluated by a VAS, was significantly less when EANx was breathed, compared to air. Objective measurements of critical flicker fusion frequency also showed impairment with air breathing but slight improvement with EANx. More studies are needed in order to fully explore the complexity of the phenomena involved in the functional modifications of the nervous system in hyperbaric environments according to the type of gas used for the dive.

References

1 Lang M, Editor. *Proceedings of the DAN Nitrox workshop*; 2000 Nov 3–4; Durham, NC, USA. Durham Divers Alert Network; 2001. p 98.
2 Ozygit T, Egi SM, Denoble P, Balestra C, Aydin S, et al. Decompression illness medically reported by hyperbaric treatment facilities: cluster analysis of 1929 cases. *ASEM*, 2010;81(1):1-5.
3 James T, Francis R, Mitchell SJ. Manifestations of the decompression disorders. Brubakk AO, Neuman TS, editors. *Bennet & Elliott's physiology and medicine of diving*, 5th ed. London: Saunders. 2003. p. 578-99.
4 Kobayashi K. Experimental studies of the effects of enriched air nitrox dive on shortening of decompression time and reduction of risks of decompression sickness [in Japanese] *Sangyo Igaku*. 1993 Jul;35(4):294-301.
5 Charlton WH. Diving at Bozburun. *Institute of Nautical Archaeology Quarterly* Winter 1998;25(part 4):14-15.
6 Harris RJD, Doolette DJ, Wilkinson DC, Williams DJ. Measurement of fatigue following 18 msw dry chamber dives breathing air or enriched air nitrox. *Undersea Hyperb Med*. 2003;30(4):285-90.
7 Baterlink RA. The diagnostic value of automated threshold perimetry. *Cur Opin Ophthalmol*. 1999;10(2):135-9.
8 Tytla ME, Trope GE, Buncic R. Flicker sensitivity in treated ocular hypertension. *Ophthalmology*. 1990;97(1):36-43.
9 Whitehead L. The measurement of fatigue in chronic illness: a systematic review of unidimensional and multidimensional fatigue measures. *J Pain Symptom Manage*. 2009;37(1):107-28.
10 Hewlett S, Hehir M, Kirwan JR. Measuring fatigue in rheumatoid arthritis: a systematic review of scales in use. *Arthritis Rheum*. 2007 Apr;57(3):429-39.
11 Petri NM. Change in strategy of solving psychological tests: evidence of nitrogen narcosis in shallow air-diving. *Undersea Hyperb Med*. 2003 Winter;30(4):293-303.
12 Hobbs M, Kneller W. Effect of nitrogen narcosis on free recall and recognition memory in open water. *Undersea Hyperb Med*. 2009;36(2):73-81.
13 Fukuda T. Relation between flicker fusion threshold and retinal positions. *Percept Mot Skills*. 1979;49:3-17.
14 Truszczynski O, Wojtkowiak M, Biernacki M, Kowalczuk K. The effect of hypoxia on the critical flicker fusion threshold in pilots. *Int J Occup Med Environ Health.* 2009;22(1):13-8.
15 Davranche K, Pichon A. Critical flicker frequency threshold increment after an exhausting exercise. *J Sport Exerc Psychol*. 2005;27(4):515-20.
16 Carmel DV, Rees G, Lavie N. Perceptual load modulates

conscious flicker perception. *J Vision*. 2007;7(14):1-13.
17 Luczak A, Sobolewski A. Longitudinal changes in critical flicker fusion frequency: an indicator of human workload. *Ergonomics*. 2005;48:1770-1792.
18 Seki K, Hugon M. Critical flicker frequency (CFF) and subjective fatigue during an oxyhelium saturation dive at 62 ATA. *Undersea Biomed Res*. 1976;3(3):235-7.
19 Inhalational anesthetics. In: Morgan GE, Mikhail MS, Murray MJ, Larson CP, editors. *Clinical Anesthesiology*. 3rd ed. New York: McGraw-Hill; 2002. p. 127-50.
20 Brerro-Saby C, Delliaux S, Steinberg JG, Jammes Y. The change in neuromuscular excitability with normobaric hyperoxia in humans. *Exp Physiol*. 2009;95:153-9.
21 Reinertsen RE, Flook V, Koteng S, Brubakk AO. Effect of oxygen tension and rate of pressure reduction during decompression on central gas bubbles. *J Appl Physiol*. 1998;84(1):351-6.
22 Roth R, Gillepsie D, Nonner W, Eidenberg RE. Bubbles, gating and anesthetics in ion channels. *Biophys J*. 2008;94(1):4282-98.

Acknowledgement
The authors would like to thank the following diving centers of Sharm el Sheikh and their instructors: “Scuba Dreamer”, “Camel Diving Center”, and “Diving and Discovery”, and the staff at the Hyperbaric Medical Center,Sharm el Sheikh, for their assistance in conducting this study.

Submitted: 01 June 2010
Accepted: 20 July 2010

Pierre Lafère, MD, is, an anesthesiologist and physician in diving and hyperbaric medicine at the Centre for Hyperbaric Oxygen Therapy of the Military Hospital in Brussels and an associate researcher at the Environmental & Occupational Physiology Laboratory of the Haute Ecole Paul-Henri Spaak, Brussels.
Costantino Balestra, PhD, is Professor of Physiology, Director of the Environmental & Occupational Physiology Laboratory of the Haute Ecole Paul-Henri Spaak and Vice-President Research & Education DAN Europe.
Walter Hemelryck, MSc, DO, is an associate researcher at the Environmental & Occupational Physiology Laboratory of the Haute Ecole Paul-Henri Spaak.
Nicola Donda, BSc, is CEO of HBT Technology and an associate researcher at the Environmental & Occupational Physiology Laboratory of the Haute Ecole Paul-Henri Spaak.
Ahmed Sakr, MD, is a physician in diving and hyperbaric medicine at the Hyperbaric Medical Center in Sharm-El-Sheikh, Egypt.
Adel Taher, MD is the Medical Director of the Hyperbaric Medical Center in Sharm-El-Sheikh.
Sandro Marroni, MD, is the Founder and President of DAN Europe and President of International DAN.
Peter Germonpré, MD, is the Medical Director of the Centre for Hyperbaric Oxygen Therapy of the Military Hospital in Brussels and an associate researcher at the Environmental & Occupational Physiology Laboratory of the Haute Ecole Paul-Henri Spaak.

Address for correspondence:
P Lafère, MD
Centre for Hyperbaric Oxygen Therapy
Military Hospital “Queen Astrid”
Rue Bruyn 1
1120 Brussels, Belgium
Phone: *+32-(0)2-264 48 68*
Fax: *+32-(0)2-264 48 61*
E-mail: *<doc.lafere@skynet.be>*

Medical assessment of fitness to dive – comparing a questionnaire and a medical interview-based approach

Catherine A Meehan and Michael H Bennett

Key words
Fitness to dive, recreational diving, questionnaire, medicals – diving

Abstract

(Meehan CA, Bennett MH. Medical assessment of fitness to dive – comparing a questionnaire and a medical interview-based approach. *Diving and Hyperbaric Medicine*. 2010;40(3):119-24.)

Introduction: In Queensland, most entry-level recreational diving students have to complete two diving medical forms (the Recreational Scuba Training Council (RSTC) or similar, and the appendix to Australian Standard 4005.1), as well as undergoing a medical consultation by a medical practitioner experienced in diving medicine. This provides an opportunity to evaluate the performance of the health questionnaire compared to the medical interview.

Methods: We conducted a retrospective analysis of 1,000 consecutive entry-level scuba-diving students assessed by one doctor (CM). Using the medical consultation as the reference standard, we analysed the number of incorrect or inconsistent answers in each of the forms. The main outcome was the number of individuals who were found 'unfit to dive' following the medical, but who appeared fit according to their responses on the RSTC form.

Results: Of the 1,000 students, 3.7% failed the medical, 9.4% gave inconsistent answers and 29.9% gave incorrect answers. 63.2% had answered 'no' to all the questions on the RSTC form, and nine of these students (1 in 70) were assessed at the medical as 'unfit' for scuba diving, (0.9% of the total). Logistic regression could not identify factors that reliably predict those at high risk of failing the medical consultation after passing the RSTC questionnaire. Those who gave incorrect responses were more likely to fail (8.4% versus 2.0%, $P < 0.0001$).

Conclusions: One in 70 candidates failed during the medical consultation after indicating they had no relevant medical problems on a questionnaire. Face-to-face medical interview does identify individuals who are at risk while diving, where two commonly used medical screening forms do not. The practical significance of these conclusions remains unclear.

Introduction

Hundreds of thousands of people flock every year to North Queensland, Australia, to dive on the Great Barrier Reef (GBR), one of the seven natural wonders of the world. This heritage-listed area is the largest coral reef system in the world, composed of over 2,900 individual reefs and 900 islands and stretching for 2,600 kilometres over an area of approximately 344,400 square kilometres. Cairns, in Far North Queensland, is a major hub for these divers and among them are entry-level candidates in all shapes and sizes and from all corners of the world.

In most countries, an individual contemplating any form of compressed gas diving will have a medical assessment of some sort. The purpose of this assessment is the identification of individuals who have a medical condition that would present a substantial risk if they were to undertake compressed-gas diving. For recreational scuba diving, this assessment is usually a self-declaration medical questionnaire. The complexity of the questionnaire varies according to whether the person is about to embark on a full scuba course or a guided introductory dive.

The medical clearance of recreational divers is usually undertaken by the diving training agencies.[1] Only rarely are there statutory guidelines in place, and Australia is one of those rarities. The Australian Standard (AS) 4005.1-2000 outlines how entry-level scuba diving training should be conducted and includes an appendix outlining the medical assessment recommended for all candidates for training.[2] Not all Australian states have regulations for employed divers that govern how diving or dive training is to be conducted.[3] Queensland does, and in that state the Workplace Health and Safety Act 1995 directs the worker to adopt and follow a stated code of practice.[4] The Recreational Diving, Recreational Technical Diving and Snorkelling Code of Practice 2010, outlines how these activities should be conducted in Queensland and also directs that medical assessments should be made in accordance with the Australian Standard.[5] The Code of Practice mandates that a medical practitioner with experience in diving medicine conducts the assessment. Thus, all would-be recreational divers in Queensland are required to have a medical consultation with a detailed questionnaire that informs a face-to-face interview and examination by a medical practitioner with experience in diving medicine.

In many other countries, only the self-declaration health questionnaire is required. Most commonly, when a candidate gives a positive response to any question they are directed to have a medical assessment with a doctor. The Recreational Scuba Training Council (RSTC) Medical Statement has been widely used, including by many Queensland dive training operators.[6] Thus, in Queensland, candidates often have to complete both forms and have a medical consultation. This provides a unique opportunity to compare the way in which candidates complete these two health questionnaires, and to compare the RSTC form with the medical consultation process. It is important to recognise that the two forms are designed for different purposes. The RSTC consists of 34 questions asking for a yes or no response and is designed to identify those who may be at medical risk from diving and require a medical consultation. On the other hand, the appendix to the Australian Standard is a screening tool designed to assist and direct the face-to-face component of the medical consultation. It asks more questions (98) and many may require a short narrative response. There is also a space for medical notes on these responses. Thus, the two forms differ significantly from each other, both in the number of questions and their wording, and may perform quite differently in practice.

Our primary purpose in this study was to establish and characterise any cohort of candidates who pass through the RSTC screening, but who would be found unfit on medical consultation. These individuals are a group at risk of diving-related morbidity and mortality should Queensland move to a questionnaire-based system. We also aimed to examine in detail any differences in the way individual candidates filled out the two questionnaires.

Methods

We conducted a retrospective analysis of the questionnaires filled out by 1,000 consecutive recreational diving students who attended one of the authors (CM) for a diving medical during 2008. Each candidate had completed two medical questionnaires prior to being seen: the AS4005.1 (1992 version) and the RSTC Medical Statement (1998 version) as required by the Queensland Code of Practice and a recreational diving training agency respectively. Both forms were available in English, Japanese, Korean and German. The Human Research Ethics Committee, Cairns and Hinterland Health Service District granted ethical committee approval for the study.

All analyses were made on the assumption that the information found during the face-to-face medical (interview and examination) was correct (a 'gold standard'). We compared the findings of the medical assessment to the answers indicated by the candidates on each of the forms. We evaluated four aspects:

- the number of individuals with incorrect answers on each form (absolute and proportion);
- the number of individuals with answers that were inconsistent between the two forms;
- the identification of additional medical information during the face-to-face interview and examination;
- the candidates who failed at the face-to-face medical who did not indicate a problem on the RSTC form.

To facilitate an appropriate comparison, we entered the two questionnaires into a spreadsheet (Microsoft Excel 2003) and grouped together all questions with the same or very similar meaning. CM made these groupings and they were reviewed by MB. Disagreements were settled by consensus. We identified 11 sets of questions and used these to determine inconsistent responses (Table 1).

For each individual, the responses given were transferred in a de-identified form to an Excel™ spreadsheet. This spreadsheet was then re-sorted and imported into a statistical package for analysis (StatsDirect version 2.7.8, StatsDirect Ltd). We defined the outcomes of interest as below:

- Incorrect responses: If the student answered 'no' to a question on either form, but at the medical examination it was found that the correct answer should have been 'yes', the answer has been identified as 'incorrect'. Note that we did not examine the responses for those who answered 'yes' when the answer should have been 'no' because we are interested primarily in those who would pass the questionnaire despite a medical problem.
- Inconsistent responses: If the student has answered 'yes' to a question on one form but 'no' to a question with the

Table 1
The eleven questions on each form that were deemed to have the same meaning; * we excluded from comparison parts of the questions that do not have the same meaning, e.g., agoraphobia in the question on RSTC form.

Australian Standard 4005.1	**Recreational Scuba Training Council (RSTC)**
Have you ever had or do you now have any of the following?	*Have you ever had or do you currently have…?*
Claustrophobia	Claustrophobia or agoraphobia* (fear of closed or open spaces)
Asthma or wheezing	Asthma, or wheezing with breathing or wheezing with exercise
Hernia or rupture	History of any type of hernia
Fainting or blackouts	History of blackouts or fainting (full/partial loss of consciousness)
Convulsions, fits or epilepsy	Epilepsy, seizures, convulsions or take medications to prevent them
Heart disease	History of any heart disease
High blood pressure	History of high blood pressure or take medicine to control blood pressure
Pneumothorax (collapsed lung)	Pneumothorax (collapsed lung)
Diabetes	Any history of diabetes
Blood disease or bleeding problem	History of bleeding or other blood disorders
Are you now pregnant or planning to be?	Could you be pregnant, or are you attempting to become pregnant

same meaning on the other form, the answer has been identified as 'inconsistent'.

- Failed medical: If the student was not cleared to undertake dive training. This included both those who were found 'unfit to dive', and those who required further specific investigation but were unwilling or unable to undertake this.

STATISTICAL METHODS

No sample-size calculation was undertaken prior to commencing this study and an ad hoc decision was made to complete the study at 1,000 individuals. In order to ensure appropriate statistical methods, the demographic characteristics were plotted where appropriate (e.g., age) in order to determine the pattern of distribution. For univariate analyses, we compared the number of incorrect and inconsistent responses using a Chi-square test for significance for two by two, two by three and two by four tables as appropriate. Multivariate analysis was undertaken where appropriate using logistic regression. Potentially important factors were included in the multivariate analysis if the univariate analysis suggested the P-value for an association between factor and outcome was <0.1. A step-wise backward elimination technique was then employed in order to determine the most predictive model. Statistical significance was accepted if the chance of a type-I error was less than one in twenty ($P < 0.05$).

Univariate analysis was performed using first language (English, European, or Asian), age (four subgroups), sex, previous diving or occupational group as the predictor variables for inconsistent and incorrect responses. Multivariate analysis was undertaken as appropriate to the methodology above. We took a similar statistical approach to determine the likelihood of failing the medical if there were inconsistent, incorrect or all negative responses for the whole group and all the subgroups indicated above.

Results

DEMOGRAPHICS

Of the 1,000 student divers whose questionnaires were analysed, 46.2% were female and 53.8% were male. The mean age was 25 years (range 13–65 years; 70% of the students were aged 20–29 years). There were no significant differences in the sex ratio across age groups. 79% admitted to consuming alcohol, with a median weekly consumption of six units per week (range 1–60). 18% admitted to smoking a median of eight cigarettes per day (range 1–30). The mean body mass index (BMI) for the group was 25 (range 16–40 for females, and 16–35 for males; 3.8% were obese (BMI > 30) and 9.6% were underweight (BMI < 20).

Most of the candidates were international tourists, mainly from Continental Europe and Scandinavia (33%), followed by Japan (16.6%), the United Kingdom (14.8%) and USA (8.9%). Only 8.6% were from Australia. Overall, 40.6% were English-speaking, 30.5% spoke a European language, and 28.9% spoke an Asian language.

FAILED MEDICALS, INCONSISTENT AND INCORRECT ANSWERS ON QUESTIONNAIRES

Of the 1,000 candidates, 37 (3.7%) failed the medical, 9.4% had inconsistent answers and 29.9% had incorrect answers. Of the latter, 26.1% had 'no' on a form, when the answer should have been 'yes', and 5.8% answered 'yes' when the answer should have been 'no'; 2% made both errors. We did not examine this latter group any further, as discussed in methods above. Of those eventually identified as having a history of asthma, 26% failed to mark this on their questionnaires. Overall, clinically significant medical history was missed on the AS form in six (0.6%) cases and on the RSTC form in 47 (4.7%) and some additional information was found during consultation in 110 (11%) of the cohort. Those who answered at least one

Table 2
The reasons given in nine cases for being declared unfit following a face-to-face medical in the group who answered 'no' to all questions on the RSTC form. (n = 632)
***spirometry required by AS4005.1: FVC and FEV_1 ≥80% of predicted values, FEV_1/FVC ≥75%[2]**

System affected	Details recorded at medical consultation	Requires further specialist investigation to determine if permanently unfit
ENT	Eardrums pink, recent URTI, unable to equalise; temporarily unfit	No
ENT	Eardrums red, recent skydiving, unable to equalise; temporarily unfit	No
ENT	Congenitally narrowed ear canals, possible atresia	Yes
Respiratory	Failed spirometry*, smoker, recent URTI	Yes
Respiratory	Failed spirometry*, ex smoker, wheeze on auscultation	Yes
Respiratory	Failed spirometry*	Yes
Cardiovascular	Heart murmur on auscultation, history of hole in the heart or great vessels	Yes
Cardiovascular	History of palpitations, ECG shows sinus tachycardia	Yes
Other	Fainted in classroom and on the way to the toilet; bradycardia	Yes

question incorrectly were more likely to fail the medical consultation (8.4% versus 2.0%, Chi square = 20.4, $P < 0.0001$. The relative risk (RR) of failing for this group was 2.4 (95% confidence interval (CI) 1.7 to 3.1).

Six-hundred-and-thirty-two candidates (63.2%) answered 'no' to all questions on the RSTC form and were less likely to be failed at medical consultation (1.4% versus 7.1%, Chi square = 20.8, $P < 0.0001$. RR 0.38, 95% CI 0.21 to 0.63). Of the 632, nine candidates (1.4%) then failed the medical. Table 2 documents the reasons given on the medical forms for this.

Univariate analysis

We examined the predictive value of language spoken, age, sex and occupation on the likelihood of failing the medical, giving incorrect or inconsistent answers, answering 'no' to all questions on the RSTC and answering 'no' to all, but failing after the face-to-face medical examination. The results are summarised in Table 3. The only statistically significant relationships were a higher proportion of those aged more than 39 years gave at least one incorrect answer when compared to other age groups (59.5% versus 24.8%, Chi-square = 22.2, $P < 0.0001$), those in the medical and allied professions were more likely to give inconsistent answers ($P = 0.008$, Fisher's exact test), men were more likely to answer all 'no' on the RSTC (43.3% versus 31.2%, Chi-square = 15.55, $P < 0.0001$) and women more likely to give inconsistent and incorrect answers (12.1% vs 7.1%, Chi-square = 6.88, $P = 0.009$; 31% vs 22%, Chi-square = 10.62, $P = 0.002$). Although the overall Chi-square test for age as a potential predictor of failing after answering all 'no' on the RSTC was not statistically significant, we noted that all such cases were in the 20–29 year age group. When tested against all other groups, this age group was more likely to fail after answer all 'no' (2% versus 0%, $P = 0.48$, Fisher's exact test).

Table 3
Unvariate analysis of potential predictors for the outcomes of interest: deemed unfit after medical evaluation; gave inconsistent answers; gave incorrect answers; gave all 'no' responses on RSTC form; failed and gave all 'no' responses; * statistically significant

Potential predictor	Outcome	Chi square	*P*-value
Language group (English/Euro/Asian)			
	Not fit	0.15	0.52
	Inconsistent	0.48	0.89
	Incorrect	1.15	0.32
	All 'no'	1.88	0.17
	All 'no' but failed	0.45	0.9
Age group (<20yrs/20–29yrs/ 30–39yrs/>39yrs)			
	Not fit	1.05	0.77
	Inconsistent	2.62	0.08
	Incorrect	5.15	<0.0001*
	All 'no'	2.33	0.14
	All 'no' but failed	1.96	0.28
Occupation (medical/other)			
	Not fit	2.2	0.09
	Inconsistent	(Fisher's)	0.008*
	Incorrect	0.35	0.55
	All 'no'	0.74	0.39
	All 'no' but failed	(Fisher's)	0.7
Previous experience (yes/no)			
	Not fit	0.33	0.24
	Inconsistent	0.36	0.55
	Incorrect	0.20	0.65
	All 'no'	0.66	0.20
	All 'no' but failed	(Fisher's)	0.46
Sex	Not fit	2.19	0.14
	Inconsistent	6.88	0.009*
	Incorrect	10.62	0.002*
	All 'no'	15.55	<0.0001*
	All 'no' but failed	(Fisher's)	0.47

Multivariate analysis

We used the results of the univariate analyses to construct our initial models for prediction of the outcomes of interest. The final models and predictive values are summarised in Table 4. We did not identify any such factors for failure at the medical consultation or for those who answered all 'no' on the RSTC and failed at the consultation. Only sex was found to predict the likelihood of answering all 'no' (see above). Potential predictive factors for supplying inconsistent answers were age, sex and occupation, but only occupation and sex were significant predictors, suggesting that the odds of a female health worker to give inconsistent answers on the two forms were 2.4 to 1 ($P = 0.001$). Similarly, both age and sex were predictors of giving an incorrect answer, suggesting the odds of a female greater than 39 years old giving such an answer to be 2.2 to 1 ($P < 0.001$).

Discussion

The International Organization for Standardization (ISO), of which Australia is a member, is a network of the national standards institutes of 157 countries with a central secretariat in Geneva. In 2007, the ISO accepted a common medical standard for fitness to dive, ISO 24801-2:2007. This standard requires the student to have documentary evidence of medical screening by appropriate questionnaire or medical examination.[7] During the development of this standard, it became evident that most countries did not have a compulsory diving medical examination, but depended on the self-declaration questionnaire.

Although both options have been included in the ISO standard, there is ongoing discussion as to whether the Australia Standard should adopt the self-declaration questionnaire and discard the compulsory face-to-face diving medical in order to fall in line with common practice

Table 4
Multivariate analysis of potential predictors for the outcomes of interest

Outcome	Potential predictors	Final model	Odds ratio	*P*-value
'Not fit'	Nil	Nil		
Inconsistent	Age/occupation/sex	Health worker/female	2.4	0.01
Incorrect	Age/sex	>39 years/female	2.2	<0.001
All 'no'	Sex	Univariate		
All 'no' but failed	Nil	Nil		

throughout the rest of the world. Independently, the SPUMS has been considering the same question for the past five years. The prospect, as described elsewhere in this issue, that both the Australian Standard and the SPUMS recommendations might change has created some debate both in the region and more widely. There is little evidence upon which to base any such decision. This study was devised in an attempt to answer some of the questions raised by the debate.

We have compared the ability of the RSTC screening questionnaire and the SPUMS approach, involving the AS 4005.1 questionnaire and a medical consultation, to identify medical problems that might prevent a candidate from safely undertaking scuba diving training. Of our cohort of 1,000 consecutive and unselected candidates, only nine individuals indicated no problems on the RSTC form, but then revealed information during the medical consultation that may have posed a risk of misadventure such that they were found unfit to undertake training. Of these nine, two were probably only temporarily unfit whilst the other seven needed further investigations or specialist review to determine their fitness to dive. The two students with equalisation problems would likely have been identified by the instructor during pool training; it is unlikely that the student with congenitally narrow canals and hearing loss would ever have been assessed as fit to dive. While it is not possible to know if any of the nine would have suffered morbidity or died during or after their dive training, it is important to recognize that the absolute numbers of individuals in this category might be quite large. In 2008, the year of the study, approximately 20,000 people trained to dive in Queensland, suggesting nearly 200 of these would fall into this 'at risk' category, based on our data.

In addition, we have examined the predictive ability of a number of potential factors that might identify a group at risk of misadventure if screening were based solely on a medical questionnaire such as the RSTC form. While there were some statistically significant determinants of the likelihood of giving either inaccurate or inconsistent responses, there were no such predictors of the small numbers of candidates who were failed during medical consultation. We are, therefore, unable to suggest a subgroup in which compulsory medical consultation would be particularly useful.

The usefulness of medical consultation has been questioned elsewhere. In the United Kingdom until March 2000, a diving candidate needed to answer a questionnaire and attend a medical consultation with a registered medical practitioner. Trained diving doctors were available in the case of a potential problem, but the examining medical officer did not require any training in the area.[8] Since that time, the United Kingdom Sport Diving Medical Committee (UKSDMC) has moved to a self-declaration medical system with a form being completed at entry and at between one- and five-year intervals, depending on the medical condition and age of the diver. An answer of 'yes' to any of the questions mandates a review from a medical officer trained and experienced in diving medicine (a 'medical referee').[9] This change was made in response to a study that reviewed the information found on the medical forms of the Scottish Sub-Aqua Club (SSAC) between 1991 and 1998.[8] The authors evaluated 2,962 forms and concluded that face-to-face medical examinations were of little added value. All conditions preventing the subjects from diving were detected by the questionnaire and no important and unexpected abnormalities were found on clinical examination. A review of the new approach after three years in operation concluded that the self-administered questionnaire was an effective screening tool for the detection of divers requiring further detailed assessment.[10]

In Australia, the situation is further complicated by coronial inquest findings that need to be addressed. Rather than relaxing the current process as in the UK, several such inquests over the last few years have recommended more stringent diving medical fitness standards. Most recently, in April 2008, the NSW coroner recommended compulsory diving medical examinations, preferably annually, but not less frequently than every two years.[11]

When using a self-declaration health questionnaire as the screening method, the honesty and accuracy with which the form is completed are clearly important. There are many factors that might influence the frankness with which individuals approach this task. For example, to what extent does each individual understand the risks posed by concealing information? Even if the risk is conveyed accurately, responses may vary depending on the risk acceptance of the candidate. Further, it is not clear that a person is more likely to be honest during a face-to-face interview than when filling out a self-declaration questionnaire. Our difficulty in understanding the extent of any problems is compounded by the fact that there is likely to be both a time and financial penalty incurred if an affirmative answer is given to a question. In a 1991 paper, Parker considered the relative importance of different parts of the diving medical in identifying fitness to dive and observed it was surprising that many questions were not answered correctly by the diver.[12] When the condition was detected and admitted to, varying reasons for the omissions were given including: "*I didn't think it mattered*", "*I forgot*" and "*I didn't see it*".

Medical consultation with a trained and experienced physician has utility beyond simply identifying those unfit to train for diving. Prompted by responses to the questionnaire, the medical interview may be valuable for identifying and discussing risk and risk minimisation strategies. This has certainly been the experience of the two authors. It has not been possible to estimate the practical impact of this discussion in the present study.

Both the forms used by the diving students in this study have been updated. The Australian Standard form was changed little, but there have been some improvements to the RSTC form that may reduce the observed inaccuracies. For example the question "*do you regularly take prescription or non-prescription medications?*" has been changed to "*are you presently taking prescription medications?*", and "*are you currently receiving medical care*" has been added for candidates over the age of 45 years.

Conclusions

Approximately 1% of all the diving candidates 'passed' the RSTC screening questionnaire but were subsequently found on medical consultation to be 'unfit to dive'. The impact on morbidity or mortality remains unknown. Evidence exists both in favour of face-to-face medical assessment before undertaking scuba training and that such consultations add little of value to the prospective diver. More work is needed in this area. At this time, we recommend caution before implementing changes to the current system of assessment in Australia, and the inclusion of a valid and meaningful assessment of the impact of any such change.

References

1 Mitchell SJ, Bennett MH. Clearance to dive and fitness for work. In: Neuman TS, Thom SR, editors. *The physiology and medicine of hyperbaric oxygen therapy*. London: Elsevier; 2008.
2 Australian Standard AS4005. 1-2000. *Training and certification of recreational divers. Part 1: Minimum entry-level SCUBA diving*. Strathfield, NSW: Standards Australia International Ltd; 2000.
3 Meehan C. The Australian diving medical. A look at the standards in Australia and overseas. *SPUMS Journal*. 2004;34:137-41.
4 *Workplace Health and Safety Act 1995*. Queensland Government; reprinted July 2010. Part 3: Workplace health and safety obligations, Section 26: Subsection 3. Available from: <http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/W/WorkplHSaA95.pdf>
5 *Recreational Diving, Recreational Technical Diving and Snorkelling Code of Practice 2010*. Queensland Government, Workplace Health and Safety Queensland; March 2010. 2.3.1.2: Medical fitness of entry-level certificate divers. Available from: <http://www.deir.qld.gov.au/workplace/resources/pdfs/divingrecreational_code2010.pdf>
6 Richardson D. The RSTC medical statement and candidate screening model. *SPUMS J*. 2000;30(4):210-3. Available from: <www.wrstc.com/downloads/RSTCMedStatementGeneric.pdf>
7 ISO 24801-2:2007. *Recreational diving services - Safety related minimum requirements for the training of recreational scuba divers - Part 2: Level 2 -Autonomous diver*. Geneva, Switzerland: International Organization for Standardization; 2007.
8 Glen S, White S, Douglas J. Medical supervision of sport diving in Scotland: reassessing the need for routine medical examinations. *Br J Sports Med*. 2000;34:375-8.
9 *UK Sport Diver Medical Form*, November 2005. Available from: <http://www.uksdmc.co.uk>
10 Glen S. Three year follow up of a self certification system for the assessment of fitness to dive in Scotland. *Br J Sports Med*. 2004;38:754-7.
11 C1. Coroners Act, 1980, *Inquest held at the Court House of Kurri Kurri on the 31/3/08 & 1/4/08, Magistrate Crews, Coroner, concerning the death of Jane Majella McQuillan*.
12 Parker J. The relative importance of different parts of the diving medical in identifying fitness to dive and in detecting asthma. *SPUMS Journal*. 1991;21(3):145-53.

Conflict of interest: Dr Meehan is one of several diving medical practitioners in the Cairns region listed to provide assessment services for entry-level divers, as required by Queensland state legislation and paid for by the candidates. Candidates in this study were referred by an outside organisation without active recruitment by Dr Meehan.

Acknowledgements: Ms Paula McDonell provided invaluable advice on setting up and analysing the data spreadsheet. Associate Professor Simon Mitchell was the supervisor for this research paper, which was initially submitted as part of a Post Graduate Diploma in Medical Science, The University of Auckland.

Submitted: 06 July 2010
Accepted: 03 August 2010

Catherine Meehan, MBBS, PGDipMed Sc, is a general practitioner in Cairns.
Michael Bennett, MD, FANZCA, MM (Clin epi), is Associate Professor, Department of Diving and Hyperbaric Medicine, Prince of Wales Hospital and University of NSW, Sydney.
Address for correspondence:
Dr Catherine Meehan
Mcleod Street Medical
67 McLeod Street
Cairns, Queensland 4870
Australia
Phone: *+61-(0)7-4052-1583*
E-mail: *<cmeehan@mcleodstmed.com.au>*

Referral patterns and outcomes of dive medical examinations in a tertiary hyperbaric facility

Lin Min Ong, Michael H Bennett and Paul S Thomas

Key words
Fitness to dive, medicals – diving, medical conditions and problems, cardiovascular, respiratory, asthma

Abstract

(Ong LM, Bennett MH, Thomas PS. Referral patterns and outcomes of dive medical examinations in a tertiary hyperbaric facility. *Diving and Hyperbaric Medicine*. 2010;40(3):125-30.)

Introduction: Scuba diving involves risks, and candidates in Australia usually have a medical evaluation prior to undertaking a diving course. Hyperbaric physicians act as secondary referral practitioners for these assessments. This study aimed to identify reasons for these secondary referrals, and document the assessment process and outcome for potential dive candidates.

Methods: This was a retrospective case-note analysis of candidates for dive medicals presenting to the Department of Diving and Hyperbaric Medicine (DDHM) at the Prince of Wales Hospital, Sydney, over 10 years.

Results: We identified a total of 191 candidates aged 12 to 67 years. Most were candidates for recreational diving (n = 148, 77.5%) and 119 (62.3%) were male. Commercial dive candidates had higher median total number of dives (P = 0.005), median maximum depth ($P < 0.001$) and median years, diving (P = 0.018) than recreational dive candidates. Respiratory problems were the most common referral reason for presentation (35%), followed by CNS (14%), ENT (13%) and cardiovascular conditions (9%). Most candidates were assessed as 'fit to dive' (136 or 71%), 49 (26%) were 'unfit', while six (3%) were subject to restrictions. Forty-three candidates (22%) presented with a diagnosis of asthma, of whom 25 (13%) were considered 'fit to dive'.

Conclusion: The most common presentation for evaluation was for respiratory conditions, particularly asthma, but a wide range of medical conditions were assessed, and subjects were evaluated on an individual basis. Although current standards in Australia discourage asthmatic subjects from diving, over half of the candidates presenting with a possible diagnosis of asthma were assessed as 'fit to dive'.

Introduction

In Australia, it is near-universal practice for a formal medical assessment to be made prior to dive training. The aim is to screen dive candidates for conditions that could potentially compromise their safety underwater and to counsel candidates on the medical risks of this activity.[1] The South Pacific Underwater Medicine Society (SPUMS) advocates that all assessments are made by a physician with training in this area. Specialist diving physicians, many of whom work in clinical hyperbaric facilities, act as a secondary referral resource for more difficult problems. There are specific Australian Standards (AS4005.1 and AS2299) relating to examination of the candidate for recreational and commercial diving activity respectively.[2,3]

In this retrospective review, we intended to examine the pattern of referral to the Prince of Wales Hospital Department of Diving and Hyperbaric Medicine (DDHM), to characterise the findings at examination and document the recommendations for this group.

The nature of compressed-gas diving involves both exposure to alterations in ambient pressure and physiological changes that may lead to undesirable incidents. The medical risks of compressed-gas diving relate both to the rapid changes in ambient pressure (P_{amb}) and to the consequences of breathing gas at high P_{amb}. It is the purpose of the 'fitness to dive assessment' to identify and counsel those at increased risk of such adverse incidents.

The most common medical problems encountered while diving are barotraumas and decompression illness (DCI). Barotrauma occurs when any non-compliant gas-filled space within the body does not equalise with environmental pressure during descent or ascent.[4] The most common such space affected is the middle ear, while less common sites for barotrauma of compression include the respiratory sinuses and dental caries. The lungs are potentially vulnerable to barotrauma of ascent. Expanding gas may be trapped in the lungs as P_{amb} falls, either because of airway obstruction (e.g., bronchoconstriction) or pathological conditions (e.g., bullous disease). The extent to which asthma predisposes to pulmonary barotrauma (PBT) is debated but the presence of active bronchoconstriction is assumed to increase risk. Asthmatics who regularly require bronchodilator medications are usually discouraged from diving for this reason. While possible consequences of pulmonary barotrauma include pneumothorax and mediastinal emphysema, the most feared is the introduction of gas into the pulmonary veins leading to cerebral arterial gas embolism (CAGE).[5,6]

Methods

This was a retrospective analysis of case notes performed in a structured manner. Ethics approval for the study was granted by the UNSW Human Research Ethics Advisory (HREA) Panels. All candidates for diving clearance presented to the DDHM at the Prince of Wales Hospital (POWH) between October 1998 and October 2008. Candidates were identified from a patient database utilised at the DDHM. Candidate information was categorised into demographics, reasons for referral, medical conditions, investigations and outcomes. Some data were retrieved from the full medical records. Individuals inappropriately labelled 'diver medical' and those with insufficient data were excluded.

Diving experience was recorded as the approximate number of dives, years, diving, maximum depth achieved, longest dive, previous adverse dive events, type of diver (recreational or commercial) and certification level. Lastly, the outcome of assessment was recorded with candidates labelled as 'fit to dive (FTD)', 'permanently unfit to dive', 'temporarily unfit to dive', 'for instruction under special circumstances' and 'undetermined'. The final category included candidates who did not return for follow-up appointments. All data were entered on a spreadsheet for analysis (Microsoft Office Excel, Seattle, Washington, USA).

INVESTIGATIONS

Some individuals were deemed fit or unfit to dive based on their medical history and examination alone. Others required further testing, including spirometry, bronchial challenge testing, chest X-rays (CXRs) and a wide range of other specialist investigations or were referred to other specialists as indicated for risk assessment. Since neither medical examinations nor pulmonary function tests are mandatory for a return to recreational diving, this information is not available for all subjects.

STATISTICAL ANALYSIS

No power calculations were performed for this opportunistic sample. Statistical analysis was performed in Graphpad Prism v5.0 for Macintosh (Graphpad Software, San Diego California, USA). Differences in proportions were analysed by Chi-square tests and between means using unpaired t-tests.

Results

A total of 198 individuals were referred for dive medical assessments over 10 years at the HBU. Seven were excluded due to insufficient documentation, leaving 191 subjects for analysis. The candidates were aged between 12 and 67 years (mean 32.8 years). 58% were aged between 21 and 35 years and 119 (62%) were male. One-hundred-and-forty-eight (77%) presented in relation to recreational diving (recreational candidates – RC), 42 (22%) for commercial diving (commercial candidates – CC) and in two cases this was unclear.

CANDIDATE DIVE INFORMATION

CCs were more likely to have previous diving experience and had made a significantly greater number of dives (CC median number of dives 275 (range 0–3500), RC 22.5 (range 0–4000), $P = 0.005$). Similarly, the CC group had made deeper maximum-depth dives (CC median 47 metres'sea water (msw), range 0–252, versus RC 22 msw, range 3–60, $P < 0.001$) and had significantly longer diving experience (CC median 12 years, range 0–32, versus RC median 3 years, range 0–32, $P = 0.018$). There was no significant difference in the proportion of previous diving incidents between the groups ($P > 0.4$).

REASONS FOR REFERRAL TO THE DDHM

Dive candidates often presented with a history of more than one problem or checked multiple boxes indicating several diseases in their dive medical questionnaires. We thus identified a total of 507 complaints from the 191 individual candidates. These complaints were broadly categorised by system affected, and these categories are presented in Table 1. Respiratory problems were the most common (32%), followed by ENT (17%), musculoskeletal (13%), CNS (13%) and cardiovascular (6%). On analysis of the primary complaint only, respiratory problems remained the most common (35%), followed by ENT (13%) and cardiovascular conditions (9%). A detailed breakdown of all respiratory complaints is given in Table 2 and a similar analysis of all presenting complaints is available from the corresponding author. We also examined the nature of the presenting complaints according to age (Table 3), which suggested that cardiovascular problems were more common in those over 40 years compared to younger groups, but the analysis was otherwise unremarkable (Chi-square 20.2, $P = 0.03$).

FITNESS TO DIVE

Candidates were analysed for their 'fitness to dive' status at discharge from the DDHM. One-hundred-and-thirty-one (71%) were passed as fit, 49 (26%) were assessed as permanently unfit and six (3%) were temporarily unfit to dive. The remaining six candidates (3%) were unfit according to the AS4005.1 due to paraplegia but passed for instruction under special circumstances. CCs were more likely to be passed fit than RCs (88% versus 66%, $P = 0.0002$).

Asthma

Forty-five (23%) candidates presented with a possible history of asthma (28% of the RC group versus 2% of the CC group, $P < 0.0001$). Current asthma was defined using the standard of either a significant bronchodilator response or evidence of bronchial hyper-responsivenes. Twenty candidates labelled as 'asthmatic' were symptom free and had not used a bronchodilator within the past five years. Five of the remaining 23 candidates used medication daily while the others required medication intermittently.

Table 1
Presenting problems in each category (total n = 507) for 191 subjects including those with a previous history of illness, active disease and those where the diagnosis was uncertain on presentation. Only the more common conditions in each category are listed.

Categories	Common problems	Number of problems
Respiratory (*n* =162)	Hayfever	49
	Asthma	44
	Bronchitis	19
	Coughing phlegm or blood	19
Ear, nose or throat (*n* = 85)	Sinusitis	23
	Nasal problems	17
	Deafness, tinnitus	11
	TM perforation	9
	MEBT	7
Central nervous system (*n* = 72)	Concussion, head injury	14
	Migraines	13
	Headaches unrelated to diving	10
	CNS DCI	10
	Fainting, blackouts	8
Musculoskeletal (*n* = 68)	Fractures	41
	Joint problems	19
Cardiovascular (*n* = 32)	Hypertension	11
	Palpitations, awareness of heartbeat	4
Gastrointestinal (*n* = 25)	Indigestion, peptic ulcer, acid reflux	12
	Non-infective liver disease	4
Other (*n* = 16)	Need for seasickness medication	13
	Severe motion sickness	2
Endocrine (*n* = 10)	Hypercholesterolaemia	5
	Hypothyroidism	4
	Diabetes	4
Mental status (*n* = 10)	Depression	4
	Attention deficit hyperactivity disorder	4
	Anxiety attacks	2
Eye or vision (*n* = 10)	Myopia	9
	Colour blindness	1
Skin (*n* = 9)	Eczema	3
	Psoriasis	3
	Keratosis pilaris	1
	rash	1
Infectious disease (*n* = 7)	Infectious mononucleosis	2
	Hepatitis	3
	Human immunodeficiency virus	1
	Leptospirosis	1
Haematological (*n* = 5)	Von Willebrand's disease	2
	Haemophilia	2
	Venous thrombosis	1
Kidney, urinary tract (*n* = 4)	Cystitis	2
	Renal failure	1
	Renal transplant surgery	1

Pulmonary function tests

Pulmonary function tests performed included spirometry (126 candidates), bronchodilator response and hypertonic saline challenge. Five of the seven candidates having a bronchodilator response test were positive and declared unfit to dive, while eight of 35 candidates having a hypertonic saline challenge were similarly positive and declared unfit. Five candidates had chest radiographs performed, all of which were normal. Overall, 25 of those with possible asthma (58%) were passed 'fit to dive' as no evidence of current asthma was found.

Table 2
Distribution of all respiratory problems; several individuals had more than one such complaint

Respiratory problem	Number of subjects	(%)
Hay fever	49	(26)
Asthma	43	(23)
Sinusitis	23	(12)
Coughing phlegm or blood	19	(10)
Bronchitis	19	(10)
Shortness of breath on exertion	12	(6)
Wheezing	10	(5)
Pneumothorax	8	(4)
Bullous disease	1	(0.5)
Subcutaneous emphysema	1	(0.5)
Haemothorax	1	(0.5)

COMMON NON-RESPIRATORY PROBLEMS

Many candidates (*n* = 57) presented with a history of ear, nose or throat complaints, including nine with aural barotrauma and nine with tympanic membrane perforation. Some (14) were referred for ENT consultation and investigations concerning middle ear auto-inflation, possible hearing loss and tympanic membrane compliance. A minority (12 of the 57 candidates) with ENT problems were assessed as 'unfit to dive' due to ear abnormalities. Other common complaints noted at referral were fractures (41), joint problems (16), migraines (13), other headaches (14), head injuries (14), hypertension (11) and previous DCI (10). A full listing of conditions is available from the authors.

Discussion

The majority of candidates had relative or absolute contraindications to scuba diving, suggesting that referrals were in general appropriate. Many requests concerned respiratory fitness to dive and, in particular, asthma. This remains a very active area of interest for SPUMS. The connection between respiratory diseases and the pathophysiological mechanisms of PBT remains contentious.[5–8] Risk factors for PBT include both physiological and behavioral aspects, such as rapid ascents or inappropriate breath holding, but PBT, may occur in the absence of these factors.[8,9] Current Australian standards for dive medicals place an emphasis on finding conditions that may cause air trapping.[2,3] However, in one of the few studies of airway function prior to the occurrence of PBT, PBT was more strongly associated with a decreased vital capacity (restrictive lung function) than airway obstruction in a group of escape trainee submariners.[10] In another study, also of escape trainee submariners, reduced lung compliance was associated with PBT, suggesting that small, stiff lungs are the problem, rather than mild airway obstruction.[11]

There is no good-quality evidence on which to base risk evaluation for asthmatic divers, but some observational surveys suggest that the relative risk for DCI in this group is twice that of non-asthmatics.[12] A case-control study of 196 divers found a 1.98-fold increase in the incidence of AGE in those with current asthma, but this increase was not statistically significant.[13] Asthma was identified as a contributing factor in 8% of 124 diving deaths in Australian and New Zealand divers, the majority of whom had clinically mild asthma.[14] On the other hand, although there is a reported 5% prevalence of asthma in recreational divers in the USA, many asthmatics have been shown to dive without incident and asthmatics are not statistically over-represented in diving fatalities or accidents in other reports.[1,6] For example, only one asthmatic was identified among 2,132 diving deaths in one report from the USA.[15]

Bronchodilator responsiveness and bronchial provocation tests may assist in the evaluation of potentially asthmatic candidates.[1] At POWH, a hypertonic saline challenge was performed in candidates who were not taking medication, but where current asthma was a potential relative contraindication to diving. Individuals with no abnormalities on other tests and who demonstrated normal bronchial reactivity (<15% decrease in FEV_1 after 8 minutes of inhaling nebulised 4.5% hypertonic saline) were usually passed as fit for diving. Regular use of inhaled glucocorticosteroids reduces BHR in asthmatics; therefore a view becoming more widely accepted is that candidates with well-controlled asthma may be fit to dive.[1,15]

Table 3
Presenting problems by age; includes those indicated by the candidate as the reason for referral, but excludes incidental findings on questionnaire or examination; cardiovascular complaints were more common in the older age group (P = 0.03); * includes spine, head injuries and headache

Categories	0–20 years	21–40 years	>40 years
Respiratory (*n* = 52)	2	40	10
Ear, nose or throat (*n* = 59)	2	45	12
Central nervous system* (*n* = 61)	5	45	11
Cardiovascular (*n* = 26)	1	11	14
Musculoskeletal (*n* = 58)	5	37	16
Other (*n* = 107)	11	66	30

Of interest in relation to CAGE, three resort divers in our cohort were referred to us for assessment having developed pneumothoracies while diving. Two had lung bullae detectable by CXR and were made permanently unfit for diving. The third individual, who had no evidence of pulmonary blebs or scars on CT scan, but had suffered a spontaneous pneumothorax three months prior to his visit, was advised to wait another six months before diving. Six candidates had a history of traumatic pneumothorax. Four were recreational divers and only one of these elected to have a high resolution CT scan to look for pulmonary parenchymal or pleural scarring. The CT was normal and that candidate was assessed as fit to dive. The remaining three, and both commercial divers, were assessed unfit.

Dive candidates with the inability to equalise pressure via the Eustachian tube are usually advised not to dive because of the high risk of MEBT and IEBT.[1–3] One candidate suspected of IEBT had three previous episodes of left MEBT, two left tympanic membrane perforations, three diving-related external ear infections and symptoms of vertigo and disequilibrium. Both the diving physician and an ENT specialist advised her not to dive.

Migraines with aura have been associated with the presence of a right to left intracardiac shunt, usually a patent foramen ovale, which, in turn, has been associated with an increased risk of DCI.[16] In addition, headaches that occur during diving can also compromise safety.[17] Individuals with migraines without aura do not typically experience exacerbations related to diving and are not more susceptible to developing DCI.[18]

Epilepsy is a contraindication to diving.[1–3] In this cohort, two recreational dive candidates presented with a diagnosis of epilepsy, but were cleared to dive. A 61-year-old man had a seizure in association with cerebral infarction following an aortic dissection. A further stroke was deemed unlikely by his neurologist, and the risk of DCI estimated to be one to two times the baseline risk given the presence of a cerebral scar. After counselling and risk assessment, he elected to return to recreational diving. Another candidate had been free of petit mal epilepsy for 10 years without medication. Although not consistent with AS4005.1, she was considered ‘fit to dive’ on condition her dive buddy was informed of her medical history. She was advised not to dive below 30 metres’ depth.

Paraplegia is both a disability and an impairment that prevents qualification for a ‘standard’ open water certification. We assessed six paraplegic candidates who were passed fit to undertake instruction in a specifically developed diving programme.

Hypertension was a common presenting cardiovascular problem. Beta-blockers may both limit exercise and predispose to pulmonary oedema and other cardiac events upon immersion.[19] Of the 11 candidates with treated hypertension, two had a history of atrial fibrillation. One was controlled with amiodarone and elected to continue diving after risk assessment, counselling and a recommendation against further diving. The other had suffered a single episode related to caffeine ingestion. A test dive performed to 10 metres’ depth did not result in any problems and he was cleared to dive. Dive candidates with cardiovascular risk factors probably require stress tests to detect ischaemic changes during moderate exercise.[19] These were not performed in a systematic way and we are developing a general policy for future cases.

In this study, we have identified the main triggers for referral to a specialist unit performing fitness to dive assessments, and have quantified the outcomes of those assessments. While we now have a greater understanding of the specific population of dive candidates we serve in this way, this study has a number of limitations. As this was a retrospective study, the data analysed were limited to written records of dive medical assessments, and there was no independent method of verifying the accuracy of the recorded information. This also meant it was not possible to assess whether candidates omitted certain health conditions from their dive medical questionnaire. It is our intention to commence a prospective collection of information in this area in order to provide a more complete and accurate characterisation of these individuals.

In this cohort, dive candidates presented with a variety of medical conditions, many of which were associated with respiratory concerns for FTD, in particular asthma. Despite the current SPUMS advice and the AS4005.1, more than half of those with a possible history of asthma were assessed as fit to dive. This suggests that a substantial proportion of those labelled as asthmatic require further investigations, rather than a blanket response of being unfit to dive. Further, we have documented the development of a more permissive approach that may allow both those with quiescent or well-controlled asthma to dive. A similar approach has been adopted in the latest update to the SPUMS advice to doctors performing dive medicals. This approach is broadly in line with those recommended elsewhere.[6] It is possible that similar approaches may be taken with other medical complaints that have traditionally been accepted as absolute contraindications to diving.

References

1 Mitchell SJ, Bennett MH. Clearance to dive and fitness to work. In: *Physiology and medicine of hyperbaric oxygen therapy*. Neuman T, Thom S, eds. Philadelphia: Saunders; 2008. p. 65-94.

2 AS 4005.1. *Training and certification of recreational divers.* Standards Australia. Strathfield, NSW: Standards Australia International; 2000.

3 AS/NZS 2299.1 Supplement 1:2007. *Occupational diving operations supplement 1: 2299: diving medical examination forms*. Standards Australia. Strathfield, NSW: Standards Australia International; 2007.

4 Edmonds G, Lowry C, Pennefather J, Walker R. Barotrauma. In: *Diving and subaquatic medicine*, 4th ed. London: Hodder Arnold; 2002. p. 55-110.

5 Tetzlaff K, Friege L, Reuter M, Haber J, Mutzbauer T, Neubauer B. Expiratory flow limitation in compressed air divers. *Eur Respir J*. 1998;12:895-9.

6 Godden D, Currie G, Denison D, Farrell P, Ross J, Stephenson R. British Thoracic Society guidelines on respiratory aspects of fitness for diving. *Thorax*. 2003;58:3-13.

7 Blatteau JE, Boussuges A, Gempp E, Pontier JM, Castagna O, Robinet C, et al. Haemodynamic changes induced by submaximal exercise before a dive and its consequences on bubble formation. *Br J Sport Med*. 2007;41(6):375-9.

8 Tetzlaff K, Reuter M, Leplow B, Heller M, Bettinghausen E. Risk factors for pulmonary barotrauma in divers. *Chest*. 1997;112:654-9.

9 Francis J. Pulmonary fitness to dive. *SPUMS Journal*. 2001;30(4):221-6.

10 Benton PJ, Woodfine JD, Francis TJR. A review of spirometry and UK submarine escape training tank incidents (1987–93) using objective diagnostic criteria. In: Elliot DH, ed. *Are asthmatics fit to dive?* Kensington, Maryland: Undersea and Hyperbaric Medical Society; 1996. p. 17-30.

11 Colebatch HJH, Ng CKY. Decreased pulmonary distensibility and pulmonary barotrauma in divers. *Respir Physiol*. 1991;86:293-303.

12 Gorman D, Veale A. SPUMS policy on asthma and fitness for diving. *SPUMS Journal*. 1995;25:213-5.

13 Corson KS, Dovenbarger JA, Moon RE, Bennett PB. Risk assessment of asthma for decompression illness. *Undersea Biomed Res*. 1991;18:16-7.

14 Edmonds C. Asthma and diving. Some observations and thoughts. *SPUMS Journal*. 1991;21(2):70-4.

15 Neuman TS, Bove AA, O'Connor RD, Kelsen SG. Asthma and diving. *Ann Allergy*. 1994;73:344-50.

16 Wilmshurst P, Nightingale S. Relationship between migraine and cardiac and pulmonary right-to-left shunts. *Clin Sci (Lond)*. 2001;100:215-20.

17 Cheshire WP, Ott MC. Headache in divers. *Headache*. 2001;41:235-47.

18 Neuman TS. Near drowning. In: Bove AA, editor. *Diving medicine*. 3rd ed. Philadelphia, PA: Saunders; 1997. p. 218.

19 Bove AA. Cardiovascular problems and diving. *SPUMS Journal*. 1996;26:178-86.

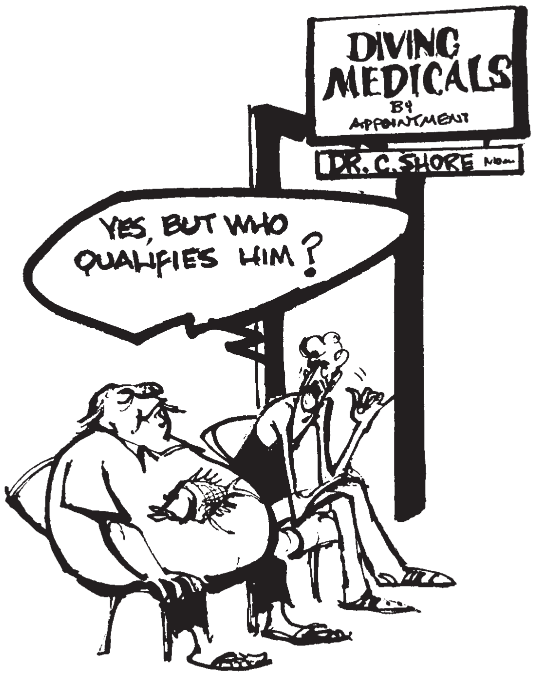
Conflict of interest: None

Submitted: 28 October 2009
Accepted: 10 July 2010

Lin Min Ong, is a sixth-year medical student at the Prince of Wales Clinical School, Faculty of Medicine, University of New South Wales. This paper was presented for her 'Independent Learning Project' in 2008.
Conjoint Associate Professor Michael H Bennett, FANZCA, CertDHM (ANZCA), MD, is a specialist in diving and hyperbaric medicine, and
Professor Paul S Thomas, FRACP, MD, is a specialist in respiratory medicine, Prince of Wales Hospital, Randwick, Australia.

Address for correspondence:
Professor Paul S Thomas
Department of Respiratory Medicine, Prince of Wales Hospital
Randwick NSW 2031, Australia
Phone: *+61-(0)2-9382-4620*
Fax: *+61-(0)2-9382-4627*
E-mail: *<paul.thomas@unsw.edu.au>*

Cartoon by Peter Harrigan originally published in the *SPUMS Journal*. 1985;15(1).



Provisional report on diving-related fatalities in Australian waters 2005

Douglas Walker, John Lippmann, Christopher L Lawrence, Andrew Fock, Thomas Wodak and Scott Jamieson

Key words
Diving deaths, scuba, breath-hold diving, surface-supply breathing apparatus (SSBA), diving accidents, case reports

Abstract
(Walker D, Lippmann J, Lawrence CL, Fock A, Wodak T, Jamieson S. Provisional report on diving-related fatalities in Australian waters 2005. *Diving and Hyperbaric Medicine*. 2010;40(3):131-149.)
Introduction: An individual case review of diving-related deaths reported as occurring in Australia in 2005 was conducted as part of the DAN Asia-Pacific dive fatality reporting project.
Method: The case studies were compiled using reports from witnesses, the police and coroners. In each case, the particular circumstances of the accident and details from the post-mortem examination, where available, are provided.
Results: In total, there were 24 reported fatalities, comprising four females and 20 males. Fourteen deaths occurred while snorkelling and/or breath-hold diving, nine while scuba diving, and one while using surface-supply breathing apparatus. Four deaths from large marine animal attacks were recorded. Once again, cardiac-related issues were thought to have contributed to some deaths: five snorkel divers and at least two but possibly up to four scuba divers. Three of the deaths in breath-hold divers were likely to have been associated with apnoeic hypoxia blackout.
Conclusions: Pre-existing medical conditions, trauma from marine creatures and snorkelling or diving alone were features in several deaths in this series.

Introduction

Tragically each year in Australia (and elsewhere), there are numerous fatalities associated with compressed-gas diving and snorkelling. Some of these accidents are unavoidable. However, many fatalities might have been avoided through better education, greater experience, appropriate medical screening, better equipment maintenance and design or common sense. The aim of the DAN Dive Fatality Reporting Project (incorporating Project Stickybeak) is to educate divers and the diving industry and to inform diving physicians on the causes of fatal dive accidents in the hope of reducing the incidence of similar accidents in the future and of detecting, in advance, those who may be at risk. This report includes the diving-related fatalities between 1 January and 31 December 2005 that are recorded on the DAN Asia-Pacific (AP) database. When an accident is unwitnessed, it is often difficult to determine exactly what has occurred. We have sometimes included considered speculation within the comments to provoke thought about the possible sequence of events.

Methods

As part of its on-going research into, and reporting of, diving fatalities in Australia and elsewhere in the Asia-Pacific region, DAN AP has obtained ethics approval from the Human Research Ethics Committee, Department of Justice, Government of Victoria, Australia to access and report on data included in the Australian National Coronial Information System (NCIS). The methodology used for this report was identical to that described previously for the 2004 Australian diving-related fatalities.[1]

Snorkelling and breath-hold fatalities

BH 05/01

The victim, a 60-year-old female overseas visitor, was with a group but unknown to any of them. While on a day trip to an island she hired mask, snorkel, fins and a floatation vest and went to an unsupervised section of the beach, to swim alone. She was found floating face-down about 100 metres from the beach. When seen, she was initially thought to be snorkelling, but witnesses then thought she seemed to be in trouble. No details of what they observed are reported. Staff were alerted and, after a delay, one entered the water and brought the victim back to the beach. She had the snorkel in her mouth when she was reached but was unconscious and cyanotic. Resuscitation efforts by staff, including semi-automated defibrillation, and advanced life support (ALS) by paramedics, were unsuccessful.

Autopsy: Autopsy revealed oedematous lungs (R 768 g, L 606 g) consistent with a diagnosis of drowning; the right pleural cavity was almost obliterated by fibrous adhesions. The heart weighed 276 g and was normal with mild coronary atherosclerosis. The cause of death was given as drowning due to salt water immersion.

Comment: Nothing is recorded of her health, swimming ability or experience in the use of a snorkel prior to the

Table 1. Summary of snorkelling
BNS – buddy not separated; BSB – buddy separated before problem; BSD – buddy separated during problem; n/s – not stated;

ID BH	Age	Gender	Height (m)	Weight (kg)	BMI	Training	Experience	Dive group
05/01	60	F	1.62	60	22.9	n/s	n/s	Solo
05/02	26	M	n/s	n/s	n/s	trained	yes	GSB
05/03	63	M	1.78	81	25.6	nil	nil	GNS
05/04	40	M	1.93	87	23.4	nil	yes	Solo
05/05	37	M	1.80	77	23.8	trained	yes	BSB
05/06	51	F	n/s	n/s	n/s	n/s	n/s	Solo
05/07	42	M	1.77	75	23.9	trained	yes	Solo
05/08	21	M	1.87	71	20.3	trained	yes	Solo
05/09	59	M	n/s	n/s	n/s	nil	nil	BNS
05/10	30	M	1.65	56	20.6	nil	nil	BSD
05/11	59	M	1.72	70	23.7	nil	nil	BNS
05/12	65	M	1.83	83	24.8	nil	yes	BSB
05/13	76	M	1.80	112	34.6	n/s	n/s	BSB
05/14	35	F	1.59	54	21.4	n/s	n/s	Solo

incident. The float vest failed to prevent her from floating face-down and drowning. She was wearing a bathing costume so it is probable the water was not cold. It is likely that she aspirated water through the snorkel and subsequently drowned. She was not snorkelling with a buddy and was not directly supervised.

Summary: Solo snorkelling in calm water; unknown experience; wore floatation device but floated face-down when unconscious; drowning (possibly due to inexperience with snorkel use).

BH 05/02

This victim was a 26-year-old male, an experienced snorkeller and scuba diver, working as skipper of a luxury charter boat on its maiden voyage. The vessel was anchored at one of a group of offshore islets where the water depth rapidly increased from 5 metres' seawater (msw) close to the shore to 50 msw. Some of the passengers and crew were fishing but it is unclear whether this was done directly from the boat or elsewhere. After completing some tasks on the boat, the victim and four of the crew snorkelled close to the boat; two drifted away and two left the water, leaving the victim alone. Some staff on the boat then saw the white underbelly of a large shark and a cloud of blood in the water. The victim had been bitten in half and the shark had carried away the lower portion of his body. His torso floated away, but the shark returned and appeared to make a strike about 100 metres from the boat, after which the torso could no longer be seen. One of the crew, a shark fisherman, thought it was a great white shark and estimated it to be about six metres or more in length. None of the victim's remains were recovered. No berley had been put into the water by the fishermen and none of the snorkellers were spear fishing. It was, however, the start of the crayfishing season when sharks are known to frequent the area.

Autopsy: The body was not recovered. The coroner found that the victim died as the result of an attack by a great white shark and that death occurred by accident. The cause of death was given as multiple injuries due to shark attack.

and breath-hold diving-related fatalities
GNS – group not separated; GSB – group separated before; n/a – not applicable; n/i – not inflated; recrn – recreational dive

Dive purpose	Depth (msw)	Incident (msw)	Weight belt	Wts (kg)	BCD	Disabling agent
recrn	n/s	surface	nil	n/a	nil	Asphyxia
recrn	n/s	surface	nil	n/a	nil	Trauma (shark)
recrn	n/s	surface	nil	n/a	aid	Cardiac
recrn	12	n/s	nil	n/a	nil	Asphyxia ?hypoxic blackout
recrn	n/s	surface	nil	n/a	nil	Trauma (crocodile)
recrn	n/s	surface	n/s	n/s	n/s	Cardiac
abalone	4	n/s	on	5.5	nil	Asphyxia ?hypoxic blackout
recrn	1.5	1.5	on	n/s	nil	Asphyxia ?hypoxic blackout
recrn	0.5	surface	nil	n/a	float	Cardiac
recrn	2.5	surface	nil	n/a	nil	Asphyxia
recrn	n/s	surface	nil	n/a	aid	Cardiac
spearfishing	n/s	surface	on	5.5	nil	Asphyxia
recrn	n/s	surface	nil	n/a	nil	Cardiac
recrn	n/s	n/s	nil	n/a	nil	Asphyxia ?hypoxic blackout

Comment: Although it was known that sharks frequented this area during the crayfish season, there was no evidence that the victim had collected crayfish or precipitated this shark attack in any way. It is possible that the nearby fishing might have attracted a shark to the area, but this is speculative.

Summary: Sudden lethal shark attack on snorkeller close to deep-water drop off.

BH 05/03

This overseas visitor was a 63-year-old male who had suffered a myocardial infarction (MI) 10 years earlier and had undergone regular medical checks since then. He was taking three unidentified medications but had not been advised of any restrictions to his activities. He was a weak swimmer and had never snorkelled before. He and his wife were on a commercial snorkelling day trip to the Great Barrier Reef (GBR). During the outward trip the passengers were briefed on snorkelling safety, in which health risks were mentioned. There was also a poster about medical risks on display. The victim did not report his health issues. The weather was fine, with only a slight surface chop. After the vessel moored at the reef, the passengers were issued lycra suits, mask, fins and snorkel, and 'noodles' (floatation devices). The victim was given three noodles, one under each arm, the third to be held in front of his body, then snorkelled close to the vessel with his wife. He had some problems breathing through his snorkel and was advised that he did not have to use it but could hold his breath and look down, looking up to breathe as required. After about 15 minutes, he returned to the vessel and sat on the duckboard where his wife and several other snorkellers were sitting.

Several minutes later the victim said that he felt unwell and collapsed backwards. He was unconscious, apneic and had no palpable pulse. Basic life support (BLS) was commenced using a bag-valve-mask until oxygen equipment was brought from another vessel. Resuscitation was continued until the rescue helicopter arrived and the paramedics pronounced him dead.

Autopsy: The autopsy showed his heart weighed 439 g and there was severe triple-vessel atherosclerosis with complete occlusion of the left anterior descending coronary artery and an extensive old scar in the anterior apical left ventricle (55 x 25 x 2 mm) due to the previous acute myocardial infarction. The lungs (R 912 g, L 725 g) were oedematous and congested with pulmonary oedema fluid in the bronchi. The cause of death was given as cardiac arrhythmia in consequence of myocardial fibrosis the result of severe coronary artery atherosclerosis. Only the official summaries of witness depositions are available, not their statements, so his actual health status is unknown.

Comment: The cause of death was clearly ischaemic heart disease. The lung changes were similar to cases where a diagnosis of drowning was made; however, he was out of the water when he collapsed. Nothing in his history would suggest he experienced salt water aspiration . This highlights the nonspecific pathological changes of drowning. A person with a previous infarct and this degree of ischaemic heart disease is clearly at risk of sudden death during exertion despite being declared fit to travel.

Summary: Previous heart attack; recent medical assessment as fit to travel, but no information on recent health; short period of snorkelling in non-stressful conditions, left water then reported feeling unwell and died; cardiac incident.

BH 05/04

This victim, a 40-year-old male overseas visitor, was a guest on a liveaboard vessel offering diving and snorkelling on the GBR. He stated he had no medical problems, was able to swim 5 km and that he could breath-hold dive to 10–20 msw and hold his breath for up to 2–4 minutes. The pre-snorkelling talk emphasised the dangers of hyperventilation and the importance of always diving with a buddy. On the first day, he spent 45 minutes snorkelling with others, and then took a Resort Scuba Dive after completing another medical questionnaire.

On the second day, there was another briefing, after which the victim told one of the supervisors he intended to breath-hold dive down to join the scuba divers when they were at 18 msw. He was told that would be unsafe and that he should remain in the shallower areas. He was later seen within a few metres of them at 15 msw. Following this he was seen free-diving alone near the stern. Possibly five minutes later two scuba divers surfaced and reported seeing a person on the sea bed below. The instructor immediately donned scuba gear, dived and brought the victim to the surface from a depth of 12 msw. His mask was in place but there was no snorkel. In-water rescue breathing was followed by on-board BLS with supplemental oxygen, but there was no response. Although the crew held oxygen-provider certifications, they were untrained in the use of the bag-valve-mask equipment carried on the boat. However, there is nothing to suggest that this influenced the outcome.

Autopsy: Autopsy revealed heavy oedematous lungs (R 877 g, L 856 g) consistent with drowning. The heart weighed 425 g (normal, given his size) and there was mild coronary atherosclerosis. The story is typical of post-hyperventilation apneic hypoxia. The cause of death was given as drowning due to probable apneic hypoxia following hyperventilation.

Comment: This again highlights the risks of extended breath-hold diving, especially without a vigilant buddy nearby.

Summary: Experienced breath-hold diver; solo breath-hold diving to at least 12 msw against advice; drowning (possibly due to post-hyperventilation apneic hypoxia).

BH 05/05

Although locals were well aware of the presence of numerous crocodiles and the danger they constituted, it was common practice, even by members of the local police, to swim in the waters off this beach. This victim, a 37-year-old male, had lived in the area for about six months and had been warned of the danger, but also was aware of the local practice. On this day, he was intending to snorkel with a friend while their wives remained on the beach. He was reportedly an avid scuba diver and strong swimmer. Although the two men became separated, this was not noticed as being of any significance until some time later when, after searching up and down the beach for him without success, his buddy became concerned and informed the police. The victim had been swimming close to the beach when last seen, but a full-scale search, involving air, sea, and beach searchers, was unsuccessful. The next day his body was found near a large saltwater crocodile, approximately 1.5 km from where he had been snorkelling. The crocodile was shot by the police.

Autopsy: The autopsy revealed the presence of numerous lacerations and punctate tricorn wounds on the face, scalp, trunk and shoulders, and fractures of the frontal and right temporal bones, a midline skull fracture and multiple fractures of the mandible. There was little associated haemorrhage and no intracranial haemorrhage or damage to the brain. The trachea, bronchi and stomach contained sand and gravel. The pathologist concluded that the cause of death was multiple injuries due to crocodile attack but noted a relative lack of haemorrhage associated with the fractures. This can occur due to leaching of the blood and decomposition during immersion. The mechanism of death could have been blood loss, asphyxia or terminal drowning. However, despite the presence of sand and gravel in the airways, lungs and stomach, the pathologist found no evidence that drowning was the primary cause of death.

Comment: A notice had been posted 10 days before this fatality, warning of the sighting of a crocodile in the wharf area and that there was increased risk from crocodiles with the approach of the wet season.

Summary: Snorkelling in area known to have a risk from crocodiles; local tolerance of the risk; lethal trauma.

BH 05/06

A 51-year-old overseas tourist and her husband were staying at a small island resort and decided to snorkel from the beach. She was wearing a wetsuit. After a time, her husband felt cold and swam back to the shore. He looked back, and saw his wife waving her arms in the air as if in trouble. He ran to get a kayak and to raise the alarm. She was said to have been caught in a strong current and required to swim vigorously just before she signalled for help. Meanwhile, another person (a doctor) staying at the resort saw the victim's trouble and swam out and brought her back to the beach. Initially she was gasping for air and cyanotic but when brought ashore was soon unconscious and apneic. BLS was unsuccessful.

Autopsy: The autopsy showed that "*the condition of her heart was not good*"; the cause of death was given as a coronary artery occlusion. Her medical history and specific autopsy findings are unknown as this was a 'natural' death and so did not require coronial notification.

Comment: The cause of death may have been from ischaemic heart disease but drowning may also have contributed. Such cases are uually reported to the coroner so that it can be established if the death was natural, i.e., due to ischaemic heart disease, or accidental, i.e., due to drowning or a combination of the two.

Summary: Health history unknown; snorkelling; buddy went ashore due to cold water; strong current; cardiac incident.

BH 05/07

The victim, a fit 42-year-old male, was an experienced snorkeller who usually dived alone. He called his wife to tell her that he was going spearfishing. When he failed to pick up his child from school, she became concerned. After finding his car where he usually parked it when diving, she called the police. The police found his backpack and clothing on a rock near where he would likely have entered the water, and later retrieved a buoy, with his catch bag and spear gun attached, about 50 m from the shore and close to a reef. By this time it was too dark to continue their search. The next day police divers found his body at a depth of 4 msw, about 50 metres south of where the buoy had been and 30 metres from the beach. He was on the sea bed in a sandy area close to a rock that nearly broke the surface: Visibility was 3–4 metres. There was thick kelp in the area. He was wearing two wetsuits, neoprene hood and bootees, a weight belt, mask and snorkel, and two pair of gloves. The water temperature was reported to be 9^{O}C.

Autopsy: The pathologist noted that his weight belt was old fashioned and its clasp had no quick release. There was evidence of mask squeeze with some blood around the face. The lungs were over-expanded and oedematous (R 1022 g, L 836 g) with pulmonary oedema in the upper airways and bronchi consistent with drowning. The heart weighed 340 g and there was a 50% stenosis of the right coronary artery (generally insufficient to cause death). He had a history of asthma and had histological changes consistent with asthma, which had reportedly not troubled him for years. There was no evidence of any asthma factor in his death. The cause of death was given as drowning while snorkelling.

Comment: His wife reported he had not gone snorkelling during the previous four weeks because of URTI symptoms. He had been taking long-term medication since a workplace accident resulted in him developing a hernia, which had not been operated upon. He drowned, but the precipitating factors for drowning are unclear. Possible factors include no quick release on his weight belt, possible hypoxic blackout of ascent as he had been diving for abalone in 4 msw, entanglement in kelp (although his body was not entangled when found), cold water (9^{O}C), the 50% coronary artery stenosis, or other unknown factors.

Summary: Experienced, solo breath-hold diving for abalone and fish; cold water; depth insufficient to require prolonged apnea unless determined to target a fish; drowning.

BH 05/08

This healthy 21-year-old overseas male was visiting his grandmother in Australia. He was a scuba diver with a keen desire to improve his breath-holding ability, which he claimed was three and a half minutes. He practised in his grandmother's swimming pool each morning and evening. His grandmother found him lying motionless on the pool bottom, wearing goggles and a weight belt. She called for help and her next-door neighbour arrived before she collapsed from an acute myocardial infarction. The victim was removed from the pool, but no resuscitation was attempted prior to the arrival of paramedics. He did not regain consciousness and life support was turned off three days later. His dive watch indicated that he had been underwater for over 19 minutes before he was discovered.

Autopsy: No autopsy was performed at the request of the parents. The cause of death was stated to be "*hypoxic brain injury due to near drowning*".

Comment: This was very likely a drowning due to post-hyperventilation apneic hypoxia.

Summary: Scuba diver; alone in pool, training to increase breath-hold; weight belt on; delayed drowning death (possibly due to post-hyperventilation apneic hypoxia).

BH 05/09

Minimal details are available concerning the fatality of a 59-year-old man with a history of hypertension and cardiac disease. He was visiting Australia with his wife and took a day trip to the GBR. During the outward trip, the passengers were given written advice on snorkelling and advised to report any medical conditions, advice that he followed. They were taken to an island and the victim, with two others, started to snorkel off the beach. A short time later a crew member on safety watch saw him being assisted in very shallow water. He was cyanotic and coughing up water. He was assessed to be unconscious, apneic and pulseless and BLS was attempted without success. In view of his medical history, there was no referral to the coroner and no autopsy was performed. No further details of his medical condition or medications are available.

Comment: The likely cause of death was ischaemic heart disease while snorkelling, with exertion triggering a lethal arrhythmia. There may have also been terminal drowning.

Summary: History of hypertension and cardiac disease; snorkelling in shallow, calm water; cardiac incident.

BH 05/10

The tragic death of this 30-year-old male overseas visitor on his honeymoon occurred during a day trip to an island on the GBR. He was described by his wife as an adequate swimmer who had snorkelled on two or three previous occasions. After a seemingly large lunch, the couple hired masks, fins and snorkels and began to snorkel in an unsupervised area approximately 30–40 metres from shore. They were wearing normal bathing costumes. The weather was fine, sea calm and there was reported to be no current. The water depth was approximately 2.5 msw. Possibly 20 other swimmers and snorkellers were in the water, but none were close to them. When out of their depth, the victim began to panic, grabbed his wife and nearly drowned her as she attempted to help him. She later reported that he may have swallowed water and was attempting to keep his head above the surface by trying to climb on top of her. She tried to calm him and they separated briefly as she signalled for help. She became exhausted and briefly became unconscious.

At this time, the resort manager noticed one of the people in the water behaving strangely, seeming to swim backwards in circles, and he instructed two staff members to swim out to assist. The victim's wife was motionless in the water, but breathing and she was brought back to the beach where oxygen was administered. Thirty minutes later an interpreter found that she had been trying to tell the staff that her husband had been swimming with her. A search was immediately made for him in the water and his body was found floating above the sea bed close to where she had been found. BLS was commenced but the rescuers were hindered by frequent regurgitation of stomach contents. Despite this, resuscitation was continued for 45 minutes until paramedics attended and declared the victim dead.

Autopsy: Autopsy showed oedematous lungs (R 690 g, L 687 g) consistent with drowning, a heart that weighed 304 g with no atherosclerosis. The cause of death was given as drowning following inhalation of water, and panic.

Comment: His wife said he was not scared of water and could swim; the probable reason for his panic was his reaction to water unexpectedly inhaled via his snorkel. Although there was a notice warning that there were no lifeguards on the beach, it was in English, which the couple did not speak. Although the woman waved her arms to attract attention, she did not call out, delaying the rescue response.

Summary: Minimal snorkelling experience; calm water; possible aspiration of water through snorkel, causing sudden panic exacerbated when found water too deep to stand up in; buddy at severe risk from victim's actions; drowning.

BH 05/11

This 59-year-old male overseas tourist had suffered an asymptomatic MI many years previously but had led an active life with no apparent cardiac symptoms. He was taking medication of unknown type for hypertension and high cholesterol. He and his family were visiting the GBR and had joined a day trip to go snorkelling. It is not known if he had prior snorkelling experience. During the trip out, a talk on snorkel use was given to the passengers. According to the local Code of Practice, cautionary advice should have been provided specifically for older persons or for those with heart conditions. An information form, usually available for this purpose, was not used on the day. Passengers were asked to tell the staff if they were poor swimmers or had any other possible problems, but health factors were not specifically mentioned. Poor swimmers were advised to wear a wet suit and use a floatation device.

The boat, carrying nine passengers, anchored and put its two tenders in the water. Passengers were offered the use of wetsuits, along with mask, snorkel and fins, which the victim accepted. A dive master member of the crew watched from the stern as the passengers entered the water. She asked the victim if he was a good swimmer and he replied that he was okay, although his wife later claimed that earlier that day they had told a crew member they were not strong swimmers and needed assistance. In fact, the dive master noted he had a 'noodle' (floatation device) and was not managing the current, so gave him a ring to hold and towed him to the shallows over the reef. When they had gone about 25 metres, his wife asked him how he was going and he replied "*this is different*" (from a swimming pool), and agreed that he would like to return to the boat. When they were about 10 metres away from the boat, the victim raised his head, lifted his mask, dropped face first into the water and let go of the ring. She turned him on his back to keep his face above water and called for help. She noticed that his jaw was clenched, his tongue was between his teeth and he appeared to "*jolt a couple of times*". Other crew entered the water and brought the victim aboard the vessel, where BLS with supplemental oxygen was promptly commenced, assisted by doctors and a nurse who were passengers on board. An emergency helicopter arrived, but the victim was dead and his body was transported to hospital.

Autopsy: A CT scan revealed no evidence of barotrauma. The heart weighed 404 g with severe triple-vessel atherosclerosis, with 75–90% stenosis. There was evidence of old infarction with scarring of the apical-posterior left ventricle and interventricular septum. There was no evidence of trauma. The cause of death was reported as acute cardiac failure.

Comment: The history of a 'silent' MI raises the question as to whether the victim failed to recognise angina symptoms or had atypical symptoms. It is unlikely that he did not have some symptoms with such severe coronary artery disease.

Summary: History of a 'silent' MI many years earlier; taking unidentified medication for hypertension and for cholesterol control; appeared fit; poor swimmer using floatation aid; current; severe coronary artery disease; cardiac incident.

BH 05/12

The uncertainty in reconstructing circumstances where there are no witnesses to critical events is well illustrated in this incident. The victim, a 65-year-old male, with a history of epilepsy, was an experienced spear fisherman who was fishing with a friend in an area with which they were familiar. They had been in the water approximately 1.5 hours when the buddy indicated he was going back to shore to clean his catch; the victim said he would follow shortly.

A fisherman on the rocks had first noticed two men on the surface, one swimming towards the shore as the other dived. He did not see this diver return to the surface so assumed he had surfaced beyond the headland. There was reported to be a submerged rock close to where the victim was last seen. A small boat came into view about 100 metres out. The driver of this boat later reported that he had been travelling at a speed of about 4 knots. The sea was described as calm but with a strong current. The buddy said it took him 20 minutes swimming from when they separated until he reached the beach and left the water.

It was only when the buddy had finished cleaning his catch, about 30 minutes later, that he noticed his friend had not returned. He could not see him from the beach, but when he walked along the headland he could see something floating in the water about 100 metres from the shore. He saw it was drifting towards an anchored boat from which another man was spear fishing. He called out and managed to get his attention, and that of another person in the boat, who then saw the victim's body moving in the strong current. The spear fisherman swam to the victim and, with assistance, pulled him aboard. It was obvious that the victim was dead. After picking up the buddy, they brought the body back to shore. When found, the victim was wearing his mask, snorkel, wetsuit, weight belt, fins and also a net catch bag attached by a rope. Although a search was made, his spear gun was never found. He was not using a float or dive flag.

Autopsy: At autopsy a laceration was observed on the back of the head with a 100 mm bruise under the scalp. There was also an abrasion on the bridge of the nose probably caused during retrieval of the body. There was no skull fracture, intracranial haemorrhage or damage to the brain. The heart was slightly enlarged, weighing 390 g. Mild atheroma was present in the right coronary artery only. The cause of death was given as drowning.

Comment: Three possible underlying causes for this drowning can be considered:

- Superficial head injury from impact with rocks or a boat could have led to altered consciousness and/or inhalation of water. The cause of the head injury is uncertain. If he had been hit by a boat there would probably have been more extensive injury, especially if struck by the propeller. The two boats known to have been in the area were not thought to have been implicated.
- Seizure activity: There was a history of six grand mal episodes in 1998, for which he had been fully investigated and no cause found. He had had no further seizures, was retired and now taking regular carbamazepine (at autopsy blood level was therapeutic, 3.4 mg L^{-1}). There was no direct evidence, such as biting his tongue, to suggest this condition played any part in his death.
- Apneic hypoxia of ascent, with or without hyperventilation.

The spear fisherman who recovered the body was an off-duty police officer and had seen many dead bodies. He estimated that the victim appeared to have been dead for about an hour when the body was recovered.

Summary: Experienced spear fisherman; solo after buddy swam to land; on medication for epilepsy; evidence of fresh head injury; no dive flag; boats in area; drowning.

BH 05/13

The victim was a 76-year-old male with a history of aortic valve replacement, coronary bypass and cardiac stent insertion. Although he was taking medication for hypertension and hyperlipidaemia, there was no record of his recent health. He and several friends went snorkelling from a boat. After 5–10 minutes, he signalled that he wished the boat to pick him up and started to swim towards it. When he climbed aboard he was breathless, and said he was feeling tired, which was the reason for his return. About 10–15 minutes later a crew member found him slumped over, unrousable, apneic and pulseless. BLS, with supplementary oxygen, was commenced while the boat headed ashore, transferring him en route to another boat

Table 2. Summary of scuba and surface-supply diving-related
BNS – buddy not separated; BSB – buddy separated before problem; BSD – buddy separated during problem; GNS – group not separated; GSB – group separated before; GSD – group separated during; CAGE – cerebral arterial gas embolism

ID	Age	Gender	Height (m)	Weight (kg)	BMI	Training	Experience	Dive group
SC								
05/01	71	M	1.70	104	36.0	trained	expcd	GSB
05/02	52	M	1.84	98	28.9	trained	some	BNS
05/03	39	M				trained	expcd	GSB
05/04	45	M	1.88	120	34.0	trained	nil	GNS
05/05	30	F	1.64	n/s		trained	some	BNS
05/06	23	M				trained	expcd	BSD
05/07	67	M	1.60	57	22.3	trained	expcd	GSB
05/08	45	M	1.83	87	26.0	trained	expcd	BSD
05/09	51	M	1.68	83	29.4	trained	expcd	BSB
SS								
05/01	55	M	1.70	92	31.8	trained	expcd	BSB

with a defibrillator. On arrival, ALS from waiting paramedics was unsuccessful.

Autopsy: Autopsy revealed a large heart (780 g) with left ventricular hypertrophy and a porcine aortic valve graft showing calcification. There was severe narrowing of the native coronary arteries by atherosclerosis, with a recent thrombus in the left anterior descending and a stent in the circumflex. Venous bypass grafts showed sclerosis. The cause of death was given as acute coronary artery thrombosis due to ischaemic heart disease and aortic stenosis (surgically treated).

Comment: This event could have occurred in many different circumstances, with or without exertion.

Summary: History of aortic valve and coronary arteries bypass surgery; reportedly now 'fit and active'; became breathless while snorkelling; cardiac incident.

BH 05/14

A 35-year-old female overseas tourist was staying at a hostel or similar accommodation with a residents' swimming pool. A man was sitting beside the pool, looking after his two children swimming in the pool. He noticed a towel and some clothing on a chair. Thinking it indicated that someone else must be in the pool but seeing no-one on the surface, he became curious, walked to the poolside and saw the victim lying face-down on the bottom of the pool with her arms folded across her chest, wearing goggles and snorkel. He thought she was training to hold her breath but soon realised she had been holding her breath far too long. He jumped into the pool and nudged her. When there was no response he grabbed her, brought her to the shallow end of the pool and pulled her out. He then phoned for help. Resuscitation was commenced only after the arrival of an ambulance a few minutes later, and she failed to respond.

Autopsy: Autopsy revealed oedematous lungs (R 808 g, L 725 g) with some pulmonary oedema fluid in the trachea and bronchi consistent with drowning. The heart weighed 304 g and was normal with minimal coronary arteriosclerosis. Toxicology showed no trace of alcohol or recreational drugs. Nothing is known of her personal history. There is no evidence concerning how long she had been in the pool before being discovered. The cause of death was drowning, possibly due to post-hyperventilation apneic hypoxia.

Comment: The sparse documentation of this fatality is devoid of details of the victim's personal history although the ascribed cause of her death is almost certainly correct.

Summary: Found dead in a swimming pool; drowning (probably as a result of post-hyperventilation apneic hypoxia).

fatalities in Australian water in 2005
++ 1/4–1/2; + sufficient air (to surface safely); expcd – experienced; recrn – recreational dive;
n/s – not stated; nad – nothing abnormal discovered; dns – defect not significant; n/a – not applicable;
n/i – not inflated;

Dive purpose	Depth (msw)	Incident (msw)	Wt belt	Wts (kg)	BCD	Remaining air	Equip test	Disabling injury
recrn	32.5	ascent	on	n/s	part infl	low	n/s	CAGE? cardiac?
recrn	20	ascent	on	n/s	inflated	++	nad	CAGE? cardiac?
cray	21	n/s	off	n/s	inflated	nil	nad	CAGE? asphyxia?
class	53	surface	n/a	n/a	n/a	n/a	dns	DCS
recrn	5.2	3.6	on	5.4	n/i	++	nad	Asphyxia? CAGE?
work	18	5	on	n/s	n/i	+	nil	Trauma (shark)
recrn	25	surface	off	n/s	n/s	low	nil	Cardiac
recrn	9	ascent	on	8	fail infl	nil	n/s	CAGE? asphyxia?
crayfish	n/s	surface	off	n/s	inflated	+	nad	Cardiac
work	n/s	n/s	on	n/s	n/s	n/a	n/s	Trauma (crocodile)

Scuba fatalities

SC 05/01

The victim, an obese but apparently fit 71-year-old male overseas visitor, was on a liveaboard dive vessel on the GBR. He had a history of 300 dives, although he had not dived during the previous two years. He claimed to have obtained a 'diving medical' within the previous three months and reported no adverse health conditions although he was taking an unidentified medication.

The victim was dressed in a wetsuit jacket and bathing costume and was using his own equipment, other than the tank, weight belt and dive computer, as his was found to be faulty. The sea was described as 'a bit choppy', visibility 'not good', and there was some current. The victim was buddied with two other divers who were judged to have a similar level of diving experience. The dive plan was for them to swim on the surface to the reef, and then start their dive. However, shortly after the trio entered the water, the victim dived and the other two followed. Although he had been told not to dive deeper than 18 msw on this dive, the dive computer he was wearing later showed a maximum dive depth of 32 msw.

The trio found they were over a sandy sea bed and could not locate the reef so, after 13 minutes, they began their ascent. Although the victim's ascent rate alarm sounded on two occasions, indicating that his ascent rate exceeded 10 m min^{-1}, there is no indication that his rate of ascent was excessive. He spent two minutes at a safety stop at 7 msw before surfacing, the ascent alarm being triggered again during this final ascent.

At the surface, the three divers exchanged 'OK' signals. They were several hundred metres from the boat and decided to swim back on the surface although a tender was sent to pick them up. After collecting two other groups of divers and returning them to the vessel, the tender driver noticed the victim lying on his back, mask and snorkel missing, BCD partly inflated and weight belt and fins in place. He was unresponsive and cyanotic, with froth coming from his mouth. The tender driver was unable to lift the victim into the tender so he returned to the vessel for assistance. The victim was lifted into the tender and BLS commenced. It was continued on the dive vessel until the staff received medical advice to cease. The air contents gauge was noted to show 55 bar.

Autopsy: A CT scan performed two days after death showed the presence of gas in the vasculature throughout the body. The autopsy revealed a large heart, 529 g, with left ventricular hypertrophy (18 mm) and right ventricular hypertrophy (5 mm) but no significant coronary atherosclerosis. The lungs (R 677 g, L 605 g) were oedematous and there was pulmonary oedema fluid in the upper airways. There was no description at autopsy of the gas seen on CT. The cause of death was given as cerebral arterial gas embolism (CAGE) due to pulmonary barotrauma. The pathologist commented that "*anyone with a heart weight of over 450 g was at increased risk of sudden death*".

Comment: The results of the CT scan are difficult to evaluate since the examination was performed two days after death. This pattern of gas could be due to decomposition or even post-mortem off-gassing rather than CAGE. While his dive computer indicated two ascent alarms, the alarms are triggered at a rate of only 10 m min^{-1} so the rate may not have been excessive or uncontrolled. This is supported by the fact that he completed a safety stop at 7 msw. The victim apparently signalled that he was okay at the surface and was only later found unconscious. Another possible explanation for what happened is that during the swim back to the boat he drowned after experiencing a loss of consciousness due to a cardiac arrhythmia triggered by his enlarged heart.

Summary: Trained, experienced, no dives for two years; obese and on unidentified medication; separation during surface return swim; CAGE or cardiac incident.

SC 05/02

This 52-year-old male overseas visitor had been scuba trained in his home country. He had made only 20 dives, the most recent about two years before. He was reported to have been taking several medications, including a statin for hypercholesterolaemia, SSRI for depression, hydrocortisone spray for allergic rhinitis, and esomeprazole magnesium for reflux. The dive shop was aware of his lack of recent dives and that he was overweight, and decided that the dive master taking the three customers for this dive would buddy him. He was shown and practised the use of the equipment he had hired before leaving the dive shop. Another customer heard him say that he was a doctor and very much aware of the risks involved in diving, although this witness thought the victim "*wasn't in very good physical condition*".

The dive was on the wreck of a scuttled warship about two km offshore. Water depth was 30 msw, the deck at 20 msw. No details of the weather or sea conditions are noted. The dive master (instructor) briefed them, checked their equipment and then observed them as they entered the water and descended to the wreck's foredeck. The dive master had the victim tighten his weight belt before they swam along the vessel's side to the stern. Some minutes later the victim gave a 'low air' signal. His buddy, the dive master, checked and found he had sufficient air (130 bar), so wrote on his slate "*Is it your chest*?" and got the answer "*Yes, slight cough*", so he decided to abort the dive and to take him slowly to the surface. Only 14 minutes of the planned dive had elapsed.

The dive master linked arms with the victim to ensure they stayed close together as they slowly ascended. When they reached shallower water, the victim appeared to panic and began to inflate his BCD to increase his ascent rate. The dive master quickly 'dumped' the air from the BCD and guided him to the surface. There he ditched their weight belts and signalled for assistance from the dive boat. Before it reached them, the victim removed the regulator from his mouth and said "*I'm dying. It's my heart*". He appeared distressed and was clearly unwell. He went rigid and stopped breathing. The dive master removed the victim's BCD and supported his head above the water till the dive boat reached them. Resuscitation efforts were unrewarded.

The equipment was examined and tested by police divers to 20 metres and worked correctly. Though the weight belt was retrieved and given to the police, neither its weight nor the amount of air remaining in his tank was recorded.

Autopsy: A CT scan three days after death showed gas throughout the arterial system. Observable gas bubbles were noted in the blood and the anterior mediastinum during the autopsy. When the heart was opened underwater numerous bubbles were noted in each chamber. The heart was moderately enlarged (540 g) with some dilatation of each of the chambers, with left ventricular wall hypertrophy up to 20 mm thickness. The coronary arteries showed atherosclerosis but the degree of narrowing is not described. The presence of fibrous scarring on histology suggested ischaemic heart disease.

The lungs (R 750 g, L 650 g) were hyper-expanded and bulged forward when the chest was opened. Palpable crepitus was noted on the cut surfaces of the lungs, which had multiple, dark red-coloured areas several millimeters in size, and some pale areas, giving a mottled appearance. There were no obvious sub-pleural haemorrhages or large collections of gas. There were bubbles in the pulmonary vessels. No other pathology was noted.

The cause of death was given as CAGE, with coronary atherosclerosis as a contributing factor. The pathologist considered that the coronary atherosclerosis was insufficient to cause death, and was not abnormal in degree for a person of this age, most of whom have no ill-effects from its presence.

Comment: The victim was a trained but unfit diver making a dive while closely and efficiently monitored by his buddy, an instructor. He suffered chest discomfort underwater. There is histological evidence of ischaemic heart disease. Whether the death was related to a cardiac event due to the ischaemic heart disease, or as a result of CAGE from a stressful ascent as suggested by the pathologist, is difficult to assess because of the post-mortem delay of three days and the potential for decomposition and post-mortem off-gassing.

Summary: Trained; no dives for two years; overweight and unfit; on unidentified medications; probable chest discomfort underwater; possible short period of fast ascent; CAGE or cardiac incident.

SC 05/03

This 39-year-old male victim was an experienced diver who swam regularly and was reportedly fit, albeit a little overweight. He joined three friends for a recreational dive from the boat one of them owned. He "*had been his usual chirpy self and had appeared fairly fit*" before the dive despite having a few drinks and being out until 4 am. After anchoring over a reef about 2 km offshore, they all descended the anchor line. The water was calm and visibility good. They met at the anchor and, having checked that their equipment was okay, moved off together. One diver (not the victim), who was only recently qualified, was the main focus of the others' attention for safety considerations on the dive.

The victim was last seen alive swimming alone down the reef, and appeared to be chasing a crayfish. At about that time, his contents gauge had shown 100 bar. He was diving solo, as was the diver who last saw him. When the other two divers reached the boat, one asked the other solo diver where the victim was. On scanning the surface, the victim's BCD was seen floating about 30 metres away. One of the group thought that it was initially partly on the victim, who also appeared to have his mask on his forehead. However, when one of the divers swam to the victim, the fully-inflated BCD was several metres away and the victim was unconscious, with no mask, fins or weight belt, and floating with the aid of his wetsuit. He towed the victim to the boat and pulled him aboard, where he was pulseless. A Mayday call was made, the anchor rope cut, and the group made a hurried and bumpy drive back to the marina. Apparently what had occurred had so shocked them that none of the friends attempted to effectively resuscitate the victim. The ambulance crew initiated resuscitation as soon as the boat docked but the victim was pronounced dead shortly afterwards.

Examination of the equipment showed there was a 'sticky' inflator valve, the BCD taking 10 minutes to fill and re-inflating itself. No other adverse findings were made. His GP reported that, apart from some relatively minor periodic ailments and arthritis and ligament damage in one leg, he had been generally in good health.

Autopsy: Only a summary of the autopsy findings was available. In this, the pathologist noted the absence of excessive fluid in the lungs and stomach. An abrasion of 1 x 2 cm consisting of three parallel lines each approximately 4 mm wide was also noted to be present on the right side of the deceased's forehead. A CT scan, performed many hours after death, showed the presence of gas in the heart and great vessels although the origin of this gas was not determined.

Comment: This case once again demonstrates the limited utility of CT when performed with significant delay post mortem. While gas was said to be present in the heart and great vessels, this could be due to putrefaction, post-mortem off-gassing, or method of specimen collection prior to autopsy and while it may have resulted from CAGE these results in themselves are unhelpful in providing evidence to support that hypothesis. The abrasions on the deceased's forehead were consistent with the markings of the aluminium tread plate of the decking, making it likely that he struck his head on the deck. It was suggested that he had ascended rapidly (as indicated by his dive computer) possibly due to being out of air (his cylinder was empty though the BCD inflated). He possibly reached the boat before the other divers ascended and part removed his BCD/backpack when he slipped or passed out and hit his head on the decking and was unconscious when he fell back into the water and drowned. This unproven estimation of the series of events has much to commend it. Whether CAGE occurred is uncertain, as is whether, if it occurred, it affected the course of events. A part-ditched back pack/BCD would have impaired any attempt to avoid drowning even if he had not first hit his head on the boat.

Summary: Experienced; solo; found floating on surface without gear on; cylinder empty; possible rapid ascent; lacerations on forehead; possible CAGE and/or head trauma followed by drowning.

SC 05/04

The victim, a 45-year-old male, was a highly educated and skilled professional who had taken up diving 19 months earlier and had since done numerous training courses and logged 127 dives. He had a history of hypertension, later found to be Conn's syndrome, obesity (BMI 34), severe headaches, chest pains, and sleep apnea. The chest pains were relieved by activity and, after investigation, were considered to be 'non-cardiac'. The headaches were considered to be exercise-induced and reduced after a neurologist suggested a NSAID be taken before strenuous exercise. He was taking diclofenac to prevent headaches, amiloride for hypertension, and diphenylhydantoin to prevent seasickness. He underwent a commercial diving medical with a doctor trained and experienced in diving medicine prior to a technical diving course. He was assessed as 'fit to dive', although no tests were conducted by the examining dive physician to investigate the implications of the sleep apnea and Conn's disease on his diving. Both of these diseases had been thoroughly investigated by his treating physicians, but it is unclear whether the results of these investigations were provided to the diving physician.

On an open-circuit-scuba, technical-diving training weekend, he completed three incident-free dives. On the previous day, he dived to 42 msw and 40 msw, and the first dive on the day of the accident was to 43 msw. After a surface interval of about three hours the victim planned to dive to 50 msw. Decompression was planned on decompression software with little conservatism built into the calculations. The victim was carrying twin cylinders filled with air, as well as two sling tanks for decompression. One contained pure oxygen for use at the 6 msw and 3 msw stops. The other was supposed to contain a nitrox mix with 50% oxygen but was subsequently analysed as 59%.

The victim, his buddy, and their instructor entered the water and descended uneventfully, although two minutes faster than the dive plan calculated; they also exceeded the planned bottom depth by 3 msw before returning to the correct depth. No in-dive allowances were made for these departures from the dive plan. Once at the sea bed, they performed several training drills before beginning the ascent after a bottom time of 25 minutes. There is no indication that substantial exertion was required underwater. The initial stop was at 27 msw with subsequent stops every 3 metres thereafter. EAN50 was used for the stops from 21 msw to 9 msw and 100% oxygen at the 6 msw and 3 msw stops.

The victim was described by the instructor as "*calm and relaxed and met the requirements for diving perfectly*". He reached the boat's stern 59 minutes from starting the dive, passed up the sling cylinders then climbed onto the boat up a small ladder while still wearing the backpack main cylinders and other equipment. He slipped on the ladder and was helped to prevent him falling. He then walked along the deck, and it was as they started to remove his equipment that the victim was noticed to be unwell. He looked uncomfortable and complained of "*really burning*" chest pains and difficulty breathing. He was given oxygen from his sling tank, but his condition deteriorated rapidly with shallow, laboured breathing, groaning between breaths, pallor and he appeared to be in severe pain. When he became unable to hold the regulator mouthpiece, a full face-mask was used to provide oxygen, but the tank was not full and the supply was soon depleted. The victim soon became unconscious and pulseless and BLS was commenced and continued on the boat for about 90 minutes. Paramedics arrived and, despite ALS, the victim died en route to hospital.

His equipment was checked and no faults were identified apart from the tank supposedly containing 50% oxygen in reality containing 59% oxygen. The breathing apparatus alone weighed 47 kg.

Autopsy: A CT scan performed two days after death showed intravascular gas in four chambers of the heart (fluid level in left atrium) the internal carotid and basilar arteries, aorta, pulmonary trunk, jugular veins and cavernous sinus. There was also gas in the parapharyngeal and facial soft tissues. There was opacification of the trachea and major bronchi (pulmonary oedema/gastric aspirate). No bullae, pulmonary lesions, pleural fluid, or pneumothorax were seen. There was extensive gas throughout the liver, portal vein, and superior mesenteric vein (decomposition).

The heart weighed 560 g, partly reflecting a body mass of 120 kg; left ventricle wall thickness was 13 mm, right 3 mm. The coronary arteries showed less than 20% narrowing. The pathologist initially attributed the death to CAGE but amended this to decompression sickness (DCS) following input from several diving medical experts.

Comment: The investigation of this technical diving fatality was extremely thorough with input from numerous diving medicine experts, albeit with some differing opinions. The coroner's 'finding' comprised a 21-page summary of the 10 cm-thick file of documents; a thoughtful, thorough and well-crafted exposition of facts.

The diagnosis of death from DCS is very difficult at autopsy. This is especially so after a long, deep dive where large amounts of nitrogen are absorbed by the body tissues and released into the blood and tissues post-mortem, in addition to any gas that is present ante-mortem (e.g., from CAGE or DCS). This may be further complicated by gas due to putrefaction, which can occur in eight hours and could be widespread by two days. Deaths during technical diving are more complex and investigation of the cause of death should properly be undertaken by collaboration between a pathologist with experience of diving autopsies and a diving physician with knowledge of technical diving. Multiple unusual physiological issues, such as decompression time and oxygen toxicity at depth, need to be considered.

Many salient points arose from the investigation of this fatality. Some deserve brief comment here and warrant on-going discussion by diving medical practitioners and others.

The coroner and several expert witnesses expressed concern about the dive medical examiner's failure to further investigate the victim's sleep apnea. This dysfunction can cause pulmonary hypertension, leading to increased risk of right heart failure, atrial arrhythmias and possibly a reduced capacity of the lungs to filter venous bubbles.[2–4] Without the results of the investigation of the victim's co-existing disease, it is impossible to provide adequate advice on the risks of undertaking this type of diving. The issue was raised about the role of the dive medical examiner when conducting a dive medical – whether it is to determine a definitive pass/fail, or to provide a risk assessment and advise the individual. From the perspective of the individual requesting the medical, the discussion is generally more focused on risk assessment and understanding rather than acceptance or rejection. However, from the perspective of the dive industry, there is a requirement for a pass/fail answer.

Concerns were reasonably expressed about the lack of validation of the decompression algorithms routinely used by technical divers, including the inclusion of deep decompression stops, and it was perhaps cavalier that a student diver with some obvious risk factors was allowed to build in so little conservatism to his planned profile. There was some debate about the fact that reverse-order depth dives were conducted and the potential effect this could have on decompression. This issue remains somewhat controversial. No allowance was made in-dive for the departures (fast descent and deeper dive) from the dive plan.

That the victim was carrying 59% oxygen in his sling tank rather than 50% oxygen was a matter of concern. Although it did not cause harm in this particular case, there was an increased potential for oxygen toxicity. The dive operator was held to account by workplace authorities and received a large fine as a result of this and other breaches.

The victim was not wearing a weight belt, and even without this his equipment weighed 47 kg. Technical divers and those who take them diving need to consider the substantial weight of the equipment often used and should take precautions to minimise the exertion required by divers when exiting the water, so reducing the likelihood of precipitating a decompression or cardiac event, or musculoskeletal injury.

Forensic pathologists are becoming increasingly aware of the potential cardiovascular effects of obstructive sleep apnea and its possible role in sudden death due to arrhythmia. However, functional abnormalities like cardiac arrhythmias cannot be detected at autopsy. This is amply demonstrated in the present case where extensive investigations performed pre-morbidly showed cardiac abnormalities and rhythm disturbances. The contribution of these to the final outcome will never be known.

Complex medical conditions such as Conn's disease result in patients being on a variety of medications, the effects of which cannot always be predicted with immersion. Whether the victim's medications contributed in this case is unknown, but prolonged immersion, exposure to high PO_2 mixes and medications that alter fluid and salt balance in the body pose a risk of unknown proportions especially in the unfit and overweight.

Summary: Experienced; undergoing technical diving training; history of severe headaches, 'non-cardiac' chest pain, Conn's syndrome, obstructive sleep apnea; hypertension, seasickness, and obesity; dive plan lacking conservatism profile; collapsed and died soon after exiting water; fulminating decompression sickness.

SC 05/05

The victim was an apparently healthy 30-year-old female overseas visitor on a dive trip to a GBR resort. She had done only 15 dives, two of these conducted in the 24 hours prior to the incident dive. The victim, who spoke enough English to hold a basic conversation, was paired with a companion from her country of origin, as part of a group of four divers, accompanied by a dive master. She was using equipment hired from the resort.

After a briefing, which was later reported by the victim's buddy as incomprehensible to her as it was delivered in English only, the divers entered the water from the shore and then swam a short distance on the surface to a mooring buoy to commence the dive. Current was flowing at 1–2 knots, depth was 3–4 msw, with visibility between 5 and 10 metres. The four divers were split into two buddy teams. One of the other pair had difficulty during the descent and the dive master stopped to assist. When he looked for the other pair of divers, he could see only one of them, who was also having some difficulty in descending. When the other divers were on the bottom an exchange of signals indicated that none of them knew where the victim was. After only one minute, the dive master signalled for the group to ascend, telling them to hold onto the buoy and watch for bubbles or anyone at the surface while he descended and made an underwater search down-current for 20–30 metres for about five minutes, without success. He then brought the three divers back to shore, where he reported that a diver was missing and initiated a broader search.

After about 50 minutes, the victim was found lying on her back unconscious on the bottom at about 5 msw and approximately 120 metres from the original dive location. Her regulator hose was initially trapped in coral but was easily freed and she was brought to the surface after inflation of her BCD and release of her weight belt. Pink, frothy sputum was coming from her mouth and an attempt was made to clear this and perform in-water rescue breathing until the victim was brought aboard the rescue boat. BLS, including the use of a resuscitation mask and oxygen, were hampered by frothy sputum and vomit. A rescue helicopter arrived but further resuscitation attempts by the paramedic were unavailing.

The equipment was found to be in serviceable condition. The air cylinder contained at least 170 bar. The cylinder air was analysed five months later and no impurities were found. The profile recorded on the victim's computer was 50 minutes at 5.2 msw, with no indication of ascent prior to the body recovery. The victim was wearing a 3 mm wetsuit and 5.4 kg of weight on her weightbelt, similar to that which she had worn on the previous dives without apparent problems.

Autopsy: The autopsy, performed two days after death was preceded by a CT scan but no report of the scan is on file. There was evidence of mask squeeze and petechiae on the conjunctivae. Small bubbles were present in small vessels over the cerebral hemispheres and a few in the Circle of Willis vessels. There was a small amount of air in the right pleural sac and bubbles were seen in the upper descending thoracic aorta near the isthmus. There was gas in the left ventricle and multiple small bubbles were seen in the inferior vena cava. The lungs (R 700 g, L 600 g) were voluminous with the appearance of emphysema aqueosum (over-expanded with prominent rib markings) and were boggy with frothy fluid exuding from cut surfaces. There was some interstitial air and haemorrhages in the lung parenchyma. There were also 20–25 mm bruises on the frontal and occipital scalp. The pathologist concluded that she suffered CAGE while attempting to ascend and then drowned.

Comment: This is ultimately a drowning but the precipitating factor is not clear. The autopsy was performed two days after death and the gas seen at autopsy is likely to be a combination of post-mortem off-gassing and decomposition, rather than a result of CAGE. The CT scan could have resolved this issue if it had been performed early post mortem. As there was at least 170 bar of air remaining in the cylinder, it is obvious that the victim stopped breathing early in the dive. The profile recorded by the dive computer during the 50 minutes was more consistent with a body being gently moved by the water motion rather than a conscious diver swimming.

It is important in the forensic examination of diving deaths that there is a good understanding of the limitations of any dive-profile recording equipment worn by the victim. Although the dive computer print-out of the victim's dive profile indicated that she descended directly to around 5 m and stayed at that depth for almost 50 minutes before being brought to the surface by the rescuer, this could be misleading. This computer samples depths at 20-second intervals, recording only the maximum depth reached within that interval. If the victim had made a rapid ascent at the start of the dive when she became separated from her buddy, this may not have been recorded. It is possible, therefore, that she made a rapid ascent, suffered a CAGE, lost consciousness and sank to the seabed within 20 seconds, and remained there for 50 minutes prior to being found. The presence of mask squeeze and petechiae indicate inadequate equalisation on descent, which is likely if the victim became unconscious and sank, but could also have occurred as a result of inattention and/or panic. Given that this event was unwitnessed, other scenarios such as hitting her head on one of the other diver's tanks or on coral in the current and entrapment are also possible but again unproven.

Summary: Trained; some experience; apparently healthy; separation on descent; became unconscious shortly after descent and found 50 minutes later; questionable evidence of CAGE; drowning.

SC 05/06

The tragic death of this 23-year-old male marine scientist, an experienced diver, occurred while he and a buddy made a safety stop at 5 msw after a dive to 18 msw collecting cuttlefish eggs for research purposes. Visibility underwater was estimated to be 3–5 metres. From the dive boat, others saw a large shark approaching the two divers. The buddy said he had felt something bump into him with sufficient force to rotate him in the water. He then saw the shark, estimated to be about 5 m long and believed to be a great white, directly approach his buddy who struck it on the snout, causing it to retreat momentarily. However, it came back, took the victim's leg in its jaws and dragged him deeper. He was seen to surface momentarily, surrounded by a pool of blood, before disappearing underwater. The buddy surfaced and was soon picked up by the boat. Although some of the victim's equipment, including intact and undamaged BCD and tank, was later recovered, his remains were never found.

This area, an artificial reef 5 km offshore, was known for sharks although no sightings had been reported that day. A number of fishing boats were in the area as there were plenty of fish running. There were unconfirmed reports that berley was used by some fishermen in the area although this was not mentioned in the coronial documents.

Comment: Although shark-repelling devices were present on the boat, the divers did not use them and were unaware that they were available. At the inquest, various expert witnesses were consulted on both the behaviour patterns of large sharks and on the use of shark-repelling devices. It was noted that the divers were employed by an educational institution that owed the divers a 'duty of care'. This raises the question whether it should have been deemed safe to dive in that area at that time. There was much discussion of the reasons for and against the use of shark-repelling devices, why they were not used and whether they might have deterred this particular attack if they had been, with no definitive conclusions being reached.

Summary: Marine biologist collecting cuttlefish eggs; substantial fishing activity nearby; attacked by 5 m shark; probably died from massive blood loss.

SC 05/07

A 67-year-old, highly experienced, male diver visited Australia with seven of his compatriots and dived from a liveaboard boat on the GBR. He declared a medical history of a CVA, hypertension and diabetes (NIDDM) for which he took a variety of medications including glimepiride, metformin, amlodipine, cilostazol, diphenhydramine, aspirin, and KH1010 (for unknown reasons). He stated he was fit to dive and made two uneventful dives before the fatal one. One of his companions thought he was looking tired, but he had not reported feeling unwell.

Safety information was given in the visitors' own language and, although they were advised to dive as buddy pairs, they chose to dive as a group. The dive was without incident but one of the victim's companions was surprised when, after only 20 minutes, the victim's contents gauge read 50 bar. He and two others ascended separately, in a normal manner, the victim making a safety stop at 10 msw. The safety watcher on the boat saw them on the surface soon after and they indicated to him that they were okay. They started to swim back to the boat, the victim in the rear, but it is uncertain whether they were using scuba or snorkel. The victim appeared to stop, as if waiting for the remainder of the group to reach him, and seemed to be paying attention to his snorkel. The alarm was raised when these following divers reached him and found him unconscious, floating face-down, with mask, snorkel and weight belt missing. He was quickly turned face-up and the safety tender summoned. BLS was commenced and continued until paramedics arrived by air and declared life extinct.

There is no record of his equipment being tested, but a note was made that the depth gauge gave a maximum depth for the dive of 25 metres for a total dive time of 23 minutes and remaining air at 20 bar. There is no record whether his BCD was inflated when he was found.

Autopsy: There was no visible evidence of trauma, brain pathology, or barotrauma noted at the autopsy. The heart weighed 340 g and appeared macroscopically normal apart from a stenosis of the anterior interventricular branch of the left coronary artery, confirmed histologically as 70% occluded. There was patchy myocardial interstitial fibrosis suggesting previous ischaemia (possibly due to small vessel disease from his diabetes). The lungs (R 711 g and L 611 g) were oedematous and there may have been agonal drowning. A finding was made of death from ventricular arrhythmia resulting from myocardial fibrosis due to severe coronary artery atherosclerosis.

Comment: There was no information about this victim's functional health beyond his claim to be fit. Although he was a man with severe health problems, as evidenced from his medical history, this dive was not considered to be overly strenuous. There was no explanation for his apparent excessive use of air. He made no comment about feeling unwell. The possible hypotheses for his death include cardiac arrhythmia or a hypoglycaemic event, causing him to become unconscious and drown.

Summary: Experienced; history of CVA, NIDDM, angina but apparently fit; excessive air usage during dive; unconscious during relatively non-stressful surface swim; probable cardiac incident.

SC 05/08

This 45-year-old male victim was 'instructing' his girlfriend to scuba dive and this was her third dive. He had obtained an open-water certificate nine years earlier but his diving experience is unknown, although it appears that he was not a registered instructor. They planned to dive in a waterway much frequented by vessels but also popular with snorkellers and scuba divers and commonly used by local dive schools for scuba instruction. The southern wall of this waterway had a concrete platform on which the victim and his buddy donned their equipment. There were numerous other people in the water, some snorkelling and others scuba diving. The water conditions were described as initially calm with visibility of 15 metres. However, there was a strong inflowing tidal current that later reduced visibility substantially. The current was described by the victim's buddy as stronger than when they last dived there, a day earlier.

The pair entered the water and swam out underwater for about 40 metres to where the depth was 9 msw. They were about mid-channel at this time and when the victim looked at their contents gauges he saw it was time for them to return to the shallow area close to the wall rather than surfacing where there was risk from vessels. Before they reached the wall he signalled that he was out of air and both ascended. When his buddy looked round she saw him struggling to remain at the surface and frequently swallowing water, so she called for help. When both divers began to sink, she felt him pushing her up from below and a swimmer who had come to assist her pulling her from above. A search was begun after her buddy failed to re-surface. A short time later he was located on the sea bed, unconscious with mask in place but regulator out of his mouth. His weight belt was difficult to release because of a poor release mechanism. He was brought to the surface and taken ashore aboard a surf ski. He was apneic and pulseless. BLS was attempted, initially by a bystander, then by a rescue service volunteer, prior to the arrival of a paramedic. Unfortunately there was no response.

The buddy was taken to hospital where she recovered from the incident. She reported that she believed their tanks were full at the start of the dive. The equipment was sent for checking. There is no report on the findings, but there is no suggestion of any equipment problem except for the weight belt release and being out of air.

Autopsy: A whole body CT scan was performed one day after his death and the autopsy was performed two days after death. The CT scan showed gas in the internal and basilar arteries, less in the anterior and middle cerebral arteries and some other small vessels. A large amount of gas was noted in the right ventricle with a fluid level in right atrium, a small amount in the left ventricle, with the ascending aorta and aortic arch totally gas-filled and gas throughout the proximal arterial tree. Gas was also detected in the soft tissue of the orbit and face. There was an air fluid level in the sinuses, commonly seen in drowning. The portal vein and its intra hepatic branches also contained gas.

Autopsy revealed very heavy lungs (R 1050 g, L 940 g) with distention and pulmonary oedema. The heart weighed 490 g and appeared slightly dilated, with up to 50% narrowing of the left anterior descending coronary artery. Histology of the brain showed decompositional gas formation in the brain. In the coronary arteries, described as 'basically healthy', a slightly less than 50% concentric narrowing of the proximal left anterior descending artery was present, which was accepted by the pathologist as a non-contributory finding. The pathologist suggested that he suffered a severe PBT/CAGE as he made his final attempt to reach and stay at the surface. The cause of death was given as air embolism due to, or as a consequence of, pulmonary barotrauma.

Comment: The CT scan was performed more than eight hours after death and there is some decompositional gas present at autopsy. There is a history of rapid ascent and there may well have been a PBT/CAGE. However, given the out-of-air situation, strong current and the heavy weight belt this may simply represent drowning. It was suggested that the buddy's fatigue and panic affected her ability to stay afloat. Being unable to inflate his BCD as his tank was empty, and unable to ditch his weight belt, the victim had no chance of maintaining himself at the surface. He probably sank and drowned. Inexperience on the part of both divers was apparent. The victim failed to properly monitor his air and took an untrained, extremely inexperienced diver into open water subject to a strong current and potential boating hazard. The reportedly poor release mechanism on his weight belt would have made it more difficult to ditch and might have contributed to the outcome of this incident Though the buddy had some remaining air, she failed to realise the value of trying to inflate her BCD or of ditching her weights. This incident also highlights the value of assessing one's buddy as being competent to provide assistance in adverse circumstances. 'Training' dives should be planned and conducted in safer conditions than those encountered on this dive and should be done by a qualified instructor.

Summary: Trained; some experience and recent diving; apparently healthy; out-of-air ascent; weight belt difficult to release and BCD deflated; struggled on surface then sank; CAGE or drowning.

SC 05/09

The victim, a 51-year-old male, had been scuba diving for over 12 years. His only health factor was raised cholesterol level for which he took atorvastatin and had regular medical checkups. On a dive to catch crayfish they used the buddy's boat at a site approximately 500 metres offshore. The victim had dived here before, unlike his buddy, and so was the leader for this dive. There was a strong current and the wind was estimated at around 15 knots. The victim was a strong swimmer and, once underwater, the buddy "*could only just keep up*" with him. After about 30 minutes, the buddy checked and found his contents gauge read 105 bar and the victim's 95 bar, and they decided it was time to begin their return. Both surfaced to determine the boat's location, then descended to about 10 msw depth to start their underwater swim of approximately 200–250 metres. As the victim was swimming faster, he was soon lost to sight. When the buddy reached the boat he saw the victim was about 40 metres away. They exchanged OK signals. After boarding the boat and removing his equipment, he saw that the victim was swimming into the strong current and wind. They again exchanged OK signals and the buddy decided to take the boat to pick him up. It took him several minutes to free the anchor, and when he reached the victim, he was floating face-down with his regulator out of his mouth, BCD inflated and weight belt missing. The buddy jumped into the water to assist him and attempted some in-water rescue breathing by the side of the boat. After ditching the BCD and tank, he managed to pull the victim into the boat. He sent a radio distress call and continued resuscitation efforts while returning to the boat ramp where the efforts were continued by bystanders and then a paramedic, without success.

Although the victim's equipment had floated away, it was later recovered and was found to perform correctly. The dive computer showed that the victim's dive duration was 31 minutes whereas the buddy's computer indicated 48 minutes. This was taken to indicate that the victim had surfaced and started a surface return swim very shortly after they both commenced their underwater return.

Autopsy: The heart weighed 485 g and there was multi-focal atherosclerosis with a 70% stenosis at the origin of the diagonal branch of the left anterior descending artery. The lungs (R 914 g, L 810 g) showed significant oedema and there was watery fluid in the upper airways and stomach. There was no apparent evidence of either trauma or CAGE. The formal cause of death was drowning and associated multifocal coronary atherosclerosis.

Comment: This was an apparently healthy man who underwent regular medical checks. The only indication of a potential medical problem was elevated cholesterol, managed by prescribed medication. It is likely that the level of exertion required in swimming to the boat against a strong current and wind caused a cardiac event. He appears to have become unconscious and drowned despite apparently ditching his weight belt and inflating his BCD. In the context of this review, the death is regarded as being due to cardiac factors.

Summary: Experienced; apparently healthy; swimming against strong current and wind; gave no warning that he required assistance; cardiac-related.

Surface-supply fatality

SS 05/01

This 55-year-old victim and his employee were experienced commercial divers, diving on a remote reef, collecting fish for salt-water aquariums. They were diving from a dinghy with an air compressor supplying the two hoses for their hookah system. The victim's 10-metre fishing vessel was moored nearby. On surfacing, the buddy saw the other hookah hose was at its full length and noticed a large shape floating at the surface about 100 metres away. Becoming concerned, he investigated by pulling the hookah hose gently and then more firmly. He pulled it in until he saw a large crocodile with what he recognised as his employer's dive gear. He got out of the water, contacted police by satellite phone and marked the spot with an emergency locating beacon. Searchers found the victim's body five hours later in the mouth of a large saltwater crocodile, which then let it go and disappeared. The body was then recovered.

Autopsy: There were lacerations to the face, neck, and scalp, and compound comminuted fractures of his right temporal bone and zygoma, as the main injuries with some subarachnoid haemorrhage. The cause of death was given as blunt head trauma from crocodile attack.

Comment: The population of saltwater crocodiles in this region has increased to 75,000 since they were declared to be a protected species 33 years ago. This fatality occurred only five days after the death of a snorkel swimmer (BH 05/5) in a similar attack, though not in the same area.

Summary: Experienced commercial diver; diving in remote area with potential for crocodiles; lethal crocodile attack; trauma.

Discussion

Once again, 2005 saw a number of tragic and some potentially avoidable accidents. A summary of the possible sequence of events (root cause analysis) in these incidents is shown in Table 3. Despite the well known hazards of apneic diving and apneic hypoxia, several deaths can be attributed to this (BH 05/04, BH 05/08 and BH 05/14), some possibly involving hyperventilation. It is important, if extended breath-holding is attempted, that there is a vigilant buddy present in order to quickly rescue the person. This is necessary even in shallow, sheltered waters such as a swimming pool.

Some of the victims in this series came to grief while diving, snorkelling or breath-holding alone (BH 05/01, BH 05/04, BH 05/08, SC 05/03). Some divers dive alone through preference while others do so through lack of a companion. In any case, when a problem occurs with a solo diver or snorkeller, the reality is that there is no-one close at hand to assist. Diving with a buddy certainly does not guarantee their immediate awareness and assistance, but does increase the likelihood of a helping hand should it be required.

This series includes two cases involving attacks by crocodiles (BH 05/05, SS 05/01) which occurred within a week of each other, both in locations known to be frequented by large saltwater crocodiles. Both victims were said to have been aware of the potential presence of crocodiles in the area in which they dived, but had chosen to do so despite this.

The victims of the shark attacks (SC 05/06 and BH 05/02) were both diving in areas known to be frequented by great white sharks. However, the likelihood of an attack would have been increased with the substantial fishing activity and probable presence of berley in the area with SC 05/06, and possibly the fishing from a nearby boat with BH 05/02. It would be common sense to modify diving plans where there is the potential for increasing shark activity. Perhaps a more laissez faire attitude to dangerous marine creatures has developed due to the preponderance of television programmes depicting presenters interacting with such creatures, even outside of a cage. Standing his ground and behaving in a suitably aggressive manner, did not save the victim in SC 05/06. These creatures are large apex predators and suitable respect should be exercised at all times.

It was noted in the analysis of the technical diving fatality (SC 05/04) that, during previous dives, additional decompression stops appeared to have been added without recalculation of the decompression profile for the final dive. Similarly, there has been a trend in recent times in recreational diving towards adding extra 'safety stops' at 10 msw and 5 msw for what would otherwise be no-decompression dives. The addition of any time in the water must be included in the decompression planning. The assumption that these extra stops occur during the ascent and therefore are adding to the safety is not necessarily correct and can, in some cases, actually result in inadequate decompression being conducted.

Similarly, the presence of co-existing disease and its associated medication may have unpredictable effects in the setting of immersion and diving. While the death in case SC 05/04 was attributed to fulminant pulmonary decompression illness, this is a very rare event especially in the apparent absence of grossly omitted decompression. In this individual, the combination of multiple medical conditions may have played a significant part in his ultimate demise. While the effects of immersion in young healthy individuals has been well studied, and is known to cause considerable physiological effects, the effects in the setting of co-existing disease and in the presence of medications that affect fluid balance and vascular tone are unknown. The decision of fitness to dive in such individuals must therefore be made cautiously with as much information as possible available. Cross referral to specialists with experience in the affected areas and suitable investigations are essential if there is to be any meaningful discussion with the candidate with regard to risk and risk acceptance.

The concept of risk acceptance in diving has led to some individuals being passed as fit to dive with co-existing diseases that were previously considered contraindications. These include diabetes and asthma. The debate over fitness to dive with these conditions is beyond the scope of this paper, but divers who decide to dive with these conditions must be cognizant of the correct management of their disease and the effects that immersion and the hyperbaric environment will have on it. In case SC 05/07, there was no mention in any of the witness statements that the diver took appropriate steps prior to the dive to check his blood glucose, nor that he had on hand a source of glucose should he develop a hypoglycaemic event during the dive.

The investigation of deaths associated with diving is always difficult. Delays in autopsy, often caused by the remote locations in which many accidents happen, compound these difficulties. Although pre-autopsy CT scans were conducted on several of the scuba divers, these were often delayed for more than eight hours, so reducing their reliability.

Table 3
Root cause analysis of diving-related fatalities in Australian waters in 2005
PBT – pulmonary barotrauma; CAGE – cerebral arterial gas embolism; DCS – decompression sickness

Case	Trigger	Disabling agent	Disabling injury	Cause of death
BH 05/01	Unknown	Water aspiration from snorkel?	Asphyxia	Drowning
BH 05/02	Fishing activity?	Shark attack	Trauma	Trauma
BH 05/03	Mild exercise / salt water aspiration?	Cardiovascular disease	Cardiac incident	Cardiac related
BH 05/04	Extended breath-hold	Loss of consciousness (sudden)	Asphyxia	Drowning
BH 05/05	Presence of crocodile	Crocodile attack	Trauma	Trauma
BH 05/06	Exertion in strong current	Cardiovascular disease	Cardiac incident	Cardiac related
BH 05/07	Extended breath-hold / entrapment?	Loss of consciousness (sudden)	Asphyxia	Drowning
BH 05/08	Extended breath-hold	Loss of consciousness (sudden)	Asphyxia	Drowning
BH 05/09	Mild exercise / salt water aspiration?	Cardiovascular disease	Cardiac incident	Cardiac related
BH 05/10	Water inhalation from snorkel / panic?	Laryngospasm?	Asphyxia	Drowning
BH 05/11	Mild exercise	Cardiovascular disease	Cardiac incident	Cardiac related
BH 05/12	Contact with boat?	Head injury?	Asphyxia	Drowning
BH 05/13	Mild exertion	Cardiovascular disease	Cardiac incident	Cardiac related
BH 05/14	Extended breath-hold	Loss of consciousness (sudden)	Asphyxia	Drowning
SC 05/01	Exertion / rough water	Ascent related?	PBT / CAGE? Cardiac-incident?	CAGE? Drowning?
SC 05/02	Chest discomfort	Ascent related / cardiac related?	CAGE? Cardiac incident?	CAGE? Cardiac related?
SC 05/03	Gas-supply related?	Ascent related / head trauma?	CAGE? Asphyxia?	CAGE? Drowning?
SC 05/04	Inadequate decompression	Bubble formation	Fulminating DCS	Fulminating DCS
SC 05/05	Unknown	Unknown	Asphyxia? CAGE?	Drowning
SC 05/06	Presence of fish eggs / fishing?	Shark attack	Trauma	Trauma
SC 05/07	Unknown	Cardiovascular disease / diabetes	Cardiac incident	Cardiac related
SC 05/08	Current / gas-supply related?	Ascent / buoyancy related?	CAGE? Asphyxia?	CAGE? Drowning?
SC 05/09	Exertion against strong current and wind	Cardiovascular disease	Cardiac incident	Drowning
SS 05/01	Presence of crocodile	Crocodile attack	Trauma	Trauma

Where divers have had a significant nitrogen uptake into their tissues ante-mortem, gas will be released into both the tissues and intravascularly, independent of gas present at the moment of death, confusing the diagnosis of gas embolism. Furthermore, gas may be created by putrefaction and intravascular gas may result from prolonged CPR attempts. Where possible, a pre-autopsy CT scan should be conducted within eight hours of death to minimise artifacts and gas sampling may be of value to determine the origin and composition of the gas.[5]

Given that drowning is a diagnosis of exclusion and that unrecognised ischaemic heart disease is common, the recent trend for fewer or less extensive autopsies may reduce our ability to understand the causes of diving deaths and undermine efforts to improve preventative strategies.

Conclusions

There were 24 reported diving-related fatalities during 2005, which include 14 deaths while snorkelling and/or breath-hold diving or shortly thereafter, nine while scuba diving, and one while using surface-supply breathing apparatus.

Causal factors associated with these deaths included apneic hypoxic blackout from extended breath-hold, cardiac disease or other co-existing illnesses, attacks from sharks and crocodiles and inexperience diving in adverse conditions.

The main disabling injury (Table 3) with snorkellers was asphyxia (seven cases), followed closely by cardiac involvement (five cases). With scuba divers, the main disabling injury appears to have been CAGE, which was possibly associated with five cases. Cardiac causes were thought to have been the disabling injury in at least two, but possibly up to four, scuba fatalities.

Factors that may reduce mortality in the future include improved medical screening of older divers; cessation of the practice of hyperventilation prior to breath-hold diving; avoidance of diving in areas and/or times of increased crocodile or shark activity; and improvement of, and increased adherence to, the buddy system.

References

1 Walker D, Lippmann J, Lawrence C, Houston J, Fock A. Provisional report on diving-related fatalities in Australian waters 2004. *Diving and Hyperbaric Medicine*. 2009;39(3):138-61.

2 Miguel A. Obstructive sleep apnea and its relationship to cardiac arrhythmias. *J Cardiovasc Electrophysiol*. 2007;18(9):1006-14.

3 Otto M, Belohlavek M, Romero-Corral A, Gami AS, Gilman G, Svatikova A, et al. Comparison of cardiac structural and functional changes in obese otherwise heathly adult with versus without obstructive sleep apnea. *Am J Cardiol*. 2007;99(9):1298-302.

4 Strickland M. Intrapulmonary shunt and pulmonary gas exchange during exercise in humans. *J Physiol*. 2004;561:321-9.

5 Fact File – *Autopsy and the investigation of scuba diving deaths*. Surry Hills: The Royal College of Pathologists of Australasia; 2008.

Conflict of interest: John Lippmann is the Executive Director of Divers Alert Network (DAN) Asia-Pacific. DAN is involved in the collection and reporting of dive accident data and provides evacuation cover and dive injury insurance to recreational divers.

Funding: This study was funded by DAN Asia-Pacific.

Acknowledgements: We acknowledge Monash University National Centre for Coronial Information for providing access to the National Coronial Information System (NCIS), and State and Territory Coronial Offices, various police officers, dive operators and divers who provided information on these fatalities. We also thank the staff at DAN Asia-Pacific, who have worked on this project.

Submitted: 28 June 2010
Accepted: 16 July 2010

Douglas Walker, MB, ChB, MM, is a retired general practitioner, former Editor of the SPUMS Journal and Project Stickybeak researcher.
John Lippmann, OAM, BSc, Dip Ed, MAppSc, is the Executive Director of Divers Alert Network (DAN) Asia-Pacific.
Chris Lawrence, MB, BS, FRCPA, is Director, Statewide Forensic Medical Services, Royal Hobart Hospital, Tasmania.
Andrew Fock, MB, BS, FANZCA, Dip DHM, is a senior specialist for the Hyperbaric Services, The Alfred Hospital, Melbourne.
Thomas Wodak, LLB, is a retired County Court judge with an interest in litigation involving medical matters, and a past dive instructor.
Scott Jamieson is a researcher for DAN Asia-Pacific.

Address for correspondence:
John Lippmann
PO Box 384, Ashburton, VIC 3147, Australia
Phone: *+61-(0)3-9886-9166*
Fax: *+61-(0)3-9886-9155*
E-mail: *<johnl@danasiapacific.org>*

The SPUMS recreational diving medical

This journal issue marks an important occasion for the SPUMS. After eight years' consideration, a fully updated version of the SPUMS '*Guidelines of medical risk assessment for recreational diving*' (RDM) is published.[1] This document remains central to the aims and purpose of this Society. While individual members have long provided guidance to colleagues and divers, this document outlines in some detail our formal advice for medical practitioners on the examination of people wishing to go scuba diving. Before discussing the major changes of philosophy and practice within the RDM, it is worth considering how we reached this point.

SPUMS first published an RDM in 1992. The original 'certificate of fitness to dive'was replaced with a more nuanced *Statement of Health for Recreational Diving* in 1996, and the whole document was most recently revised in 1999. Throughout this period, the philosophy remained clear: a guideline summarising the criteria by which a prospective diver could be prevented from taking up this sport. This cast the diving physician as a policeman guarding the entrance to the underwater kingdom. The physician also carried a substantial burden of risk for every diving candidate pronounced 'fit to dive'. Because of an ongoing lack of good data, few of the recommendations were solidly evidence-based, leading to a risk-averse approach.

Further, this was a document about entry into the sport rather than assessment of ongoing suitability for compressed-gas diving: "*The medical criteria... are relevant only to examination of individuals considering entry-level recreational scuba diving… carried out before the candidate first uses compressed air underwater.*"

From about 2000, both these aspects came under increasing scrutiny. At the 2002 SPUMS ASM and in a landmark article in 2003, Gorman discussed modern approaches to health surveillance through occupational diving medicals.[2] He stated that "o*ccupational health surveillance differs from healthcare-oriented surveys, and is an exercise in facilitated, informed risk management*". In an analysis of risk, risk theory and how SPUMS had traditionally approached risk in diving, I suggested that the recreational pre-diving medical could be even more readily seen as a risk assessment process than the occupational assessment.[3]

Unsurprisingly, this generated some controversy. While most members accepted that risk assessment was an important part of the medical, there were a number who were uncomfortable with the move away from a black-and-white approach where the candidate either passed or failed. What caused the most discussion, however, was the idea that the face-to-face component might be optional rather than compulsory.

In 2005, a SPUMS subcommittee was formed to consider changes to the medical. The new *Guidelines of Medical Risk Assessment for Recreational Diving* is now available on the Society website <www.spums.org.au> for all to read.[1] What follows is a brief guide to the major changes.

Risk assessment approach: In general, the RDM takes a risk-assessment rather than proscriptive approach. Following legal advice, the Committee rejected making the face-to-face medical optional, dependent on responses to a questionnaire. For a fuller discussion of some of these issues, see Meehan and Bennett.[4] The legal advice was that, given SPUMS was instrumental in developing an apparently safe and functional system, any proposed changes would need to be based on compelling evidence that the change was beneficial. The view of the Committee was that no such compelling evidence exists.

Age and repeat medicals: While the recommended lower age limit for recreational scuba remains unchanged at 14 years, the medical now recommends repeat medicals for those over 45 years. In the cardiovascular assessment section there is now more detailed advice for divers.

Visual acuity: The recommendation in earlier versions of the RDM was untestable in the doctor's surgery and open to considerable interpretation. The new medical is now consistent with the standard required for a conditional driving licence and can be tested in the surgery.

Respiratory system: There is no longer a recommendation that candidates with current asthma are potentially 'unfit'. The physician is directed to an appendix (reproduced here) by which an asthmatic candidate can be assessed. This appendix clarifies the circumstances under which a stable asthmatic may be passed for diving.

Diabetes: The appendix dealing with divers who have diabetes is possibly the most controversial section and is reproduced here. Some individuals with either insulin-requiring or non-insulin-requiring diabetes may be able to dive with an acceptable level of risk. For example, non-insulin-requiring candidates with diabetes may be at a lower risk of hypoglycaemia, but have significant risks of end-organ damage. Health surveillance for diving of those with diabetes should address all relevant risks.

What happens now?

The RDM has been ratified by the Committee and this notification constitutes its official release. This is now our advice for diving physicians. This produces a potential problem as the previous medical is the document adopted by Standards Australia. Also, the situation is complicated by the developments in the International Standards Organisation.[5] We will keep members apprised of developments. SPUMS will also be negotiating with legislators in Queensland and the dive training organisations.

Finally, please do not hesitate to contact me if you spot any obvious flaws or problems in this document. Although all parents would disagree, no baby is perfectly formed!

With thanks to members of the subcommittee for all their hard work; Cathy Meehan, Simon Mitchell, Chris Edge, David Smart, Mark Porter and Phil Bryson

References

1 Bennett MH, editor. *Guidelines of medical risk assessment for recreational diving*. Melbourne: South Pacific Underwater Medicine Society; 2010. www.spums.org.au
2 Gorman D. From police to health adviser: the evolution of modern occupational health surveillance. *SPUMS Journal*. 2003;33(3):134-9.
3 Bennett MH. Risk perception and sport. The doctor as policeman? *SPUMS Journal*. 2004;34(2):75-80.
4 Meehan CA, Bennett MH. Medical assessment of fitness to dive – comparing a questionnaire and a medical interview-based approach. *Diving and Hyperbaric Medicine*. 2010;40(3):119-24.
5 Smart D, Meehan C. Australian standards for occupational and recreational divers. Change in the wind? *Diving and Hyperbaric Medicine*. 2010;40(3):160-1.

Mike Bennett, President SPUMS

Key words
Medicals – diving, medical society, editorials

Appendix C: suggested assessment for the diver with asthma

Introduction

Asthma is a chronic inflammatory lung disorder characterised by wheezing, cough, shortness of breath and chest tightness. Inflammatory changes cause the bronchial smooth muscle to be hyper-responsive to a variety of stimuli including exercise and dry air. The narrowed airways, combined with the production of thick dry mucus, mean airflow may be severely limited and threaten life if not promptly treated. Prevalence depends greatly on how asthma is defined and may be as much as 30% in Australia and even higher in New Zealand.[1,2]

Importantly for diving physicians, a resolution of asthma during adolescence may be more apparent than real, suggesting it may be unwise to assume that once clinically resolved, asthma will not pose a future threat to health in a young diving candidate.[3]

Asthma and diving

There are several reasons why divers with asthma may be at greater risk of misadventure than those without asthma:

- Bronchial hyper-responsiveness may lead to air trapping during ascent and overpressure within the lung units involved, and therefore increase the risk of pulmonary barotrauma (PBT) and cerebral arterial gas embolism.
- Even in the person with well-controlled asthma, an exacerbation may be provoked in response to exercise (submerged or on the surface), salt water aspiration or breathing dry, cold air. Such an exacerbation is difficult to treat while submerged and may restrict the ability of a diver to safely complete or abort the dive.
- A diving regulator may produce a fine mist of seawater (hypertonic saline with added biological material), which may provoke bronchoconstriction.
- Bronchial constriction, added resistance in the regulator and increased gas density at depth will increase the work of breathing, further exhausting an individual with acute bronchospasm.
- There is a possibility that bronchodilators may provoke the passage of bubbles across the pulmonary filter and therefore predispose an asthmatic to decompression illness.
- There is some evidence that breathing through a scuba regulator increases airway resistance in people with asthma compared with those who do not have asthma.[4]

Prospective divers with asthma may be so well controlled by the current generation of inhaled corticosteroids and long-acting bronchodilators that their lungs are no longer reactive to stimuli such as exercise and salt water. Such 'well-controlled' individuals may have risks from diving that are close to those of individuals without asthma. If this is so, then the implication is that people with asthma who are asymptomatic and show normal lung function on testing with spirometry and bronchial provocation may be able to dive with an acceptable level of risk.

Asthma therapy

The emphasis is on the administration of long-term modulation of airway inflammation with inhaled corticosteroids (ICS), combined with long-acting beta-two agonists. These two classes of agents complement each other by acting on the two major components of asthma: inflammation and bronchoconstriction. The general approach to pharmacological therapy is to step up medication until control of symptoms is achieved. Current guidelines for treatment are published by the National Asthma Council Australia and can be found online through their website at <http://www.nationalasthma.org.au>. This organisation publishes an evidence-based guide to managing asthma that is available without cost in hard copy or electronic format (*The Asthma Management Handbook*).[5] These comprehensive guidelines emphasise the importance of an established doctor-patient relationship within which adequate attention can be paid to education, joint goal-setting, monitoring, review and the identification of risk factors. Any consideration of the suitability for a candidate to undertake diving should start with the assurance that such an arrangement is in place.

Assessing a candidate with asthma for diving

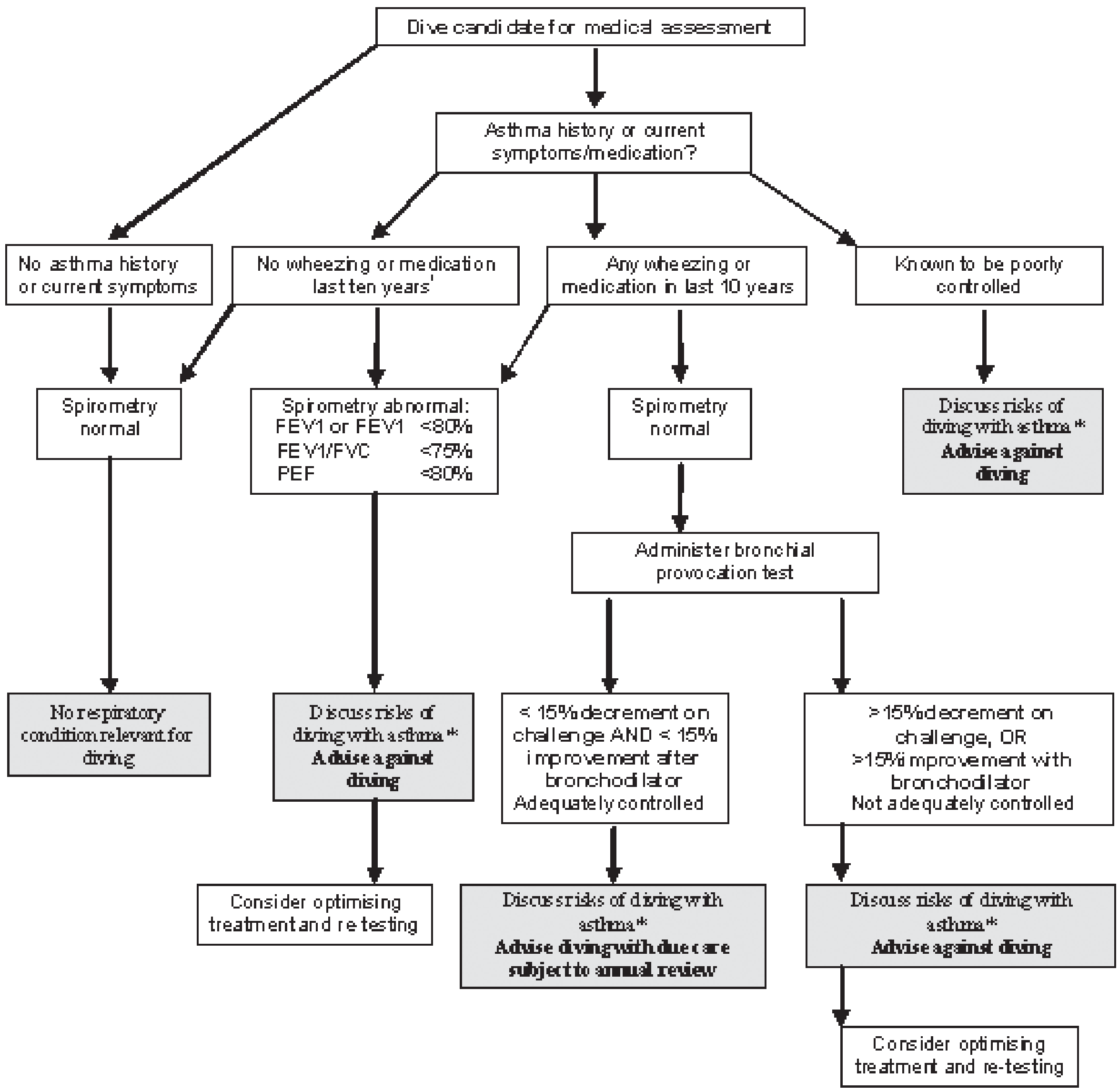
These candidates should have simple spirometry including measurements of forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), the ratio of FEV_1/FVC and peak expiratory flow (PEF). A single-breath flow-volume loop is recommended (by referral to a pulmonary laboratory, if necessary) as the information obtained (particularly changes in mid-expiratory flow rates and in the response to bronchodilators or to exercise), provides better evidence of small airways disease than an FEV_1/FVC ratio alone. The best of three attempts should be accepted.

Those who indicate a history of asthma in the last ten years, exhibit signs of wheezing or an unexplained cough, but have normal spirometry, should have bronchial provocation testing. The SPUMS recommended definitions of abnormal spirometry are one or more of: FVC <80% predicted; FEV_1 <80% predicted; FEV_1/FVC ratio <75% predicted or PEF <80% predicted. For a more thorough discussion of lung function testing, please refer to the joint American Thoracic Society and European Respiratory Society document.[6]

Bronchial provocation testing

These tests should be performed in an appropriate laboratory

Figure 1
A suggested schema for dealing with asthmatics who present for an assessment for fitness to dive; * see text for a discussion of appropriate advice; [1] assess these candidates with a low threshold for provocation testing if there is any doubt about possible symptoms of exercise-induced bronchospasm.



in order that both challenge and response are measured in a standardised way. The role of testing was reviewed recently by the Thoracic Society of Australia and New Zealand.[7]

Indirect methods, including dry air hyperpnoea, exercise and hypertonic challenges (saline or mannitol) are more specific for identifying individuals with current airways inflammation because they cause release of mediators from inflammatory cells in the airways, probably via an osmotic effect. The choice of which test to use will depend partly on local resources, but both exercise and 4.5% saline have the benefit of exposing the diver to stimuli that may actually be encountered during scuba diving. Another advantage is that treatment with ICS will reduce bronchial hyper-responsiveness over several weeks, making this a useful indicator of the response to therapy.[8]

In general, most authorities accept a reduction in FEV_1 of greater than 15% as a 'positive response' to indirect challenges. The same implication is derived from demonstrating more than a 15% improvement with the administration of a bronchodilator. A positive response should lead to a recommendation against undertaking diving, but does not preclude re-testing and re-assessment after asthma control has been established. A proposed schema for dealing with an asthmatic patient is contained within Figure 1.

Advice to those who 'fail' bronchial provocation

Diving is inadvisable for any person with asthma who fails bronchial provocation testing by an indirect method. These candidates should be counselled with regard to the theoretical dangers discussed above and the implications of their response clearly pointed out. Candidates may be re-tested when control has been established by stepwise escalation of therapy. Current data suggest that normalisation of response with treatment is possible, and these candidates may be able to dive at some future time provided asthma control is maintained. These individuals should be re-assessed annually.

Advice to candidates who 'pass' bronchial provocation testing

There are two groups of candidates who do not demonstrate bronchial hyper-responsiveness: those not taking medication do not require follow-up unless they develop symptoms; those taking anti-asthma medication should be re-assessed annually or sooner if they develop any symptoms.

All current divers with controlled asthma are strongly encouraged to monitor their peak flow twice daily during diving periods, with the recommendation to refrain from diving if PEF is more than 10% below their best value.[9] The SPUMS strongly advise divers against diving when symptomatic. Medical review is required after the development of any symptoms related to asthma.

Conclusions and recommendations

- Asthma may place an intending diver at increased risk of drowning, pulmonary barotrauma, and/or arterial gas embolism.
- Those with asthma who are symptomatic or display hyper-reactivity of airways to indirect stimuli should be advised against diving due to the potential risk from pulmonary barotrauma and an exacerbation of their disease either underwater or on the surface.
- Spirometry should be performed in all intending divers with any respiratory symptoms or a history of significant respiratory disease. Peak flow meters are of limited use in assessing respiratory function for diving fitness, but may be useful for day to day monitoring of status. Spirometry should be a single-breath flow-volume curve if possible.
- Divers with controlled asthma who are cleared for diving should have annual review of their diving fitness.
- All risks should be explored fully in discussion with the candidate, and the diving physician should satisfy themselves that the candidate appreciates these risks. Written guidelines should be provided and the individual should accept responsibility for following these guidelines. The consultation should be carefully documented.

References

1 Ross Anderson H, Gupta R, Strachan DP, Limb ES. 50 years of asthma: UK trends from 1995 to 2004. *Thorax*. 2007;62:85-90.
2 National Asthma Council Australia. *Asthma - the basic facts; Asthma management handbook 2002*. Melbourne: National Asthma Council Australia Ltd; 2002.
3 Taylor DR, Cowan JO, Greene JM, Willan AR, Sears MR. Asthma in remission: can relapse in early adulthood be predicted at 18 years of age? *Chest*. 2005;127:845-50.
4 Gotshall RW, Fedorczak LJ, Rasmussen JJ. Severity of exercise-induced bronchoconstriction during compressed-air breathing via scuba. *SPUMS Journal*. 2004;34(4):178-82.
5 Guidelines Committee. *The asthma management handbook 2006*. Melbourne: National Asthma Council Australia Ltd; 2006. Available at <http://www.nationalasthma.org.au/cms/index.php> (last accessed 21 July 2010)
6 Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. Brusasco V, Crapo R, Viegi G, editors. ATS/ERS Task Force: Standardisation of lung function testing Series (2). *Eur Respir J*. 2005;26:319-38.
7 Anderson SD, Wong R, Bennett M, Beckert L. Summary of knowledge and thinking about asthma and diving since 1993. Discussion paper for the Thoracic Society of Australia and New Zealand, November 2004. *Diving and Hyperbaric Medicine*. 2006;36:12-8.
8 Koskela HO, Hyvarinen L, Brannan JD, Chan HK, Anderson SD. Responsiveness to three bronchial provocation tests in patients with asthma. *Chest*. 2003;124:2171-7.
9 British Thoracic Society Fitness to Dive Group: British Thoracic Society guidelines on respiratory aspects of fitness for diving. *Thorax*. 2003;58:3-13.

Appendix D: suggested assessment for the diver with diabetes

Introduction

Diving by individuals with diabetes has been one of the most controversial issues in debates over ‘fitness to dive’ for several decades. A recent report from a joint UHMS/DAN workshop in 2005 has summarised the position.[10]

Diabetes and diving

Selection of appropriate individuals with diabetes (whether insulin-requiring or not) who could be recommended for diving is important because many of the acute and chronic complications of diabetes are potentially a profound risk during and after diving. A brief summary of the major concerns is given in Table 1. People with diabetes who are prone to acute complications (such as hypoglycaemia) or suffering chronic complications that might impact significantly on diving safety should be advised against diving. Similarly, the progressive nature of many complications of diabetes suggests there should be longitudinal health surveillance and periodic reassessment of suitability over the period of the individual’s participation in diving.

Divers with diabetes should always have immediate access to the surface and adopt a strategic approach to management of blood glucose during a diving day.

Which people with diabetes may be able to dive?

The following criteria are appropriate for recreational dive training for a candidate with diabetes:

- Age 18 years or over.
- At least six (6) months have passed since the initiation of treatment with oral hypoglycaemic agents (OHAs) or one (1) year since the initiation of treatment with insulin. An appropriate ‘observation period’ must be imposed after introduction or major change of medication.
- No hypoglycaemic episodes requiring intervention from a third party for at least one (1) year, and no history of ‘hypoglycaemia unawareness’.
- HbA1c </=9% when measured no more than one (1) month prior to initial assessment and at each annual review.
- No admissions or emergency visits to hospital for any complications of diabetes for at least one (1) year.
- No known retinopathy (worse than ‘background’ level), microalbuminuria, significant nephropathy, neuropathy (autonomic or peripheral), coronary artery disease or peripheral vascular disease. This requires clinical judgement and close liaison between the physician managing the diabetes and the diving physician, on a case by case basis.
- Prior to the first diving medical assessment and each annual evaluation, a review must be conducted by the physician managing the candidate’s diabetes, who must confirm that:
  * the criteria above are fulfilled
  * the candidate demonstrates accurate use of a personal blood glucose monitoring device and
  * the candidate has a good understanding of the relationship between diet, exercise, stress, temperature and blood glucose levels.

Table 1
Acute and chronic complications or associations recognized in diabetes, and potential interactions with diving

Complication	Potential interaction with diving
Hypoglycaemia	• May be precipitated by stress, cold and exercise during diving • Potentially catastrophic consequences due to impaired mentation and consciousness underwater. These may endanger both the diver and buddy • Impending symptoms may be less likely to be noticed during diving • Potential for confusion with symptoms of DCI or other possible problems such as hypothermia or sea sickness
Hyperglycaemia	• May augment dehydration stress; a possible risk factor for DCI • May worsen outcome in neurological DCI
Coronary artery disease	• Impairment of exercise tolerance • Possibility of myocardial ischaemic event
Resetting of hypothalamic glucose control	• Release of adrenaline during hypoglycaemia occurs after neuro-glycopenia and patient may become incapacitated before noticing hypoglycaemic symptoms: a phenomenon known as ‘hypoglyacaemia unawareness’
Autonomic neuropathy	• Blunting of adrenaline release expected when blood glucose falls thereby worsening potential for hypoglycaemia
Peripheral neuropathy	• Possible confusion with signs of DCI
Peripheral vascular disease	• Impairment of exercise tolerance
Renal impairment	• Multiple possibilities depending on severity

- Prior to commencing diving and at each annual review, a diving medical risk assessment must be completed by a doctor who has successfully completed an approved post-graduate diving medical examiners course (see Appendix E of the SPUMS diving medical, 2010). A review report by the physician managing the diver's diabetes must be available. This risk assessment will include appropriate assessment of exercise tolerance and, for candidates over 40 years old, should include an exercise ECG.
- As part of the assessment by the diving medical examiner, the candidate must acknowledge (in writing):
  * receipt of and intention to use the recommended diabetic diving protocol (see below)
  * the need to seek further guidance if there is any material that is incompletely understood
  * the need to cease diving and seek review if there are any adverse events in relation to diving suspected of being related to diabetes.
- Steps 2–9 of this protocol must be fulfilled on an annual basis. Where possible the same diabetic physician and diving medical officer are used for these annual reviews.

Scope of diving

The following restrictions are appropriate for recreational divers with diabetes:

- Divers with diabetes should undergo training within a programme designed specifically for that purpose.
- Divers with diabetes are unsuitable for occupational diving, which involves focus on a task or purpose that demands attention and concentration. This will inevitably detract from self-monitoring and is not recommended.
- Divers with diabetes should not undertake dives deeper than thirty (30) metres of seawater, dives longer than one (1) hour, dives that mandate compulsory decompression stops, or dives in overhead environments. These practices all hamper rapid access to surface support.
- Divers with diabetes do not undertake more than two (2) dives per day and use a minimum surface interval of 2 hours.
- Divers with diabetes must dive with a buddy who is informed of their condition and aware of the appropriate response in the event of a hypoglycaemic episode.
- Divers with diabetes should avoid combinations of circumstances that might be provocative for hypoglycaemic episodes such as prolonged, cold dives involving hard work.

Blood glucose management on the day of diving

The following protocol is taken from the Divers Alert Network guidelines for divers with diabetes and is reproduced with permission.[10] Divers with diabetes (whether insulin-dependent or otherwise) should use this protocol to manage their health on the day of diving:

- On every day on which diving is contemplated, the diver must assess him or herself in a general sense. If he or she is uncomfortable, unduly anxious, unwell in any way (including sea sickness), or blood glucose control is not in its normal stable pattern – DIVING MUST NOT BE UNDERTAKEN.
- The diver should establish a blood glucose level (BSL) of at least 9 mmol L^{-1}, and ensure that this level is either stable or rising before entering the water. Measurements should be taken three times before diving at 60 minutes, 30 minutes and immediately prior to gearing up. Diving should be postponed if blood glucose is <9 mmol L^{-1}, or there is a fall between any two measurements.
- Attempts to comply with the requirements at 2 (above) should not result in a blood glucose level greater than 14 mmol L^{-1}, and diving should be cancelled for the day if levels are higher than 16 mmol L^{-1} at any stage.
- Divers must carry oral glucose in a readily accessible and ingestible form at the surface and during all dives. We strongly recommend that these divers also have parenteral glucagon available at the surface. If premonitory symptoms of hypoglycaemia are noticed underwater, the diver must surface, establish positive buoyancy, ingest glucose and leave the water. An informed buddy should be in a position to assist with or initiate this process.
- Blood glucose levels must be checked at the end of every dive. The requirements for blood glucose status outlined above remain the same for any subsequent dive. In view of the recognized potential for late decrements in blood glucose levels following diving, BSL should be checked 12–15 hours after diving.
- Divers are strongly recommended to drink between 1000 and 1500 ml of extra water over a period of several hours prior to their first dive of the day.
- Divers must log all dives, associated diabetic interventions, and results of all blood glucose level tests conducted in association with diving.

This protocol should be combined into an information package to be given to the diabetic by the examining doctor on completion of their diving medical examination.

Reference

10 Pollock NW, Uguccioni DM, Dear G deL, editors. Diabetes and recreational diving: guidelines for the future. Proceedings of the Undersea and Hyperbaric Medical Society / Divers Alert Network 2005 Workshop. Durham NC: Divers Alert Network; 2005.

Key words
Medicals – diving, asthma, diabetes, medical society, reprinted from

Opinion

A personal overview of accidents and risk management in the recreational diving industry

Bret Gilliam

Key words
Accidents, diving accidents, recreational diving, medical conditions and problems, risk management, legal and insurance

Abstract

(Gilliam B. A personal overview of accidents and risk management in the recreational diving industry. *Diving and Hyperbaric Medicine*. 2010;40(3):156-9.)
Recently the recreational diving industry has experienced an increase in accidents and fatalities (per capita, based on reliable estimates of diver populations). Many of these incidents have resulted from a degradation of training standards for 'performance-based' learning of skills and knowledge, both for students and the instructors, dive masters, and assistants who are responsible for their initial training and subsequent courses aimed at 'advanced' curricula. The industry has also seen a decline in the experience and practical expertise of diving leadership staff responsible for the management of resorts and liveaboard diving operations. The resulting incidents have led to a rise in legal actions and settlement costs or trial verdicts. The important contributing issues in accident causation are discussed. A fundamental lack of understanding of how to effectively use the tools of risk management (waivers and releases, defensive teaching, good record keeping), as well as inadequate pre-training screening that might eliminate some participants based on age, physical condition, or pre-existing medical issues, are contributing to this increase. These factors also complicate the efficient management of litigation through the courts. The costs associated with litigation are now causing increased insurance premiums, reduced scope of coverage for some activities, and outright denial to some seeking insurance. This paper provides a personal perspective based on a 40-year involvement in all aspects of the diving industry and extensive experience in the litigation process as a consultant and expert witness.

Introduction

Obviously our goal is to identify and recognise the precipitating events that cause diving accidents so they can be prevented and reduced. It is important to understand and address these issues from an actual body of expertise in the formulation of standards and training, field operational protocols, and insight into the litigation arena. It is impossible to accurately assess incident rates and underlying causation factors solely from public accident records or simple statistics. The author provides a personal perspective on causation issues, suggestions for improvements, and an explanation of risk management in layperson's language based on his 40-year involvement in all aspects of the diving industry as well as ongoing direct involvement in the legal and litigation process as an 'insider' with direct knowledge of facts in more than 235 case files.

Elemental issues of accident causation

- Some scuba training agency programmes lead divers to believe they are more qualified than they are, with ratings like 'Advanced Diver' being achieved with as few as 9–10 total dives and 'Master Diver' with fewer than 50, and 'rescue' courses that are so simplistic as to be largely impractical in actual emergencies, etc.
- Divers can qualify for instructor ratings with as few as 50 dives in some agencies.
- No effective oversight is made within some agencies to interdict and restrict those instructors with repeated standards breaches and accident records.
- Courses tend to be abbreviated for the sake of moving the student through the system instead of ensuring that skills and knowledge are fully learned and mastered. One agency claimed to use a performance-based standard of qualification, but in the discovery disclosures of one lawsuit that premise was proved to be totally misstated. For example, if a student tried two dozen times to clear their mask and finally got it right on the 24th time, they were 'passed' in spite of the fact that this clearly did not demonstrate the 'mastery' and 'repeatability' of the skill; only that the student had successfully cleared their mask once! This hardly meets a standard wherein the skill can be repeated as needed with competence and confidence.
- Students need the opportunity to make mistakes under direct supervision and then have them corrected by the observing instructor who turns the process into a positive learning experience instead of into a lesson in survival when it occurs in the field with no outside help.
- The number of divers entering the sport has historically been vastly overstated for marketing purposes. Diving Equipment & Manufacturing Association (DEMA) census reporting in recent years has confirmed this.[1] When the database of divers is not accurate, it skews the ratio of participants' accident incident rates and makes

forecasting risk predictability and actuarial insurance ratings impossible to determine and assess.

- The drop-out rate for divers and instructors is at an historic high. This is particularly important for instructor and other 'leadership' level ratings, as existing 'professionals' tend to be replaced with those even less qualified. This is mostly due to employment conditions and lack of financial compensation. Although touted as a career path by many agencies, the majority of those entering instructor roles find that they lack the means to earn a living wage unless their ratings are supplemented with legitimate extra credentials such as EMS training, maritime licenses, or specific expertise in such fields as photographic training to supplement their value in a retail, resort, or liveaboard position.
- With the decline in diving participation in the last decade, there has been a corresponding decline in experienced mentors for new instructors and dive masters for on-the-job or in-the-field training in actual scenarios. This has contributed to accident rates and the failure of early identification of behaviour patterns that would have been more likely to be recognised as potentially dangerous by more experienced diving supervisors.
- As a general observation from a review of lawsuits and accident reporting, we are seeing more accidents resulting from a simple lack of common sense, maritime experience, etc, since little of such specific training and assessment is included in the curricula of many agencies.
- There is also a need for enhanced training in evacuation, field assessment and treatment, and perhaps, most importantly, disqualification of divers from some activities due to lack of experience before being allowed to engage in more challenging conditions. For example, the September 2009 issue of *Undercurrent* magazine reported the celebration of a diver's 25th logged dive aboard a liveaboard vessel at Cocos Island, a site notorious for the need for more advanced diving skills and the ability to dive independently.
- The role of the remaining (and rapidly shrinking) diving press in print media is not helping either. Just take a casual review of photos showing dangling gear, octopus emergency second stages dragging on the bottom, unsuitable equipment, over-weighted divers, etc.
- The tragic record of diver-error rebreather accidents/fatalities, expedition trips led by less than qualified leaders with associated fatalities, lack of pre-qualification protocols, failure to provide a designated, overall, qualified supervisor on specialised-equipment, deep, or penetration dive programmes is rampant.
- Finally, while most training agencies do a creditable job of developing worthy standards and procedures for training, many resorts and liveaboard ship operations lack even rudimentary operations manuals that address field-condition protocols for more advanced medical assessment, search and rescue, adequate evacuation methods, or even sufficient supplies of oxygen with demand masks for surface-breathing first aid.

So you want to climb Mount Everest?

Many divers who emerge from initial diving certification programmes with an 'open water' certification choose not to pursue further formal training, going forward by acquiring practical experience through their diving activities. Often this works well, since practical, real-life experience arguably is just as relevant in producing a qualified diver… at least, for warm waters, and not too difficult conditions. While certification agencies would now prefer that divers progress at least partly through an enhanced system of ratings, there is no requirement that they actually do so.

Many travelling divers are now 50 years or older. With age and prosperity also come limitations that should be recognised as serious considerations. The 50-year-old plus diver has to take into account the realities of aging that include reduced stamina, possible high blood pressure, cardiac problems, reduced flexibility and mobility, arthritic joints, vision and hearing loss, deteriorating muscular strength, postoperative limitations, side effects of required medications, and general reduced physical fitness. Of course, there are exceptions to such broad-based generalities, but within the general population that I am identifying, possible limitations exist that can affect their fitness to dive. Older divers may be perfectly fine with their original training and the life experience they have acquired through continuing dive participation, provided they recognize their limitations and restrict their diving to suitable environments and situations. However, if they want to indulge in more rigorous or technically challenging diving activities, then seeking out the proper training before jumping off to dive the *Andrea Doria* would generally be a pretty good idea.

Herein lies a problem that has increasingly raised its ugly head. I call it the '*into thin air*' mentality. This references the account of the multiple fatal tragedies on Mount Everest in 1996, as chronicled in Jon Krakauer's infamous and revealing book.[2] The lesson from that tragic year was that there were a lot of amateur climbers on the mountain who should not have been there, but they had the financial resources to pay the hefty expedition fees and figured the alpine guides would look after them in spite of any limitations they might have. One woman climber even paid extra to be 'short-roped' to the summit, a practice wherein she had a Sherpa essentially drag her up the face of Everest on a tether. When a series of unexpected weather conditions occurred, several amateur climbers died along with the professional guides who tried to save them.

In recent years, some of the same issues have arisen within the diving industry as well-intended, but perhaps under-qualified, folks have signed up for diving expeditions that turned out to be beyond their capabilities. Most operators have screening processes designed to determine the applicants' expertise in advance. Typically, this requires an application that details training, diving experience, medical history, fitness to dive, etc. This should work well, in theory.

The breakdown occurs when divers misrepresent their diving skills and/or medical fitness. This is tough for an operator to determine and, of course, there is the underlying element of wanting to procure a well-paying customer for these exotic trips. So, sometimes the screening process breaks down. Some divers get injured or die, while the lucky ones have close calls or were scared out their wits when the harsh reality of field conditions caught up with them and they were unable to cope.

Consider a few real-life examples that I have had to deal with in the last few years: a 58-year-old who did not feel it necessary to disclose that he had only one lung; a 46-year-old who was in such poor physical condition that she could not climb back aboard the dive launch without assistance (and this was with no equipment on!); a 64-year-old with a history of four cardiac events in the last two years; a 55-year-old who was sufficiently obese that he could not reach down to put on his own fins; a 52-year-old taking three antidepressant medications and with a recent history of suicide attempt and a 57-year-old in such poor shape he could not swim from the stern to the bow line of a 20-foot dive launch to reach the descent line. While the above citations are daunting, they were unknown to me or to my staff until we had to engage in rescues. Incredible? Yes. But the frequency of such misrepresentations is more than occasional; it is happening more and more and has caused many operators to adopt far more stringent screening and risk-management policies.

There are a great variety of focused advanced training programmes that can ease the diver into gaining the experience and expertise to participate in more challenging diving. While it is difficult to define really what an advanced diver might be, I think any modicum of common sense would suggest that fewer than 10–12 total experiences in any activity, quite apart from diving, would hardly meet any reasonable definition of 'advanced'. The ocean can be a very unforgiving place to play chicken in traffic. You can also risk the lives of fellow divers who may need to forsake their safety in attempting to rescue you.

Rebreathers are another example. By comparison, open circuit equipment is fairly simple and relatively foolproof. If you don't turn the valve on, the regulator will not work. In rebreathers, however, you can actually breathe through the closed or semi-closed loop without turning the gas supply on. There is no immediate warning that things are amiss until you pass out from hypoxia. A recent New Zealand fatality is a classic example. Rebreathers have demanding and unforgiving maintenance regimes as well as lengthy checklists and set-points before diving. If you are not willing to make a commitment to taking on the added responsibility that such equipment requires, then stay on open circuit.

Understanding risk management

Nothing in life is safe, and diving, like many other sports activities, is inherently dangerous. In fact, a lot of the diving industry's risk-management protocols were liberally adapted from those of the snow-skiing business. As the popularity of other potentially dangerous sports became more widespread (think snowmobiling, ATVs, skateboard parks, skydiving, hang gliding, and even youth football and baseball leagues), the use of waivers and accompanying risk-management practices to warn participants in advance of hazards became routine.

LIABILITY INSURANCE

There are few buzzwords to come into the lexicon more important to professional diving instructors than 'risk management' in today's society of litigation. Luckily there are some relatively simple steps that instructors can take to help balance the odds in their favour. The obvious first step is to acquire professional instructor liability insurance. In addition to obtaining insurance, it is important for the diving professional to have a fundamental grip on the basic tenets of risk management in order to conduct themselves with all possible caution to protect their students, divers in their care, and themselves.

TEACHING DEFENSIVELY

Probably the single best advice an instructor can follow is to 'expect the unexpected'. In other words, never assume that anything will go right or as planned. Remember, the whole purpose of supervision is to give the student diver a chance to learn the skills of diving and, if mistakes are made, the instructor is right there to help turn those mistakes into positive learning experiences instead of grim survival tests. It is vital that instructors conduct all programmes in accordance with agency standards. These provide a proven curriculum of academic knowledge and practical skills that progress the student on the path of self-sufficiency and independent activity. Bear in mind that instructor/student ratios are based on site conditions. In situations that are suboptimal, such as reduced visibility, surf conditions and the presence of currents, especially if the class has students needing special attention, the number of students should be reduced and/or additional assistant instructors added to ensure proper direct supervision.

PROPER USE OF RECORDS AND WAIVERS

The proactive use of the arsenal of waiver and release forms available to the instructor or dive operators is vital to the successful conduct of their activities. These will generally include at least a medical history form and a general release of liability and assumption of risk agreement. No instructor, resort, or dive-vessel operator should conduct their activities without proper use of such documents. The whole idea of waivers and releases is to establish a contract between the student/diver and instructor/dive operator that stipulates certain understandings as to the nature of the activities about to take place in training. Sufficient time for contemplation and absence of threat of monetary loss are essential, as these alone can be grounds to deny applicability. Asking a class of students or group of divers to sign waivers shortly before pool activities or open-water diving activities begin does not meet the spirit of the release. Execution of the waiver and release documents should be handled as one of the most important parts of the relationship with students or divers participating in post-certification activities. This is a formal contract that affects their legal rights and the rights of their families.

After initial certification, subsequent waivers require the diver to represent his diving experience and prior training. This is to clearly establish that the person executing the release has a body of life experience in the sport, separate from the specific warnings as to hazards and risks, on which he may base his decision to participate. For example, a person signing up for basic entry-level scuba really has no understanding of the inherent risks of the sport until his instructor covers that material in his class. On the other hand, a certified diver with six years of diving in a variety of conditions and depths since his original training already is aware of most of the standard hazards associated with scuba participation. He can make an informed decision based upon that experience and prior training.

TRAINING AND DIVING ACTIVITY RECORDS

Written evidence of a student's successful completion of tests, skills, pool and open water sessions is essential. Safeguard the student training record, medical history forms, physician's approval if necessary, as well as waiver documents. These files should be preserved for at least seven years. Obviously if an accident were to occur during training they would be of immediate use. They have additional importance if an accident were to occur after certification and a law suit was filed with allegations that the original course was lacking full content or that the student failed certain academic topics or skills without proper reinforcement or review to ensure the student's complete understanding or proper mastery of skills. Keeping paperwork up to date as the training programme or diving activities proceed and always reviewing any incorrect performance by a student or diver until it is properly completed or mitigated are further elements of safe practice.

MEDICAL HISTORY

Ensure that students complete the medical history form prior to any class activities, including academic lectures. It is recommended that instructors not coach students on completion of the form. However, it is appropriate to clarify any questions that may arise. Should a student accidentally respond to a question in error, a new form should be given to them to fill in with accurate answers. When a student indicates one of the areas that require a physician's medical approval, have the student provide the executed medical approval signed by a medical professional for proper documentation of the student record.

Conclusions

The diving industry is at a crucial crossroads of evolution at this time. Without some fundamental changes in paradigms as noted in the above narrative, there are very real negative consequences that will materialise and further limit growth and profits as accidents/fatalities escalate and the insurance market contracts. Increased litigation costs from unnecessary breaches of duty by those insured will only increase underwriters' reluctance to participate in this risk and eventually exit the market, or result in costs that may prove unaffordable. Lawsuits will only increase and the costs of defence, settlement, or verdict awards escalate to unacceptable levels. One thing is certain: litigation is recession-proof. Diving professionals should use the risk-management tools available and teach defensively; they can take that advice to the bank.

References

1 Diving Equipment & Manufacturing Association (DEMA). *Open water certification count*. Available at http://www.dema.org/displaycommon.cfm?an=1&subarticlenbr=290 (last accessed 21 July 2010)
2 Krakauer J. *Into thin air*. New York: Anchor Books; 1999.

Submitted: 07 July 2010
Accepted: 17 July 2010

Captain Bret Gilliam is a USCG Merchant Marine Master, professionally involved in the diving industry since 1971. His background includes scientific expeditions; military/commercial projects; operating hyperbaric diving treatment facilities, liveaboard dive vessels and luxury yachts; retail dive store and resort operation and ownership, and filming projects. He has published widely on diving-related subjects. He was the founder and President of the training agencies TDI and SDI, ex-Chairman of the NAUI Board, and ex-Vice President for IANTD. He has an extensive practice as a litigation consultant and expert witness in the fields of diving, maritime operations, and field management of diving barotraumas.

Address for correspondence:
54 Stonetree Road
Arrowsic, ME 04530, USA
E-mail: *<bretgilliam@gmail.com>*

Editor's note:
Having recently read, in an article in the magazine *Undercurrent*, Capt Gilliam's concerns regarding recreational diving accidents, I invited him to submit this article on the health and safety of sport divers. The opinions expressed are the author's own and are not necessarily those of the Editor, EUBS or SPUMS.

Australian standards for occupational and recreational divers Change in the wind?

David Smart and Catherine Meehan

Key words
Standards, occupational diving, recreational diving, medicals – diving, medical society

Background

Prior to 2008, Standards Australia provided the front-end resourcing for development of new standards and revision of existing standards. In 2008, this model changed to require initiation and front-end payment by organisations if they wished to develop or revise a standard. For diving standards this has led to a gap whereby no individual organisation has sufficient resources to fund such development. In addition, there has been pressure from the Federal Government to accept international standards as the applicable standards for Australia where these overlap our current standards. This is of particular relevance to the recreational diving industry whereby a number of international standards in recent times have been promulgated in Australia to cover the training of the various levels of recreational divers. These standards lack detail compared with current Australian standards and also require a lesser level of medical assessment to participate in recreational diving.

A meeting for committees SF-017 and CS-086 was convened in April 2010 to try to work out a way forward under this new business model. The meeting, chaired by Dr Ian Millar (representing the Australian Medical Association), was attended by representatives of 15 interested organisations. Workplace Health and Safety was not represented.

How a standard can be developed or revised under the new business model

New standards development has a ‘front end’, comprising initiation and design, and a ‘back end’ of implementation and finalisation. The back-end processes remain the responsibility of Standards Australia. There are several different front-end pathways by which a standard can be initiated:

- *Standards Australia driven:* This pathway primarily relies on Standards Australia’s resources, project-management expertise and infrastructure.
- *Committee driven:* Under this pathway an appropriately skilled committee undertakes project management and secretariat responsibility for the project, in addition to providing the subject-matter expertise.
- *Collaborative:* The stakeholder-funded collaborative pathway offers stakeholders choice in resourcing levels and project timeframes.

For details see <www.standards.org.au>

At the meeting, the history of Standards Australia and how it generated its income was outlined. A new business model required assessment of existing standards to see whether or not they were active, semi-active or requiring resubmission. The only two systems likely to be used for developing or revising diving standards were the standards- or committee-driven approaches. The standards-driven budget for this year has already been approved and it would be unlikely that diving standards would get funding support. Committee-driven projects require evidence of stakeholder support, and a sponsor is expected to fund the front end of the project including administrative support, and sourcing and funding committee members and interested third parties.

The front end costs of developing a committee-driven project range from AUD10,000–$13,000 with the back end approximately AUD8,000. Standards Australia reassured us that even if projects were funded, Standards Australia felt that they ‘owned’ the committee to ensure balance of committee constituency and also that the processes were appropriate and the final structure of the standard was appropriate. In other words, it would not be possible to ‘buy a result’. For occupational diving, there are numerous standards, AS2299.1–6 and the 2815 standards for training of divers in the professional industry.[1,2] There was considerable discussion about who would sponsor any further development of these standards as many are out of date (e.g., 1992 for training standards).

Committee SF-017 Occupational Diving

The Australian Diver Accreditation Scheme (ADAS) has indicated that it would provide sponsorship and secretarial support to continue the revisions and development of professional diving standards. This will allow standards for professional divers to continue as they previously have done with revisions every five years or so. Possible conflicts of interest for ADAS were discussed and it is unlikely they will impact upon the appointment of the Standard. However, this does have more relevance for the training standards.

Committee CS-086 Recreational Diving

Unfortunately discussion of this topic was left until the meeting time was almost over. The impacts of ISO standards, particularly 24801.1–5, on the recreational diving industry are significant.[3] These standards are supported by all of the training organisations and others with an active interest in increasing participation of divers through the recreational industry. It is unfortunate that these standards have been developed mostly in Europe. Block voting from the Europeans occurred and, despite serious disquiet expressed by France and Australia, they have been brought through by the ISO and, as such, will be accepted by Australian Standards in replacing AS4005.1–5.[4]

It should be noted that the medical assessment component of AS4005.1 is actually a supplement and not part of the standard itself, which is more directed at training of recreational divers. These international standards contain significantly less detail and have a lower benchmark for medical fitness for recreational diving. Hence the health requirements of these standards are lower than those of the current AS4005.1. For example the health requirements of ISO 24801-1 2006 are as follows:

"Section 5.3 Health Requirements – documented evidence shall be obtained that the student has been medically screened as suitable for recreational diving by means of an appropriate questionnaire or medical examination. In any case of doubt, or at the scuba instructor's discretion, students shall be referred to proper medical resources. If the student is not examined by a physician, the student shall be obliged to confirm by signature that she or he has understood the written information given by the scuba instructor on diseases and physical conditions which may pose diving related risk. Students shall be advised of the importance of appropriate regular medical examinations."

There is no comment that the students shall be examined by a doctor who is trained in diving medicine and the requirements are well short of the position held by SPUMS that all prospective scuba divers should have medical screening prior to commencing scuba diving. From the training industry perspective, the medical assessment required in AS4005.1 is seen as posing a trade barrier to their business and, therefore, they are quite happy to see this health requirement reduced. In a way, if ISOs are adopted, it will absolve SPUMS of some responsibility for the medical examinations and throw responsibility and liability for adverse events due to health issues firmly back on the training organisations. Given the issues identified in an accompanying paper, it is possible that there may be adverse health outcomes from diving as a result of this change in process.[5] This will not affect Queensland, as the requirement for medical assessment is enshrined in legislation in Queensland.

Interestingly, in addition to the discussion regarding 4005.1, those present from the recreational industry also indicated that they wished AS2299.3 to be eliminated from the professional diving code as it was regarded as interfering with their work. For some reason, they do not regard scuba diving instructors and dive masters as occupational divers, and believe they should be treated with a different set of rules and regulations than other professional divers. This issue will be looked at when 2299.3 is reviewed. Their objection seems very hard to follow on safety grounds. Unless there are compelling reasons to remove the 2299.3 standards, at this point there appears to be no reason for its deletion from the professional diving code. The United Kingdom Health and Safety Executive clearly defines individuals who earn a living from the recreational industry as being governed by their diving at work regulations.[6]

Where to from here?

There are three options available to SPUMS:

- Pay for and sponsor a revision of 4005.1 (of which the medical guidelines constitute two supplements rather than the full standard). This is unlikely to be supported by the recreational diving industry and, therefore, a committee would be unlikely to be convened in relation to the medical as the industry is currently happy with the international standards.
- Develop a separate medical standard. This is a reasonable option on the basis that there is protection of human health and safety, which is one of the methods by which trade restriction allegations will not be sustained. We recommend this as an option for SPUMS; it then becomes a separate medical standard. The standard may then also be applied to the commercial industry.
- Forward (as soon as possible) the new SPUMS Medical (since SPUMS is the premier advisory body in diving medicine in Australia) directly to the Queensland government, because the SPUMS Medical is referred to in its legislation. In addition, other state government occupational health and safety sections and departments of sports, recreation and tourism should receive copies. This would, at least, raise the profile of the SPUMS Medical at all governmental levels.

SPUMS and EUBS members are invited to contribute to this important debate through 'Letters to the Editor'.

References

1 Standards Australia. *Occupational diving operations*. AS 2299. (Parts 1-4). Sydney: Standards Australia Limited; 2007.
2 Standards Australia. *Training and certification of occupational divers*. AS 2815. (Parts 1–5). Sydney: Standards Australia Limited; 2006.
3 ISO 24801-2:2007 Recreational diving services - *Safety related minimum requirements for the training of recreational scuba divers - Part 2: Level 2 - Autonomous diver*. Geneva: International Organization for Standardization, 2007. www.iso.org/iso/catalogue_detail?csnumber=42444 (last accessed 24 July 2010)
4 Australian Standard AS4005.1-2000. *Training and certification of recreational divers. Part 1: Minimum entry-level SCUBA diving*. Sydney: Standards Australia Limited; 2000.
5 Meehan C, Bennett MH. Medical assessment of fitness to dive – comparing a questionnaire and a medical interview-based approach. *Diving and Hyperbaric Medicine*. 2010;40(3):119-24.
6 Statutory Instrument 1997 No. 2776 *The Diving at Work Regulations 1997*. Norwich: The Stationary Office Ltd; 1997. Available at http://www.opsi.gov.uk/si/si1997/19972776.htm (last accessed 24 July 2010)

David Smart and Catherine Meehan are the SPUMS representatives to Standards Australia on the occupational and recreational diving committees respectively.

For further information:
E-mail: *<david.smart@dhhs.tas.gov.au>*

Continuing professional development

CME activity 2010/3

Fitness to dive

Michael Bennett

Accreditation statement

To complete a course successfully, 80% of questions in each quiz must be answered correctly. Activities published in association with Diving and Hyperbaric Medicine are accredited by the Australia and New Zealand College of Anaesthetists Continuing Professional Development Programme for members of the ANZCA Diving and Hyperbaric Medicine Special Interest Group under Learning Projects: Category 2 / Level 2: 2 credits per hour.

Intended audience

The intended audience consists of anaesthetists and other specialists who are members of the ANZCA SIG in Diving and Hyperbaric Medicine. However, all subscribers to DHM may apply to their respective CME programme coordinator or specialty college for approval of participation.

Objectives

The questions are designed to affirm the takers' knowledge of the topics covered, and participants should be able to evaluate the appropriateness of the clinical information as it applies to the provision of patient care.

Faculty disclosure

Authors of these activities are required to disclose activities and relationships that, if known to others, might be viewed as a conflict of interest. Any such author disclosures will be published with each relevant CME activity.

Do I have to pay?

All activities are free to subscribers.

Background reading

Practitioners are referred to the articles in this journal dealing with fitness-to-dive issues (Meehan C and Bennett M, Ong ML et al and the new SPUMS diving medical and appendices).

How to answer the questions

Please answer all responses (A to E) as true or false.

Question 1: Which of the following is <u>*not*</u> *a clear contraindication to undertaking recreational dive training (according to the South Pacific Underwater Medicine Society)?*

A. Insulin-requiring diabetes mellitus diagnosed 10 months prior to examination.
B. A modified sharpened Romberg's test with balance maintained for less than 20 seconds after four attempts.
C. Frequent panic attacks associated with significant hypocarbia.
D. A resting arterial blood pressure of 160/100.
E. Offering training as a 13th birthday present.

Question 2: Concerning the Recreational Scuba Training Council (RSTC) statement…

A. Research suggests that roughly 63% of recreational diving candidates will answer all health questions on the RSTC form with 'no'.
B. The RSTC form was most recently updated in 1990.
C. The RSTC form was developed by the recreational dive industry as a screening tool to identify those candidates who should have a medical consultation.
D. Divers should be encouraged to fill out the statement in pencil so they can rub out any answers they wish to change at a later date.
E. We can reasonably expect that significant medical conditions will be missed in about 5% of candidates when using the RSTC statement.

Question 3: Concerning individuals referred to a diving and hyperbaric centre for fitness to dive issues…

A. More than 50% of the referred complaints involved the respiratory or ENT systems.
B. Asthma is a more commonly encountered problem in commercial diving candidates.
C. All patients with a history of migraine should have an echocardiogram.
D. Based on research, more than 70% of individuals are likely to be passed as 'fit to dive' after assessment.
E. Epilepsy is a contraindication to diving.

Question 4: With regard to candidates with diabetes…

A. The problems facing non-insulin dependent divers are very much the same as those facing insulin-dependent divers.
B. Divers with diabetes should have two buddies when performing decompression dives.
C. An HbA1c of 7% would exclude a diver candidate.
D. It is important that any diver with insulin-dependent diabetes should be unaware of any developing hypoglycaemia in order to avoid panic.
E. Glucagon administration should be avoided in divers if possible because it may result in peripheral neuropathy.

Question 5: With regard to candidates with asthma…

A. If a candidate with a history of asthma is passed as 'fit to dive', they should be supplied with written guidelines outlining ongoing monitoring and limits to their activity.
B. It is better to assess with direct methods of bronchial provocation so that one can be sure the mast cells have been stimulated.
C. A candidate with no wheezing or medication in the last ten years, yet who has abnormal spirometry, is permanently unfit for diving.
D. Repeat bronchial provocation testing may be used as a measure of treatment response.
E. Divers with well-controlled asthma who have been assessed as 'fit to dive' should be advised to have five-yearly diving medical assessments.

Answers should be posted by e-mail to the nominated CPD coordinator (for members of both SPUMS and the ANZCA Diving and Hyperbaric Medicine Special Interest Group, this will be Associate Professor Mike Bennett, <M.Bennett@unsw.edu.au>. On submission of your answers, you will receive a set of correct answers with a brief explanation of why each response is correct or incorrect. Successful undertaking of the activity will require a correct response rate of 80% or more. Each task will expire within 24 months of its publication to ensure that additional, more recent data has not superseded the activity.

Key words
MOPS (maintenance of professional standards), medicals – diving, medical conditions and problems, fitness to dive

Letter to the Editor

Free download, *Diving Medicine for Scuba Divers*

Dear Sir,

Our recent e-book, *Diving Medicine for Scuba Divers,* 3rd edition, was favourably reviewed in the last issue of DHM, and the reviewers' suggestions have been incorporated in the current on-line version. The whole text can be downloaded free from www.divingmedicine.info; there are no copyright restrictions. We encourage diving physicians to look at it.

Although written for non-professionals, it has applications for medicos as appropriate pre-course reading for diving medical courses, as it makes no presumptions regarding diving technological or medical knowledge. It does not circumvent the need for a more medically comprehensive course textbook. Secondly, it is suitable for giving to injured divers selected pages that describe simply the illness for which they are being treated; and how to prevent it in future. No matter how precise and clear the clinician may be, the anxious and naïve patient is likely to misinterpret or forget verbal information unless supported by documentation.

Thirdly medicos should consider making their courses, manuals, lectures and texts available in this manner. It is far cheaper than preparing manuscripts for formal printing, allows for unlimited colour illustrations, permits revisions and alterations on-site, encourages feedback and relieves one from the limitations imposed by editors and publishers. Since publication early this year, there have been over 24,000 downloads. Divers and dive clubs are encouraged to copy the whole text onto a CD/DVD or their mobile computers, share it with others and/or take it with them to dive sites. Thus, the full distribution, including diver-to-diver transmission, will never be known. We are delighted, and welcome feedback!

Carl Edmonds,
Bart McKenzie
Bob Thomas
John Pennefather

Contact Carl Edmonds for further information:
E-mail: *<puddle@bigpond.net.au>*

Key words
Scuba diving, underwater medicine, textbook, general interest, book reviews

Editor's comment:
We hope that the authors' comment that the on-line process "*relieves one from the limitations imposed by editors and publishers*" does not imply that they see no value in the peer review and strong editorial guidance that a recognised publication can bring!

Book reviews

Women and pressure: diving and altitude

Caroline E Fife and Marguerite St Leger Dowse, editors

ISBN 9781930536548
Hard cover, 415 pages, CD ROM included
Best Publishing Company, 2010
Flagstaff, AZ 86003, USA
Available from: <customerservice@bestpub.com>
Price: US $25.99

Being a female rural general practitioner who dives, is married to a dive instructor and attends SPUMS meetings, I was asked to review this interesting title. This book has a wide intended audience: women divers, dive instructors, men who dive with women and anyone involved in these fields. As a full-time clinician, it is a long time since I have read a textbook from cover to cover but, overall, I found this an enjoyable read with some reservations. Proceeds from the book are to be donated to the Diving Diseases Research Centre in Plymouth, England.

The book is a collection of 27 chapters written by many authors from around the world. Section 1 (five chapters) deals with decompression illness, with the first chapter written by well known SPUMS doctors Simon Mitchell and Michael Bennett. Section 2 (nine chapters) deals with human factors and Section 3 (13 chapters) deals with the work place.

Use of different authors for each chapter has some pitfalls. The styles are inconsistent and at times references to content in other chapters is not accurate. Definitions throughout the book vary and many chapters assume pre-existing knowledge; for instance, the first mention of VGE (variously defined as venous gas emboli or embolisation) on page 29 does not define how these are measured and whether they truly indicate an *"unbiased indicator of the decompression dose"*. Some chapters are very detailed and would not be comprehensible to people outside the biomedical field, whilst others are clearly intended for a general diving audience.

As a female diver/doctor, I was frustrated by the lack of clarity about the obvious questions women might ask. Am I at more risk than a man diving? Is it 'safe' to dive when bleeding? How 'safe' is it to dive when pregnant? Is the foetus harmed by diving and, if it is, when and how is it harmed? The chapters that should have addressed these questions were not at all practical. The chapters on menstruation were reviews of the insufficient research information on decompression sickness (DCS) and data from NASA about gas emboli during training. An annoying factor was that the research concentrated on the week of the cycle rather than on actual menstruation. I wondered if this was related to the sensibilities of researchers asking such a basic question. Overall, the data seem to be inconclusive and based on small numbers or retrospective studies that did not ask the correct questions. Though accepted wisdom seems to be that DCS is more likely in the early part of the menstrual cycle, I was not convinced by the research presented.

The question of safety in pregnancy is mentioned only occasionally in many of the chapters; mostly that it is accepted to be 'unsafe' and an allowable reason for discrimination in work assignments (though not in employment interviews!). The only chapter devoted to pregnancy considerations was a long chapter discussing trials done in the late 1970s in pregnant sheep, measuring VGE. As a clinician, this was not a very helpful chapter, although outlining interesting research done by an eminent man, Bill Fife (the father of one of the editors).

In Chapter six, as part of a long dissertation on *"Women and diving: medical and health considerations"*, there is a section about diving in pregnancy but, as with the rest of this chapter, much is unreferenced expert opinion. Unfortunately this whole section is not indexed under pregnancy or foetus, nor listed in the chapter headings so could easily be missed unless you read the whole book. A dedicated chapter and more practical discussion about what is known or unknown about pregnancy and diving should have been included. I understand hyperbaric oxygen therapy is used in some countries (e.g., Russia, China) for the treatment of various fertility- and pregnancy-related problems, yet this is not mentioned. After reading this book, I would be unable to answer a question about possible damage to her baby from a patient who had inadvertently dived in early pregnancy, or the medical risk to an occupational diver who wants (or needs) to keep diving. I certainly could not find the most relevant section by looking in the index.

As a diver, I found the chapters on cold-water diving physiology, psychology, dive computer algorithms, dive equipment and diving accident data interesting. However, the one entitled *"Exercise and fitness to dive"* was remarkably long-winded. In the end, Egstrom basically said the best training is to go diving regularly or mimic this in a swimming pool with weights and fins; also that rehearsing emergency drills will reduce the risk – perhaps this could have been a shorter chapter! The final chapters on women in the diving and high-altitude workplaces were interesting reading. There was a bias towards the situation in the USA, which is perhaps reasonable given that the US military has been at the forefront of allowing the involvement of women in these fields.

These final chapters in particular, would have been more enjoyable with a more expensive publication. While the accompanying CD Rom does include colour pictures, throughout the book the black-and-white pictures and diagrams were of poor quality. Not many people read a book sitting next to their computers. In some cases the diagrams were not interpretable as the lines were in similar shades of solid grey or the legend referred to patterns not reproduced properly. The book has an attractive hardback colour cover but otherwise is entirely black and white. There are a number of annoying typographical errors (one on the very first page!), also a paragraph repeated and errors in the indexing. The price, of course, is remarkably low for a large text book and the proceeds are going to a research institute.

I think perhaps the intended audience for this book is too wide with some chapters very detailed scientifically, some written for the general lay(wo)man and some of interest to divers. The poor clarity of the information on pregnancy risks is a deficiency. Two volumes with the biomedical chapters separated from a more attractive colour 'coffee table' version on the history of women in diving occupations could perhaps be considered.

Janet Watterson, General Practioner, Pambula Medical Centre, NSW, Australia.
Michael Standen, Scuba Schools International instructor trainer, Merimbula Divers Lodge, NSW.

Key words
Women, diving, scuba diving, health, physiology, pregnancy, risk factors, book reviews

---

John Lethbridge: The most successful treasure diver of the eighteenth century

John Fardell

Published by The Historical Diving Society 2010
ISBN 9780954383442

This is the latest monograph from the Historical Diving Society, based on the fascinating life of John Lethbridge.

John, a Devonshire wool merchant, found his fortunes at a low ebb in 1715. With seven children and the cloth industry in severe depression, Lethbridge needed to find another means of supporting his family. How he thought of the idea of inventing a diving apparatus (diving engine) we will probably never be sure; however, Lethbridge must have been aware of the large number of shipwrecks around the south west coast of England and could sense an opportunity.

A hogshead (barrel) was the standard container of the period and the necessary skills to build Lethbridge's version would have been readily available. Iron hoops were incorporated on the inside as well as the outside. Openings in the barrel with leather seals allowed the arms to be used and a glass viewing port gave visibility. With claims of diving to depths of 10 fathoms (18 metres) in this semi-atmospheric apparatus, circulation to the arms must have been severely restricted with the body at 1 ATA and the arms at 3 ATA. With the diver sealed in the barrel, rebreathing its volume, the barrel would be lowered to the seabed and work commenced. On a rope signal, the barrel would be recovered and the air refreshed with bellows and water leaks drained while the diver remained sealed for up to six hours of repetitive dives.

The limiting factor of the diving engine would be CO_2 production and its associated toxicity. My calculations suggest a time of 13 minutes before CO_2 content would reach 5% volume. Ten to 15% would produce serious effects and possible mortality. The three to four minutes suggested in the text would not enable much useful work to be completed, as this total time would be from leaving surface to returning to surface and having fresh air induced by bellows. On the other hand, 30 minutes, duration would certainly be stretching things. Obviously there must have been many variables. Regardless of this, the diver showed great perseverance to accomplish his work, along with a large amount of trust in his surface support crew. Near drowning through leaks in the barrel, plus CO_2 build up, must have made for some wicked headaches and a very interesting day at work.

A long list of salvage work proceeded in the following years ranging from recovery of cannon for the Ordnance Board to bullion for the Dutch East India Company. These fascinating exploits I will leave for prospective readers to discover. Lethbridge died in 1759, recovering almost £100,000 for English and Dutch merchants.

The book consists of 101 pages divided into 25 chapters with extensive appendices, bibliography and notes. Considering the bulk of the salvage was done between 1715–1743, it must have involved considerable research to come up with such a thorough and precise account.

For a relatively small book this is not a quick read. To fully absorb the history and the research involved, I found it necessary to take time to work through the chapters. Period illustrations relevant to the apparatus and wreck locations enhance the historic connections. This is a very complete, authoritative account of a remarkable man who is an important part of our diving heritage. Anyone with an interest in diving history will be fascinated.

Warren Harper, Hyperbaric Technologist, Christchurch Hospital, New Zealand

Key words
Diving, history, general interest, book reviews

SPUMS notices and news

News of SPUMS members

Dr Bob Wong awarded the 2010 ANZCA Medal

Bob Wong has been pivotal in establishing and developing diving and hyperbaric medicine in our region through his work in Western Australia, with the Australian Defence Force and through the establishment of the Diving and Hyperbaric Medicine Special Interest Group and Certificate in Diving and Hyperbaric Medicine of the Australia and New Zealand College of Anaesthetists (ANZCA).

Bob was awarded his Fellowship of the Faculty of Anaesthetists in 1975 and immediately took up a staff position at the Royal Perth Hospital. He remained in this post until 2005. He trained in diving and hyperbaric medicine at the School of Underwater Medicine at *HMAS Penguin* in Sydney in 1980 and furthered his studies in the UK and Canada. He was awarded the Diploma in Diving and Hyperbaric Medicine of the South Pacific Underwater Medicine Society in 1988 for his work on the Broome sponge divers.

In 1998, ANZCA established a special interest group in diving and hyperbaric medicine. Bob has been an executive member of this SIG since its inception and is a past chairman. He initiated a formal qualification in diving and hyperbaric medicine in ANZCA in 2003 due to his concern about the lack of formal training and recognised qualifications in the discipline. Bob has worked tirelessly since that time as a member of the governing committee for the certificate, as an examiner and as a member of the accreditation team for hospitals seeking recognition for diving and hyperbaric medicine training.

Bob became Lieutenant in the Royal Australian Navy in 1978, rising through the ranks to Commander. He was a specialist in underwater medicine from 1981 until 1989 and a consultant in underwater medicine to the Director General of the Naval Health Services 1989–91, consultant to the Royal Australian Navy 1991–97 and consultant to the Director General of the Australian Defence Health Services 1997–2000. He was awarded the Australian Defence Force Medal in 2007.

He was appointed consultant at the Freemantle Hospital's Hyperbaric Unit in 1989 and was its Director from 1999 until 2009. Since 1987, he has also been a consultant to the Pearl Producers Association where, through research, he modified their dive practice and drastically reduced the high prevalence of decompression sickness among the pearl divers. This work was recognised through awards by the Undersea and Hyperbaric Medical Society of USA.

Dr Robert Wong, May 2010

Extracts from the presentation of Dr Wong by Professor Kate Leslie to the College convocation in Christchurch, New Zealand, May 2010, with kind permission.

Peer reviewer award for Neal Pollock

Neal Pollock, PhD, has been selected to receive the new *Peer Reviewer Recognition Award* of the journal *Wilderness & Environmental Medicine*. He was chosen as one of the top 3% of 158 peer reviewers in 2009.

It is through the commitment and dedication of scientists like Neal, who is a member of this journal's Editorial Board, that *Diving and Hyperbaric Medicine* will continue to grow in its scientific impact, and we congratulate him on this award.

Masters degree for John Lippmann

John Lippmann, *OAM,* Executive Director of DAN Asia-Pacific recently obtained his Masters degree by research, MAppSc, Deakin University, Melbourne. His thesis was entitled *Comparison of two modes of delivery of first aid training*.

Australian and New Zealand College of Anaesthetists

Certificate in Diving and Hyperbaric Medicine

Eligible candidates are invited to present for the examination for the Certificate in Diving and Hyperbaric Medicine of the Australian and New Zealand College of Anaesthetists.

Eligibility criteria are:

1 Fellowship of a Specialist College in Australia or New Zealand. This includes all specialties, and the Royal Australian College of General Practitioners.

2 Completion of training courses in Diving Medicine and in Hyperbaric Medicine of at least four weeks' total duration. For example, one of:
   a ANZHMG course at Prince of Wales Hospital Sydney, **and** Royal Adelaide Hospital or HMAS Penguin diving medical officers course **OR**
   b Auckland University Diploma in Diving and Hyperbaric Medicine.

3 **EITHER:**
   a Completion of the Diploma of the South Pacific Underwater Medicine Society, including six months' full-time equivalent experience in a hyperbaric unit and successful completion of a thesis or research project approved by the Assessor, SPUMS
   b **and** Completion of a further 12 months' full-time equivalent clinical experience in a hospital-based hyperbaric unit which is approved for training in Diving and Hyperbaric Medicine by the ANZCA.
   OR:
   c Completion of 18 months' full-time equivalent experience in a hospital-based hyperbaric unit which is approved for training in Diving and Hyperbaric Medicine by the ANZCA
   d **and** Completion of a formal project in accordance with ANZCA Professional Document TE11 "Formal Project Guidelines". The formal project must be constructed around a topic which is relevant to the practice of Diving and Hyperbaric Medicine, and must be approved by the ANZCA Assessor prior to commencement.

4 Completion of a workbook documenting the details of clinical exposure attained during the training period.

5 Candidates who do not hold an Australian or New Zealand specialist qualification in Anaesthesia, Intensive Care or Emergency Medicine are required to demonstrate airway skills competency as specified by ANZCA in the document "Airway skills requirement for training in Diving and Hyperbaric Medicine".

All details are available on the ANZCA website at:
<www.anzca.edu.au/edutraining/DHM/index.htm>

Dr Margaret Walker, FANZCA, Cert DHM (ANZCA)
Chair, ANZCA/ASA Special Interest Group in Diving and Hyperbaric Medicine

South Pacific Underwater Medicine Society Diploma of Diving and Hyperbaric Medicine

Requirements for candidates (updated October 2008)

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 current financial member of the Society.
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 facility. The list of approved facilities providing two-week courses may be found on the SPUMS website.
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, in a standard format, for approval *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. Accompanying this written report should be a request to be considered for the SPUMS Diploma and supporting documentation for 1–4 above.
6 In the absence of documentation otherwise, it will be assumed that the paper is submitted for publication in *Diving and Hyperbaric Medicine*. As such, the structure of the paper needs to broadly comply with the 'Instructions to Authors' – full version, published in *Diving and Hyperbaric Medicine* 2010;40(2):110-2.
7 The paper may be submitted to journals other than *Diving and Hyperbaric Medicine*; however, even if published in another journal, the completed paper must be submitted to the Education Officer for assessment as a diploma paper. If the paper has been accepted for publication or published in another journal, then evidence of this should be provided.
8 The diploma paper will be assessed, and changes may be requested, before it is regarded to be of the standard required for award of the Diploma. Once completed to the reviewers' satisfaction, papers not already accepted or published in other journals will be forwarded to the Editor of *Diving and Hyperbaric Medicine* for consideration. At this point the Diploma will be awarded, provided all other requirements are satisfied. Diploma projects submitted to *Diving and Hyperbaric Medicine* for consideration of publication will be subject to the Journal's own peer review process.

Additional information – prospective approval of projects is required

The candidate must contact the Education Officer in writing (e-mail is acceptable) to advise of their intended candidacy, and to discuss the proposed subject matter of their research. A written research proposal must be submitted before commencing the 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, and that the candidate is the first author, where there are more than one.

The SPUMS Diploma will not be awarded until all requirements are completed. The individual components do not necessarily need to be completed in the order outlined above. However, it is mandatory that the research project is approved prior to commencing research.

The Academic Board reserves the right to modify any of these requirements from time to time. As of October 2008, the SPUMS Academic Board consists of:
Associate Professor David Smart, Education Officer
Associate Professor (ret'd) Mike Davis
Associate Professor Simon Mitchell.

All enquiries and applications to the Education Officer:
Associate Professor David Smart
GPO Box 463, Hobart, Tasmania 7001
E-mail: *<david.smart@dhhs.tas.gov.au>*

Key words
Qualifications, underwater medicine, hyperbaric oxygen, research, medical society

Minutes of the Annual General Meeting of SPUMS held at Berjaya Resort, Redang Island, on Thursday 27 May 2010

Opened: 1730 h

Present: The President and 29 voting members.

Apologies: Drs V Haller, G Williams, J Lehm and C Acott

1. **Minutes of the 2009 AGM**
   Minutes of the previous meeting were published in *Diving and Hyperbaric Medicine*. 2009;39(4):243-7 and were posted on the noticeboard. Motion that the minutes be accepted as an accurate record.
   Proposed M Bennett, seconded G Hawkins, carried

2. **Matters arising from previous minutes:** Nil

3. **President's report:** M Bennett

4. **Secretary's report:** S Lockley

5. **Education Officer's report:** D Smart

6. **Treasurer's report:** J Lehm
   (presented by S Lockley)

7. **Annual financial statement:** J Lehm
   (presented by S Lockley)
   The President stated that some inconsistencies had been identified by both the Treasurer and the Auditor in the income statement for 2009. After some discussion, it was agreed by the meeting, at Dr Bennett's suggestion, that the President and Treasurer undertake a 'forensic' review of the 2009 finances, and that the results of this review be published for members' information in *Diving and Hyperbaric Medicine* alongside the Treasurer's report and the Financial Statement.

8. **Journal Editor's report**

9. **Subscription Fees for 2011**
   On behalf of the Treasurer, the motion was raised that subscription fees be increased for 2011 by AUD20.00 for all categories. Full members AUD170 (internet transaction); AUD190 (manual/paper-based transaction). Associate/retired/medical student members AUD100 (internet transaction); AUD120 (manual/paper-based transaction).
   Proposed D Smart, seconded S Mitchell, carried

10. **Election of Office Bearers**
    No positions are open for election.

11. **Appointment of the Auditor 2010:**
    Treasurer, J Lehm, has recommended re-appointment of Barrett, Baxter and Bye (Medical Accountants) as Auditor. Motion that Barrett, Baxter and Bye be re-appointed as Auditor.
    Proposed S Lockley, seconded G Hawkins, carried

12. **Business of which notice has been given:**
    Nil further business forwarded.

Closed: 1837 h

Key words
Medical society, meetings

President's report

It remains an honour to stand before you today and deliver the annual President's report. I start by congratulating Glen, Tony and their teams for putting together such a great programme for us this year, the 39th ASM. Both from the reception they have received and the lively social interactions that have followed, I know that our two guest speakers this year have been very popular and I thank them for all their hard work in presenting over these five days. Mention should also be made of the great help Glen has had from the Committee and in particular from our Treasurer, Jan Lehm, who is currently at home looking after the kids while his wife runs another ASM in Darwin. It has been a great deal of work for him, and I will expand on the reasons a little later. Steve Goble, ably assisted by Sue, has also been working hard to make things run smoothly both before and during this conference.

While in a congratulatory mood, I should also congratulate all of you who have turned up for another SPUMS ASM despite the many changes to the organisation over the last year or two. We are acutely aware of the difficulties some of you may have had in booking for this meeting. It is easy to see with the retrospectoscope that we were a little ambitious in changing the President, Secretary and Treasurer and at the same time move to an 'on-line' booking approach through a brand new website with a first-time ASM convenor for our first combined meeting with ADHMA! Add to that the withdrawal of our booking from the resort here for the three months to November 2009, and it is easy to see why relations between the major parties involved became strained at times. In the end it has all come together and we are here together, again enjoying a stimulating meeting in a great location. At the time of writing, I believe we have 118 registrants in the resort and over 70 for the ASM itself. This represents a significant achievement for all concerned and we should be proud of what our organisation has achieved.

SPUMS has reached a turning point. At this meeting, we have a lot of new faces and some of the old faces are not with us. The Committee is working hard on selling the benefits of SPUMS membership to a much wider range of medical practitioners than we have had in the past. We believe the ASM and the Society both need a significant makeover in order to protect the long-term viability of the Society. Membership numbers have been steadily falling for several years, and the mean age has been inexorably rising. Comforting as it may be to feel that SPUMS might continue unchanged indefinitely, reality will sooner or later impose itself upon us. Part of the package the Committee is trying to sell is represented by a functioning up-to-date web presence with interactive features. Another is an increasing emphasis on the academic programme and an inevitable de-emphasis on the diving itself. While nobody imagines a SPUMS meeting without the diving component, being seen by others as nothing more than a diving junket with a few talks thrown in will not appeal to more than a very few of our colleagues.

Of course, change is not a new phenomenon for us. The first meeting I came to was in Rabaul in 1994 and it was a very different beast than the meetings of the past five or six years. Now we expect high-quality presentations, updates and workshops as a matter of course, along with truly world-class guest speakers. We need to build on what we have already achieved – and we should expect to attract hyperbaric physicians as well as our traditional diving docs. We should also expect that these meetings will be affordable both for doctors in training and allied health workers – particularly our hyperbaric nursing and technical staff around the region. This does not inevitably mean an end to those exotic destinations to which we have become accustomed, but it does, in my opinion, mean an end to the hegemony of a single pricing structure involving flights, accommodation and diving. Rather than a tendency to put a package together and say 'take it or leave it', we should be encouraging registrants to get to these meetings in future in any way they wish, stay wherever they wish, move in whatever level of luxury or squalor they wish and dive as often or as little as they wish. In other words, we should try to be more like all the other medical meetings we go to. Of course, I recognise this will not always be possible for every destination we choose – we need to remain flexible. And yes, its unique features will continue to mean that SPUMS is a better option than most academic meetings we have the opportunity to attend.

My challenge to you is twofold. First we want to hear from as many of you as possible about your ideas for the future. You are a bright bunch and I am sure there are many great ideas out there that will never occur to the Committee. Second, I want you all to aim to sell SPUMS membership, or attendance at the ASM next year, to just one person. I know I am guilty at times of failing to promote what is at its core a great medical society that is a lot of fun to belong to. How often do we meet colleagues who clearly have some interest in diving, only later to think – I should have told them about SPUMS? It is as simple as giving them the web address <www.spums.org>! Try it.

So, with that off my chest, what else has been happening in your Society over the last year? The second 'big thing' has been the upgrading of our website to allow on-line membership payments, ASM bookings and open forums on matters of interest to the membership. At present all is functioning well after a few teething problems – our biggest remaining difficulty being that all membership payments and ASM payments are directed through a single secure system that mandates a single account for deposits. This means Jan has to laboriously separate the payments into the appropriate categories and according to whether or not GST is payable. This mess should be fixed with the contractual arrangements for the ASM next year – but I will not steal our 2011 convenor's thunder with any further comments. In addition, the diving doctors list has been substantially upgraded with details, location maps and whether or not the individuals listed will consider dive medicals in those less than 16 years old. The changes to the list are a response to many complaints from potential divers about the difficulty of finding an appropriate physician. This should be a thing of the past with the information now available. Lots of other things to explore include the new SPUMS guide to the pre-diving medical with all the recent changes accepted at last year's ASM (coming soon – available to members) and the membership package I alluded to in my last column is also available for download. Try using it in a presentation to your hospital or GP division.

The third great project has been the cementing of our relationship with the EUBS. An agreement to continue joint ownership of this journal is accepted enthusiastically by both societies and we have a new editorial contract to cover the next few years. Mike Davis continues to produce a quality publication of which all members of both societies should be proud. Mike will update you on the details of the Journal in his report. Similarly, our tireless Education Officer will be filling you in on the academic side of the committee activities.

Finally, I should make an appeal to any of you who can be persuaded to consider membership of the Committee. The duties are not onerous until we lure you deeper into the web – and we can assure you that the ability to influence the activities of the Society can be greatly rewarding. Ask a present or former committee member for their thoughts.

I look forward to seeing many of you at the ASM next year – one of our most popular destinations.

Mike Bennett

Key words
Medical society, meetings

Secretary's report

The year 2009–2010 was a busy year for me, with promotion into the position of the Officer-in-Charge at the Royal Australian Navy (RAN) Submarine and Underwater Medicine Unit, and with pressures placed on the unit by fleet requirements and medical officer shortages. As a result, this did consume some of the time I was able to dedicate to the role of Secretary. I apologise for any resulting delay in responding to e-mails or addressing queries or concerns during this time. Having discharged from the RAN in April 2010 and transferring to the RAN Reserve Cell, I intend to continue my involvement with the unit and to encourage military diving medical officer involvement in the SPUMS. It is exciting to see a good representation of the RAN diving doctors at this ASM and I am hopeful that this will continue, and that the SPUMS can maintain a strong relationship with our military colleagues in the South Pacific. Hence the theme: technical diving medicine, from military, occupational and recreational perspectives, for the 2011 ASM to be held in May in Palau.

In 2010, the SPUMS has a total membership of 506, with full membership totalling 437 and 69 associate, life or free members. In May 2009, full membership was 536, with total members of 684. Hence, there has been a decline in the number of full members by 99. There have been a number of new members joining SPUMS, while those that have retired from diving medicine, or moved on have not renewed membership and perhaps this represents a new generation of diving doctors moving into the SPUMS membership.

I encourage new members to become actively involved in SPUMS by considering taking up a position on the Executive Committee when these become available for nomination, by volunteering as the Convenor of future annual scientific meetings and by contributing articles and papers for publication in the DHM. In order for the organisation to continue to be a success and to hold relevant scientific meetings and produce a Journal, it is vital that we continue to have willing and able volunteers.

Sarah Lockley

Key words
Medical society, meetings

Treasurer's report

Firstly thank you to all SPUMS members who elected me as Treasurer with absolutely no professional accounting experience. I hope I can do as well as the previous treasurers. Overall, 2009 was not as good as 2008, as seen on the comparative table of income and expenses. However, I would like to comment on some of the items. On the income side, there has been about a one-third reduction in subscriptions. This is probably due to the general membership decline as well as a one-off exit of EUBS members who were previously members of both organisations. It is also possible that the period where the website was not functional may have delayed some members into paying this year rather than last. On the positive side, it looks like we are doing better than normal at this time of the year, with more than the usual number of subscriptions being paid. The income from EUBS for the Journal has also increased in 2009.

On the expense side, there are some unusual items. There is a one-off legal fee of AUD5,000 for advice concerning the new SPUMS Medical. It looks like the cost of the Journal increased by AUD9,000 in 2009; however, this is mainly due to some 2008 mailing/printing costs paid during 2009. There was also a one-off cost for the new website of about AUD8,000. Future web maintenance costs will be far less than the previous arrangement. The net result is a loss of AUD31,000 versus a profit of AUD23,000 for 2008. This has resulted in a decline of the total assets to the Society to AUD111,000.

I wish to thank the previous Treasurer, Guy Williams, who did a great job setting up all the St George accounts and transferring all paper trails to electronic information. The banking is all done over the internet and I have not had to fill out a single paper cheque. I also wish to thank Glen Hawkins who has spent hundreds of hours organising the ASM and setting up the website at the same time. The payment of memberships via the net has saved many hours of administration, and I would like to encourage all members to pay this way in the future. Also thanks to Steve and Susan Goble, who have spent many hours keeping up the database, banking cheques and functioning as the contact between SPUMS and its members. Finally thanks to the other committee members and especially Mike Bennett who will be in debt to me forever for taking on the Treasurer's job.

Jan Lehm

Key words
Medical society, meetings

Editor's note:
The full Committee declaration regarding the financial report for 2009 and the audit report are available from the Secretary on request.

The South Pacific Underwater Medicine Society income and expenditure statement and balance sheet for the year ended 31 December 2009

Income ($)	**2009**	2008
Subscriptions and registrations	**71,655**	110,415
Interest	**2,076**	4,370
EUBS	**24,300**	16,521
ASM 2009 profit	**–**	887
Sundry income	**3,246**	107
Total income	**101,277**	132,300
Expenses		
Account fees	**1,350**	1,450
Administration/Secretarial, etc	**16,805**	16,798
Legal expenses	**5,016**	–
ASM costs	**5,064**	–
Office expense	**2,230**	1,893
SPUMS equipment	**491**	5,372
Journal and editorial expenses	**75,076**	66,305
Committee expenses	**2,774**	2,545
Computer equipment	**272**	588
Maintenance website	**9,372**	1,138
Miscellaneous/Subscriptions	**662**	175
Bank charges and card charges	**5,590**	4,582
Audit	**1,550**	2,650
Insurance	**5,245**	5,200
Telephone	**572**	765
Treasurer	**–**	82
Depreciation	**394**	–
Total expenses	**132,463**	109,543
Surplus/(Deficit) for the year	**(31,186)**	22,757

Current Assets ($)	**2009**	2008
St George General	**9,664**	109,305
St George ASM Account	**94,050**	28,508
St George Journal Account	**4,022**	5,874
GST Refund	**1,523**	
Total Current Assets	**109,259**	143,687
Non-Current Assets		
Laptop – at cost	**2,273**	–
Less – Accumulated Depreciation	**(394)**	–
Total Non-Current Assets	**1,879**	–
Total Assets	**111,138**	143,687
Current Liabilities		
GST Owing	**–**	1,363
Total Current Liabilities	**–**	1,363
Non-Current Liabilities	**–**	–
Total Liabilities	**–**	1,363
Net Assets	**111,138**	142,324
Accumulated Funds		
Balance at beginning of the year	**142,324**	119,567
Surplus / (Deficit) for the year	**(31,186)**	22,757
Balance at the end of the year	**111,138**	142,324

SPUMS Committee's declaration for the year ended 31 December 2009

Your committee members submit the financial report of The South Pacific Underwater Medicine Society (the Society) for the financial year ended 31 December 2009.

Operating report

In our opinion:

- The accompanying financial report, being a special purpose financial report, is drawn up so as to present fairly the state of affairs of the Society as at 31 December 2009 and the results of the Society for the year then ended;
- The accounts of the Society have been properly drawn up and are in accordance with the books of account of the Society and
- There are reasonable grounds to believe the Society will be able to pay its debts as and when they fall due.

Signed in accordance with a resolution of the Committee
Associate Professor Michael Bennett, President
Dr Jan Lehm, Treasurer
Dated: 14 May 2010

Independent auditor's report for the year ended 31 December 2009

Audit opinion

In our opinion the financial report of The South Pacific Underwater Medicine Society presents a true and fair view of the financial position of The South Pacific Underwater Medicine Society as at 31 December 2009 and the results of its operations and its cash flows for the year then ended.

Peter Bye, Certified Practising Accountant,
Barrett Baxter Bye
Dated: 01 June 2010

Addendum to the minutes of the 2010 SPUMS ASM: Treasurer's report and audit for 2009 calendar year – a forensic report

At the Annual General Meeting of the Society on Thursday 27 May 2010, the Committee proposed, and the meeting accepted unanimously, that the members would not accept the annual report from the Treasurer (Dr Jan Lehm) or the auditor's report for the same year. This was because of the apparent loss of approximately AUD30,000 in revenue.

This loss of revenue was first noted by Dr Lehm and brought to the attention of the previous Treasurer (Dr Guy Williams) and the President (A/Prof Michael Bennett). After discussions and an examination of the historical records, we concluded that this drop in revenue reflected the low numbers of members who had paid dues for 2010 membership in the latter part of 2009. It is usual for about 185 members to pay in the calendar year prior to the membership year for which they are paying. It appeared that very few members had paid at the end of 2009 because the website was in transition and could not accept credit card payments until early January 2010.

Similarly, the auditor had identified the drop in membership revenue and flagged this as an important issue. The auditor asked for, and received, our explanation for that drop in revenue. There has also been a steady decline in membership over the last few years, with an acceleration over the time the Journal was extended to be that of both SPUMS and EUBS. Several European-based members of both societies resigned their SPUMS membership now that EUBS membership would also entitle them to the Journal. The auditor warned that a continued drop in numbers might soon become a threat to the viability of the Society at the current rate of expenditure. The cost of the Journal currently accounts for approximately 70% of the expenses of the Society.

At the committee meeting in Redang on the 23 May 2010, this situation was discussed. At that meeting it was suggested that in 2009 we had approximately 700 members according to the records of the SPUMS Administrator. Analysis of the relevant reports (as mentioned above) suggested we had received payment from only 530 members. At that point the Committee determined not to recommend the acceptance of the Treasurer's report or the audit for 2009. ***This decision in no way reflected on the Administrator, Treasurer or the auditor – in fact the Committee was very grateful that these parties had identified a problem***.

At the AGM, the President undertook to conduct a forensic examination of the issues and this notice brings the findings of that investigation to the members' attention.

The records of the SPUMS Administrator, the Treasurer, bank records and the activity of the website (including the secure pay system) have all been examined by the Treasurer and others. The conclusions are as follows:

1 The drop in revenue is accounted for by the very low numbers paying membership subscription for 2010 during the latter part of 2009. Approximately 180 fewer memberships were paid at this time than in previous years.
2 The records of the Administrator accurately recorded the number of members in 2009 for the purposes of the journal distribution. This gave the impression that we should have received about 700 membership dues. The number was lower because of conclusion 1.
3 There is no money missing from our recorded revenue and the financial records are accurate and appropriate to circumstance. In particular, there is no indication of any monies recorded as paid to the Society, but where that money does not appear in our bank records.
4 Nevertheless, membership numbers continue to decline and reminders need to be sent as a matter of urgency. The Committee needs to find creative ways to grow the Society.
5 The Committee is, therefore, in a position to recommend the acceptance of both the Treasurer's report and the audit report for calendar year 2009 unaltered. These are recorded on the minutes of the ASM.
6 Consideration should be given to changing the SPUMS financial year to match the business financial year (i.e., 1 July to 30 June). The Treasurer will put forward his recommendation at the next committee meeting.

Michael Bennett, President, Jan Lehm, Treasurer

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

Education Officer's report

SPUMS Diplomas

The last year has seen six projects registered with the Education Officer, and two are now nearing completion. There have been no Diplomas awarded, however three projects have provisionally passed subject to revision of the papers, which is great news. There have been a number of projects registered from the Townsville facility – congratulations to Denise Blake and her team.

Recognition of overseas qualifications and the SPUMS Diving Doctors List

With the maturing strategic relationship between SPUMS and EUBS, there have been requests for recognition of overseas qualifications for doctors to be placed on the SPUMS Diving Doctors List. At present, in the absence of a mutual accreditation (see below, dive medicine courses) process, applications have been dealt with on a case-by-case basis. These requests will not be processed if the individual is not a member of SPUMS. Because SPUMS has no jurisdiction outside Australia and New Zealand, any overseas requests for recognition require the Education Officer to undertake a huge amount of work to verify the identity and qualifications of the applicant. Australian specialty colleges usually charge in excess of $1,000 to process requests of a similar nature. The issue of whether or not to introduce an administrative fee to undertake these assessments, and whether or not certain criteria need to be satisfied before processing an application, will be discussed at the next SPUMS executive meeting.

Diving medicine courses

My heavy involvement with the submissions to the Federal Government Medical Services Advisory Committee (see ANZHMG report. *Diving and Hyperbaric Medicine*. 2010;40(1):50-1) and personal health problems have prevented the progress this area that I had hoped for. We still intend to examine from first principles the essential content of and a sound educational platform for diving medicine courses in Australia. Inherent in the SPUMS Diploma process is a requirement that SPUMS accredits these courses in diving and hyperbaric medicine and evaluates course content. The process of evaluating course content, and how recently the course was completed, are relevant to the SPUMS diving medical and the Diving Doctors List. The courses need to be aligned with international standards (particularly the structures applicable in Europe), and to establish a means of comparing course content. The benefits will be threefold:

- Australian and New Zealand courses will be able to be benchmarked against other international diving medicine courses, and, possibly, create some portability/reciprocity to the skills.
- It will enhance closer links with our European colleagues who have joined with us through the EUBS.
- It will provide some international consistency and recognition of the skill levels of doctors supporting the offshore diving industry.

It is possible after the review that there will be three levels of diving medicine courses, for example:

- Basic for recreational diving medicals.
- Intermediate to cover the extra knowledge and skills to provide emergency and recompression treatment of divers, and to perform occupational medicals.
- Advanced for physicians providing support for the offshore diving industry, and provision of offshore diving medicals.

This is a huge project and will require assistance from colleagues on the SPUMS Executive, EUBS, industry stakeholders and possibly an educationalist.

David Smart

Key words
Qualifications, underwater medicine, hyperbaric oxygen, research, medical society

Editor's report

At the end of 2009, the two-year trial of cooperation between SPUMS and EUBS in *Diving and Hyperbaric Medicine* (DHM) ended with both society executives concluding that it had been a success. As a result, some administrative changes to better separate the Journal finances from the general financial affairs of SPUMS have started, and this process will be progressed in 2011, when both societies will pay for the publication of the Journal on a per member basis according to a prospective annual budget for the year. The journal costs approximately AUD80,000 (€57,000) per year to produce at present, with a worldwide distribution of about 1,100 copies per issue.

Recently a new Editor's contract was signed by the society Presidents and me. I appreciate the trust that has been placed in me for a further three years, and will do everything possible during that time to provide a diverse, readable and up-to-date publication. However, this can only be achieved with the continued, indeed increased, support of the members of both societies in submitting their research and clinical work for consideration. Despite the fact that over the past two years submissions have doubled compared to the past, the Journal still leads a somewhat hand-to-mouth existence issue by issue as members continue to publish elsewhere and a higher proportion of submissions are now being rejected. It is my hope that the EUBS will soon come to see their journal as the appropriate forum for full publication of papers from its annual scientific meetings, rather than producing a largely non-peer-reviewed mix of abstracts, mini and full papers in a proceedings publication that has often been of mixed quality.

The lack of enthusiasm in some quarters to publish in DHM is largely because it is not indexed on Medline. However, there has been a steady rise in citation rate since DHM was approved for indexing on Science Citation Index Expanded (SciSearch®) and back issues to 2005 placed in the Rubicon Foundation and German Society databases. We now have a 2-year Impact Factor (IF), albeit small.

We heard in April that DHM was unsuccessful in its recent application to Medline, but only missed the cut by a narrow margin and we have been invited to reapply again in 2011, an unusually short interval. This is the major priority for the next year. The implication of this is that members of both societies must make an especially vigorous effort to support the journal over the immediate future. Now that the Journal has an IF from SCIE, DHM should be seen by universities and other institutions as a valid publication vehicle for researchers, whether or not DHM is Medline-indexed.

The Editorial Board was increased to eight members during 2009, as we welcomed Jacek Kot, Poland, and Simon Mitchell, New Zealand, to the team. I believe that our peer-review processes are now robust, and that we have a wide international pool of expert reviewers to meet the exacting standards required for Medline citation. The Board may need to increase further in size as the workload demands; expressions of interest would be welcomed. A journal website (www.dhmjournal.com) was launched in early May, though this is still in the early stages of construction. Suggestions for inclusions, links, etc for the website would also be welcomed.

In summary, the goals for 2010/11 are threefold:

- Successful re-application for Medline citation
- Restructuring of the financial management of the Journal
- Completion of the new journal website.

Michael Davis

Key words
Medical society, meetings

South Pacific Underwater Medicine Society
40th Annual Scientific Meeting 2011

Dates: 24−28 May 2011

Venue: Further details on website soon

Theme: What's so technical about diving? Medical aspects of military, occupational and recreational technical diving

Guest speakers:

David Doolette, PhD, Navy Experimental Diving Unit, Panama City, USA
Simon Mitchell, MB, BS, FANZCA, PhD, The University of Auckland
Andrew Fock, MB, BS, FANZCA, The Alfred Hospital, Melbourne

SPUMS 2011 ASM Convenor:

Dr Sarah Lockley
C/- Hyperbaric Health
Suite 3, Ground Flr
46-50 Kent Rd, Mascot
NSW 2020, Australia

E-mail: <secretary@spums.org.au>
Mobile: +61-(0)4-3114-4817

Full details and registration available on the SPUMS website soon

EUBS European Underwater and Baromedical Society

EXECUTIVE COMMITTEE (as of September 2009)

PRESIDENT
Dr Peter Germonpré
Centre for Hyperbaric Oxygen Therapy
Military Hospital Brussels
B-1120 Brussels, Belgium
Phone: +32-(0)2-264-4868
Fax: +32-(0)2-264-4861
E-mail: <peter.germonpre@eubs.org>

VICE PRESIDENT
Professor Costantino Balestra
Environmental & Occupationa Physiology Laboratory
Haute Ecole Paul Henri Spaak
91 Av. C. Schaller
B-1160 Auderghem, Belgium
Phone & Fax: +32-(0)2-663-0076
E-mail: <costantino.balestra@eubs.org>

IMMEDIATE PAST PRESIDENT
Professor Alf O Brubakk
NTNU, Department of Circulation and Imaging
N-7089 Trondheim, Norway
Phone: +47-(0)73-598904
Fax: +47-(0)73-597940
E-mail: <alf.brubakk@eubs.org>

PAST PRESIDENT
Dr Noemi Bitterman
Technion, Israel Institute of Technology
Technion City
Haifa 32000, Israel
Phone: +972-(0)4-829-4909
Fax: +972-(0)4-824-6631
E-mail: <noemi.bitterman@eubs.org>

HONORARY SECRETARY
Dr Joerg Schmutz
Foundation for Hyperbaric Medicine
Kleinhuningerstrasse 177
CH-4057 Basel, Switzerland
Phone: +41-(0)61-631-3013
Fax: +41-(0)61-631-3006
E-mail: <joerg.schmutz@eubs.org>

MEMBER AT LARGE 2009
Dr Andreas Møllerløkken
NTNU, Department of Circulation and Imaging
N-7089 Trondheim, Norway
Phone: +47-(0)73-598907
Fax: +47-(0)73-598613
E-mail: <andreas.mollerlokken@eubs.org>

MEMBER AT LARGE 2008
Dr Peter Knessl
Steinechtweg 18
CH-4452 Itingen, Switzerland
Phone: +41-(0)44-716-7105
E-mail: <peter.knessl@eubs.org>

MEMBER AT LARGE 2007
Dr Phil Bryson
DDRC, The Hyperbaric Medical Centre
Tamar Science Park, Research Way
Derriford, Plymouth
Devon, PL6 8BU, United Kingdom
Phone: +44-(0)1752-209999
Fax: +44-(0)1752-209115
E-mail: <phil.bryson@eubs.org>

HONORARY TREASURER & MEMBERSHIP SECRETARY
Ms Patricia Wooding
16 Burselm Avenue
Hainault, Ilford
Essex, IG6 3EH, United Kingdom
Phone & Fax: +44-(0)20-8500-1778
E-mail: <patricia.wooding@eubs.org>

EUROPEAN EDITOR, DIVING AND HYPERBARIC MEDICINE
Dr Peter HJ Müller
Dudenhofer Strasse 8C
D-67346 Speyer, Germany
Phone & Fax: +49-(0)6232-686-5866
E-mail: <peter.mueller@eubs.org>

The EUBS website is at **www.eubs.org**

The EUBS website provides members with access to:

- the full-text literature database on diving and hyperbaric medicine, provided courtesy of GTUEM
- the EUBS Members Directory
- full text of *Diving and Hyperbaric Medicine*
- their own membership information and status
- a dedicated private discussion forum

EUBS European Underwater and Baromedical Society

37th Annual Meeting

Preliminary Announcement

Dates: 24–27 August
Venue: Medical University of Gdansk, Gdansk, Poland
Host: National Center for Hyperbaric Medicine in Gdynia

Organising committee contact persons:
Chairman, Zdzisław Sicko: <zsicko@ucmmit.gdynia.pl>
General Secretary, Jacek Kot: jkot@gumed.edu.pl>
Website: <www.EUBS2011.org>

The Environmental Physiology Group, NNTU, Norway
Man in extreme environments − applied physiology from subsea to space
A symposium to honour Professor Alf O Brubakk and his long research career

Dates: 16–17 December 2010

More information will be available at:
<www.ntnu.no/diving>
or contact <andreas.mollerlokken@ntnu.no>

Diving Diseases Research Centre (DDRC), Plymouth, UK

Diving medicine courses for 2010

- Medical Examiner of Divers, Refresher Course: 25–26 November

For further information: <www.ddrc.org>

17th International Congress of Hyperbaric Medicine

Dates: 16–19 March 2011
Venue: Cape Town International Convention Centre, Cape Town, South Africa
Link to ICHM: <www.ichm.org>
For further details go to SAUHMA website:
<www.sauhma.co.za>

The Historical Diving Society Conference

Date: 13th November 2010
Venue: Queen's Hotel, Portsmouth

E-mail: <enquiries@thehds.com>

British Hyperbaric Association 2010 Annual Conference

Dates: 18–21 November
Host: East of England Hyperbaric Unit
James Paget University Hospitals NHS
Lowestoft Road
Gorleston Great Yarmouth
Norfolk NR31 6LA

For further information contact:
Karen Turner <karen.turner@jpaget.nhs.uk> or
Maxine Palmer <maxine.palmer@jpaget.nhs.uk>
Phone: +44-(0)1493-453526
Fax: +44-(0)1493-453261

Scott Haldane Foundation, The Netherlands

The Scott Haldane Foundation is dedicated to education in diving medicine, and has organised over 100 courses in the past few years, both in the Netherlands and abroad.
More information can be found at:
Website: <www.scotthaldane.nl>
E-mail: <info@scotthaldane.nl>

6–13 November: Basic course in diving medicine (Zanzibar, Tanzania)
13–20 and 20–27 November: 17th Advanced course in diving medicine (Zanzibar, then Mafia Island, Tanzania)
11 December: Refresher course "Neurology and diving"

German Society for Diving and Hyperbaric Medicine (GTUeM)

An overview of basic and refresher courses in diving and hyperbaric medicine, accredited by the German Society for Diving and Hyperbaric Medicine (GTUeM) according to EDTC/ECHM curricula, can be found on the website:
<http://www.gtuem.org/212/Kurse_/_Termine/Kurse.html>

Inter-university Diploma in Diving and Hyperbaric Medicine, France

University course (1-year duration) in diving and hyperbaric medicine, organised concurrently by 13 French universities (Angers, Antilles-Guyane, Besançon, Bordeaux II, Lille II, Lyon II, La Réunion, Marseille, Nancy, Nice, Paris XIII, Strasbourg, Toulouse).

For further information go to:
<http://www.medsubhyp.org> or
<http://medecine.univ-lille2.fr/format/diu/hyperbar.htm>

Royal Adelaide Hospital Diving Medicine Medical Officers Course 2010

Week 1, 29 November – 3 December
Week 2, 6 – 10 December

Full DMT Courses:
2nd DMT course in November t.b.d.

For more information contact:
Lorna Mirabelli
Senior Administrative Assistant
Hyperbaric Medicine Unit, Royal Adelaide Hospital
Phone: +61-(0)8-8222-5116
Fax: +61-(0)8-8232-4207
E-mail: <Lmirabel@mail.rah.sa.gov.au>

2010 Royal Australian Navy Medical Officers Underwater Medicine Course

Dates: 25 October – 5 November 2010
Venue: HMAS Penguin, Sydney
Cost: $705AUD

The 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. The course includes scenario-based simulation focusing on management of diving emergencies and workshop covering the key components of the diving medical.

Board and lodging are available on board HMAS Penguin if required. Please contact below for details.

For information and application forms contact:
Mr Rajeev Karekar for Officer in Charge,
Submarine and Underwater Medicine Unit
HMAS PENGUIN
Middle Head Rd, Mosman, 2088 NSW, Australia
Phone: +61-(0)2-99600572
Fax: +61-(0)2-99604435
E-mail: <Rajeev.Karekar@defence.gov.au>

DIVING HISTORICAL SOCIETY AUSTRALIA, SE ASIA

P O Box 347, Dingley Village
Victoria, 3172, Australia
E-mail:
<deswill@dingley.net>
Website:
<www.classicdiver.org>

The Australia and New Zealand Hyperbaric Medicine Group Introductory Course in Diving and Hyperbaric Medicine

Dates: 21 February – 4 March 2011
Venue: Prince of Wales Hospital, Sydney, Australia

This course is approved as a CPD Learning Project by ANZCA – Cat 2, Level 2 – 2 credits per hour (Approval No. 1191)

For more information contact:
Ms Gabrielle Janik, Course Administrator
Phone: +61 (0)2-9382-3880
Fax: +61 (0)2-9382-3882
E-mail: <Gabrielle.Janik@sesiahs.health.nsw.gov.au>

The future of diving: 100 years of Haldane and beyond

Michael A Laing and Alf O Brubakk, editors
Smithsonian Institution Scholarly Press

Proceedings of this December 2008 symposium are available as a **downloadable pdf file through:**
<www.scholarlypress.si.edu>
To request a free print copy, e-mail SISP at:
<schol_press@si.edu>
Print copies of this publication are free upon request, limit five (5) copies while supplies last.

The Hyperbaric Research Prize

The Hyperbaric Research Prize encourages the scientific advancement of hyperbaric medicine and is awarded annually whenever a suitable nominee is identified. It will recognise a scholarly published work or body of work(s) either as original research or as a significant advancement in the understanding of earlier published science. The scope of this work includes doctoral and post-doctoral dissertations. The Hyperbaric Research Prize is international in scope. However, the research must be available in English. The Hyperbaric Research Prize takes the form of commissioned art piece and US$10,000 honorarium.

For detailed information please contact:
Baromedical Research Foundation
5 Medical Park, Columbia, SC 29203, USA
Phone: +1-803-434-7101
Fax: +1-803-434-4354
E-mail: <samir.desai@palmettohealth.org>

Instructions to authors

(Short version, revised May 2010)

Diving and Hyperbaric Medicine welcomes contributions (including letters to the Editor) on all aspects of diving and hyperbaric medicine. Manuscripts must be offered exclusively to *Diving and Hyperbaric Medicine*, unless clearly authenticated copyright exemption accompanies the manuscript. All manuscripts will be subject to peer review. Accepted contributions will also be subject to editing. An accompanying letter signed by all authors should be sent.
Contributions should be sent to:
The Editor, Diving and Hyperbaric Medicine,
C/o Hyperbaric Medicine Unit, Christchurch Hospital,
Private Bag 4710, Christchurch, New Zealand.
E-mail: *<editor@dhmjournal.com>*

Requirements for manuscripts
Documents should be submitted electronically on disk or as attachments to e-mail. The preferred format is Microsoft® Office Word 2003. 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 generally be subdivided into the following sections: an Abstract of no more than 250 words, Introduction, Methods, Results, Discussion, Conclusion(s), Acknowledgements and References. Acknowledgements should be brief. Legends for tables and figures should appear at the end of the text file after the references. Conflicts of interest and funding sources should be identified.

The text should be double-spaced, using both upper and lower case. Headings should conform to the current format in *Diving and Hyperbaric Medicine*. All pages should be numbered. Underlining should not be used. SI units are to be used (mmHg is acceptable for blood pressure measurements; bar for cylinder pressures); normal ranges should be shown. Abbreviations may be used after being shown in brackets after the complete expression, e.g., decompression illness (DCI) can thereafter be referred to as DCI.

Preferred length for **Original Articles** is up to 3,000 words. Including more than five authors requires justification, as does more than 30 references. **Case Reports** should not exceed 1,500 words, with a maximum of 15 references. Abstracts are required for all articles. **Letters to the Editor** should not exceed 500 words with a maximum of five references. Legends for figures and tables should generally be less than 40 words in length.

Illustrations, figures and tables must 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.

Table data may be presented either as normal text with tab-separated columns (preferred) or in table format. No gridlines, borders or shading should be used.
Illustrations and figures should be submitted as separate electronic files in TIFF, high resolution JPG or BMP format. If figures are created in Excel, submit the complete Excel file. Large files (> 10 Mb) should be submitted on disk.
Photographs should be glossy, black-and-white or colour. Colour is available only when it is essential and will be at the authors' expense. Indicate magnification for photomicrographs.

References
The Journal reference style is the 'Vancouver' style (Uniform requirements for manuscripts submitted to biomedical journals, updated May 2007. Website for details: <http://www.nlm.nih.gov/bsd/uniform_requirements.html>). References must appear in the text as superscript numbers at the end of the sentence 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 of the exact format for a standard paper and a book 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.

Accuracy of references is the responsibility of the authors.

Any manuscript not complying fully with the above requirements will be returned to the author before being considered for publication.

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 (and consent forms) should be available if requested.

Copyright
Authors must agree to accept the standard conditions of publication. These grant *Diving and Hyperbaric Medicine* a non-exclusive licence to publish the article in printed form in *Diving and Hyperbaric Medicine* and in other media, including electronic form. Also granting the right to sub-licence third parties to exercise all or any of these rights. *Diving and Hyperbaric Medicine* agrees that in publishing the article(s) and exercising this non-exclusive publishing sub-licence, the author(s) will always be acknowledged as the copyright owner(s) of the article.

Full instructions to authors (revised June 2009) can be found on the DHM Jounal, EUBS and SPUMS websites.

Postscript. The Canterbury, New Zealand, earthquake

As the final touches were being made to this issue of *Diving and Hyperbaric Medicine*, the region of New Zealand where I live suffered a magnitude 7.1 shallow earthquake on Saturday 4th September, resulting in severe damage to the infrasctructure of this community over an extensive area. Amazingly there has been no lose of life thus far (four days later and 300-plus aftershocks greater than magnitude 3.0). This has been partly due to the timing of the quake, 0436 h, and partly thanks to the progressively stricter building codes in New Zealand since the Napier earthquake in 1931.

The progress of this quake activity has been graphically documented on the website www.christchurchquakemap.co.nz where the chronological sequence of shocks is represented on a Google™ map of the region.

The response of the civil authorities, infrastructure and service companies (water, power, phone, waste, etc) and the community in general has been outstanding. Not surprisingly the large number of aftershocks, some of them considerable, has had a progressively demoralising effect on many people, who are finding it hard to cope. The biggest medical impact looks likely to be psychological, and there are expected to be hundreds rendered homeless as habitations are condemned as unsafe, and possibly thousands rendered unemployed as small businesses fold. The economic impact will be huge: currently estimated at over NZ$4 billion (equivalent to about $1,000 per capita of the NZ population).

Your editor's family has not escaped entirely unscathed, with my son suffering an acute cervical disc prolapse whilst rescuing his children during the quake. My home has been damaged, though is habitable and all services are up and running, whilst his is still without phone, water and sewerage as I write. We are all tired, particularly as every night we have been woken several times by the bigger aftershocks, and it is hard to get back to sleep after each one. We are fortunate indeed to live in a community with the resources and infrastructure to cope with a natural disaster like this.

Michael Davis, Editor

DIVER EMERGENCY SERVICES PHONE NUMBERS

AUSTRALIA
1800-088200 (in Australia, toll-free)
+61-8-8212-9242 (International)

NEW ZEALAND
0800-4DES-111 (in New Zealand, toll-free)
+64-9-445-8454 (International)

SOUTH-EAST ASIA
+852-3611-7326 (China)
010-4500-9113 (Korea)
+81-3-3812-4999 (Japan)

SOUTHERN AFRICA
0800-020111 (in South Africa, toll-free)
+27-10-209-8112 (international, call collect)

EUROPE
+39-06-4211-8685 (24-hour hotline)

UNITED KINGDOM
+44-07740-251-635

USA
+1-919-684-9111

The DES numbers (except UK) are generously supported by DAN

DAN Asia-Pacific DIVE ACCIDENT REPORTING PROJECT

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 regard to identifying details, is utilised in reports on fatal and non-fatal cases.
Such reports can be used by interested people or organisations to increase diving safety through better awareness of critical factors.
Information may be sent (in confidence unless otherwise agreed) to:
DAN Research
Divers Alert Network Asia Pacific
PO Box 384, Ashburton VIC 3147, Australia
Enquiries to: <research@danasiapacific.org>

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-AP website: <www.danasiapacific.org>
They should be returned to:
DIMS, 30 Park Ave, Rosslyn Park, South Australia 5072, Australia.

CONTENTS

Diving and Hyperbaric Medicine Volume 40 No. 3 September 2010

Diving and Hyperbaric Medicine is indexed on SCIE and Embase/Scopus

Printed by Snap Printing, 166 Burwood Road, Hawthorn, Victoria 3122
hawthorn@snap.com.au