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SPUMS

Hyperbaric chambers

Attendant safety
Oxygen delivery

Risk, perception and sport

Risk management in scientific and recreational diving

Freediving in cyberspace

The Broome chamber

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

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The Society's financial year is January to December, the same as the Journal year.
The 2004 subscription will be Full Members A$132.00 and Associate Members A$66.00, including GST in Australia. All those outside Australia will be charged the same amounts as the GST component to partly cover the cost of having the Journal delivered to them by Air Mail. These fees must be paid in full.

The Editor's offering

When divers suffer decompression illness, cancer patients develop post-radiation osteoradionecrosis of the jaw or diabetics have ulcers that do not heal with good non-hyperbaric care, hyperbaric oxygen therapy (HBOT) is indicated. For patients to achieve benefit, HBOT will only be as good as the technique of delivery is efficient and reliable.

A number of studies have looked at the performance of oxygen delivery devices in multi-place chambers, and it is clear that oxygen delivery can be variable and influenced by a number of equipment and patient factors. As well as the inspired oxygen fraction, breathing resistance, rebreathing and carbon dioxide levels, patient comfort and the efficient use of resources need to be addressed.

The performance of the Amron™ Oxygen Head Hood is assessed from several of these viewpoints by Davidson and Bennett. Whilst this study was performed at ambient pressure rather than at treatment pressures, it is likely that their findings are applicable to the clinical HBOT setting. This does, however, need confirmation. A reduction of 10 $l.min^{-1}$ in flow rate into head hoods for HBOT, and assuming a hyperbaric unit treats 10 patients per day, would result in a reduction of oxygen usage approaching 7,000 m^3 per year. Whilst liquid oxygen is relatively cheap, this nevertheless represents a considerable long-term saving.

At the same time, chamber attendants are breathing air at pressure and are, therefore, exposed to the risks of decompression sickness (DCS). Doolette has argued over several studies that the binomial outcome, DCS or no DCS, is not the ideal way to study health outcomes in divers, nor to validate 'safe' decompression schedules. Here he reports, in recompression chamber (RCC) attendants, on the use of the diving health survey (DHS) questionnaire, first developed to study Australian abalone divers.

Concern was expressed by a reviewer about the application of DCS computer models in which the parameter values were derived for exposures with much higher DCS rates than those reported here. In the reviewer's words, "*no matter which model you use, it brings with it another set of assumptions and uncertainties*". Nevertheless, the scores from the DHS did not differ between hyperbaric and normal ward work, suggesting that the exposure for inside attendants carried only a low risk. The one attendant in the study who developed DCS had a high score, consistent with Doolette's previous studies, the abstract from the most recent of which is also reported in this issue for comparison.

The 2003 Annual Scientific Meeting was devoted almost entirely to aspects of diving medicals and risk management in diving. The tenor of the meeting was set nicely by the convenor, Michael Bennett, in his introductory review of risk and risk perception reported here, along with international papers on risk management in scientific and recreational diving. Martin Sayer shows how restrictive legislation has been turned into effective operational constructs that enhance scientific diving safety in the United Kingdom.

John Knight and I have been accused of giving too much space to the recreational diving industry within this journal, and that this allows that industry to claim endorsement by SPUMS for their activities. The most recent example of this concern related to children and scuba diving.

We do not take this view but, rather, believe that both diving medical and teaching professionals benefit from an honest exchange of data (where they exist) and opinion. Interestingly, only one organisation within the recreational diving industry, PADI, has consistently risen to this challenge, taking an active part in this society. I hope that others will follow their example. We need good, cooperative research work between medicine and sport diving.

There is nothing like a good historical yarn! Sue Thurston's investigations into Australia's first civilian therapeutic RCC, installed in the early twentieth century to treat the Broome pearl divers, was a well-deserved recipient of the SPUMS award at the 2003 Hyperbaric Technicians and Nurses Association (HTNA) meeting. As readers will note from her letter, Sue is pursuing her historical investigations and I urge Society members to contact her if they think they may have useful information. Because of the nature of the joint meeting with the Undersea and Hyperbaric Medicine Society in Sydney this year, it was not possible to make an award in 2004.

For freediving enthusiasts, marvel at the ability of a swimmer without fins to dive to a depth of 61 m and return safely to the surface!

Hyperbaric facility accidents

Recently a fire was reported to have occurred adjacent to a hyperbaric unit in Ajaccio, Corsica, where this year's EUBS Meeting is being held in September. The following summary is written from third-party information obtained via the ANZHMG web discussion group, courtesy of Roly Gough-allen. Therefore, not all the facts may be accurate and a clearer picture will emerge with time. However, the issue of recompression chamber facility safety is topical, and the following is intended to help others look at their own facilities rather than to apportion blame in any way.

The incident was initiated outside a recompression chamber building at a public hospital. The chamber is on the ground floor of a main building and the services, like compressed air, oxygen, and electrical supplies, etc., come in from a separate building. These services are routed in an underground duct with concrete slabs over it. Some of the slabs were thought to be in a poor state of repair and there were gaps where rubbish and leaves had entered into the duct. This duct had become home for rats that could enter the chamber room. The end of the duct in the chamber room was, therefore, at some time in the past blocked up with polyurethane foam to stop the access for the rats.

It is thought that a cigarette was thrown down outside and this fell through the concrete duct-cover slabs. Lots of people smoke just outside hospitals nowadays and these areas tend to be places either under cover or out of the prevailing elements.

It is believed leaves and rubbish that had accumulated in the duct over a matter of time were ignited by the cigarette. After investigation, it also appears that the chamber built-in breathing system (BIBS) exhaust, mostly oxygen, was also routed into this duct.

When the fire reached the polyurethane foam, a heavy, dark-black smoke appeared from the control panel of the chamber. The chamber operator thought the inside of the control panel was on fire and therefore used a portable fire extinguisher on the inside of the panel. The smoke continued, the chamber operator put on his BA set and started the chamber decompression. At this point no patients or anyone else had been harmed.

However, the chamber operator had problems seeing the valves of the control panel. As soon as the chamber arrived at the surface all patients left the building except one who required assistance. The attending emergency fire service may not have understood the problems associated with a hyperbaric facility. The last patient's exit and the fire personnel helping were delayed to the point where smoke inside the chamber (which was clear of any contamination until surfacing) was now also causing concern for those inside. This delay caused minor respiratory irritation to the last patient and to the two fire personnel attending.

Main areas for concern:

- Ground-floor gutters with mixed services and their cleanliness
- Lack of access to the backs of control panels
- Exhausts to points were people may be smoking and also height of exhausts above ground
- The need for BA sets for chamber operators
- Appropriate use of the correct fire-stopping materials
- Smoke extraction from areas where operators may need to remain to assist with the evacuation of patients.

This is the second serious multi-place hyperbaric facility accident reported this year, the first being the double fatality in South Africa.[1] It highlights again that it is essential for such facilities to meet appropriate standards of construction, installation and maintenance, and to be manned by trained, dedicated technical, nursing and medical staff.

In Australia, AS 4774.2-2002 provides considerable safeguards,[2] but many countries, including New Zealand, do not have standards for therapeutic hyperbaric facilities. Now is the time for action on the part of the appropriate authorities, which should embrace all hyperbaric facilities, including the many private 'back-garden' and alternative medicine chambers scattered around our communities. I would hate for this action to be forced on us by a tragedy.

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1 News item. Cronje F. Hyperbaric chamber explodes in Polokwane, South Africa. *SPUMS J*. 2004; 34: 39.

2 Standards Australia. *Work in compressed air and hyperbaric facilities. Part 2: Hyperbaric oxygen facilities*. AS 4774.2-2002. Sydney: Standards Australia International Ltd; 2002.

Key words
Editorials, hyperbaric facilities, safety, fire or explosion

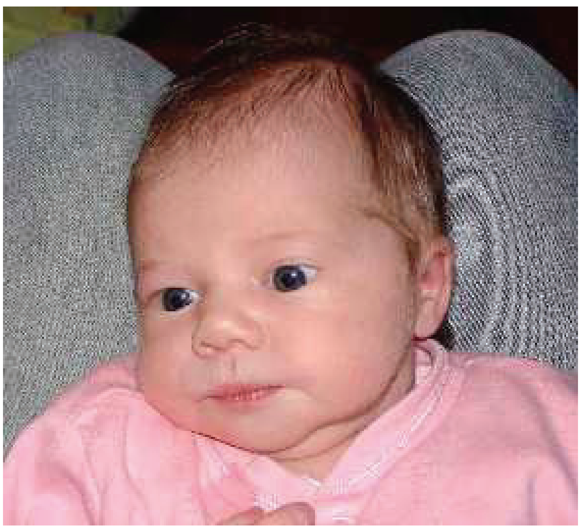
Michael Davis

Front cover photos depict SNs Nicole Heffernan and Sarah McDonnell caring for two patients on ventilators in the Prince of Wales Hospital recompression chamber, and Sue Thurston beside the original Broome chamber, now restored in the Broome Museum.

The database of randomised controlled trials in hyperbaric medicine developed by Dr Michael Bennett and colleagues at the Prince of Wales Diving and Hyperbaric Medicine Unit is at:

<www.hboevidence.com>

The newest member of the editorial team, Charlotte Grace born April 15th to Sarah Webb and Roger Kirwan



Original articles

Health outcome of hyperbaric-chamber inside attendants following compressed-air exposure and oxygen decompression

David J Doolette, Stephen J Goble and Christy J Pirone

Key words
Decompression sickness, occupational health, health surveys, regression analysis

Abstract

(Doolette DJ, Goble SJ, Pirone CJ. Health outcome of hyperbaric-chamber inside attendants following compressed-air exposure and oxygen decompression. *SPUMS J*. 2004; 34: 63-7.)
Multi-place, hyperbaric-chamber inside attendants are at risk of decompression sickness (DCS). Attendant decompression protocols vary between facilities and there has been limited specific development or testing of these procedures. Forty-six attendants completed a health survey designed to measure decompression-related health outcome following both 490 hyperbaric exposures and 26 days of ward work without hyperbaric exposure. The risk of decompression sickness (pDCS) for each different hyperbaric schedule was calculated according to a model for oxygen decompression. The contribution of pDCS to a decompression health survey score (DHS) was assessed by linear regression. DHS was not influenced by the hyperbaric exposures and was not different to non-hyperbaric DHS. Three attendants were treated for DCS in close agreement with the calculated mean pDCS. Despite non-zero incidence of DCS, mean attendant health status was not adversely affected by these occupational hyperbaric exposures.

Introduction

Decompression sickness (DCS) is a significant health risk for compressed-air workers. Gases breathed while at high pressure become dissolved in the body tissues and with reduction in ambient pressure (decompression) excess dissolved gas produces bubbles that may result in DCS. Patient attendants who work inside multi-place hyperbaric chambers are at risk of DCS. This risk is widely considered negligible; however, a survey of North American hyperbaric facilities indicates an overall incidence of 5 per 10,000 decompressions, similar to the 1 to 3 per 10,000 reported for underwater air divers.[1-4] The primary factor influencing the risk of DCS is the pressure/time/breathing gas profile. Following a hyperbaric exposure, the risk of DCS for the attendant can be minimised by a slow decompression and oxygen breathing but these decompression procedures vary widely between facilities. Unlike decompression procedures for divers there has been limited specific development or testing of attendant decompression procedures. Since decompression procedures can fail if applied outside of the range of conditions for which they were developed and tested, some attendant decompression schedules present an unknown risk.

Large-scale decompression schedule development programmes are expensive and a recently developed alternative is to collect health outcome data in the field that can be used to evaluate decompression procedures.[5] We have previously used a method based on prospective collection of objective pressure/time/breathing gas profiles and health status scores using a self-administered decompression health survey to evaluate decompression practice in occupational underwater air divers.[6,7] We have been collecting equivalent attendant health outcome data following routine hyperbaric-chamber compressed-air exposure and oxygen decompression with the long-term goal of fitting decompression models to these data. Here we report a preliminary evaluation of the present attendant decompression protocols used at the Royal Adelaide Hospital Hyperbaric Medicine Unit.

Methods

DATA COLLECTION

The study was approved by the University of Adelaide Human Ethics Committee and the Royal Adelaide Hospital Research Ethics Committee and was conducted in accordance with the National Statement on Ethical Conduct in Research Involving Humans (Commonwealth of Australia. Canberra: AusInfo; 1999). This was an observational study whereby data were collected in the course of routine hyperbaric treatments. Chamber operators submitted paper logs describing the attendants' pressure/time/breathing gas profiles. Attendants voluntarily completed a self-administered health survey several hours following decompression and periodically following non-hyperbaric ward duties.

The health survey used was a minor modification of the one developed for divers that has been described in detail elsewhere.[6] It is an inventory of nine standardised items and responses covering five symptoms of decompression sickness (paraesthesia, rash, balance, fatigue, and pain), five health status indicators (vitality, pain, physical functioning, role limitation, and health perception), and time of onset of symptoms, plus one free response, each item scored from 0 to 3. The resulting summed decompression health score (DHS) ranges from 0 (well) to 30 (unwell) and can be analysed as interval data. A DHS value of 2 is typical for a well person. The DHS correlates with diagnosed DCS and following routine occupational underwater diving the DHS increases one unit for every 1% increase in calculated risk of DCS.[6,7] The validated format of the decompression health survey and scoring instructions are available from the authors. The DHS was used as the outcome measure without any attempt to categorise outcome as DCS or not.

Health surveys and chamber logs were returned in confidence by reply-paid mail to one of the investigators. The paper logs describing chamber profiles were converted to machine-readable pressure/time/breathing gas profiles that could be used to calculate the risk of DCS and visually inspected to exclude data errors. Decompression data were managed using purpose-designed, partially automated database and analysis applications programmed in our laboratory (Access 2000 and Visual BASIC, Microsoft Corp., Redmond, WA, USA).

From August 1999 to December 2001 there were 1531 attendant decompressions, and 591 health surveys and chamber logs were collected. Some data were excluded, 94 health surveys were incorrectly completed, mostly due to ambiguous wording in an unscored item that was subsequently re-worded, and seven health surveys followed unusual chamber dives. The common hyperbaric oxygen treatments used at the Royal Adelaide Hospital are:

- 10 metres of sea water depth (msw) for 90 minutes (10:90:30)
- 14 msw for 90 minutes (14:90:30)
- 18 msw for 60 minutes (18:60:30)
- United States Navy Table 6 (USN 6)

The standard USN 6 comprises 75 minutes at 18 msw, a 30-minute linear decompression to 9 msw, and 150 minutes at 9 msw. The attendant breathes air during all the treatments and oxygen during a 30-minute linear decompression from the final treatment depth to the surface. USN 6 may include additional attendant oxygen breathing at 9 msw.

In addition, 26 non-hyperbaric DHS were collected from 14 of the attendants following normal ward duties or following 'sham' (3 msw) exposures conducted as part of a separate randomised controlled clinical trial. In total, 516 health surveys from 46 attendants were analysed.

EVALUATION OF DECOMPRESSION PRACTICE

The relative decompression stress of each of the attendant hyperbaric exposures was estimated from the pressure/time/breathing gas profile using the JAP98–1 model.[8] The JAP98-1 model returns the risk of DCS (pDCS) but was not specifically developed using low-risk attendant hyperbaric exposures. Therefore, the calculated pDCS should be considered a measure of the relative decompression stress rather than an accurate assessment of the risk of DCS for attendants. In brief, in the JAP98–1 model, nitrogen partial pressure in three compartments changes during gas breathing at different pressures, and pDCS increases whenever ambient pressure drops below compartment gas partial pressure by a specific threshold.

Unlike most decompression models JAP98–1 attributes a direct action of oxygen on decompression whereby high inspired oxygen partial pressure can reduce the rate constant for nitrogen wash-out as might be expected if tissue blood flow were reduced. The effect is to partially counteract the benefit of oxygen decompression. The JAP98–1 was calibrated by statistical best fit to a data set of 4335 well-documented experimental dives and DCS outcome, including 1013 dives using oxygen for decompression. The present implementation was written in GNU Fortran (EGCS version 1.1.2. The Free Software Foundation; 1999) and R (R base package version 1.4.1. The R Development Core Team; 2002). The pDCS was tracked over the daily pressure/time profile and subsequent 24 hours.

The DHS has been shown previously to correlate with the risk of DCS in occupational divers.[7] In our study it was used to measure decompression-related health status amongst chamber attendants during normal occupational compressed-air exposure. The contribution of hyperbaric exposure to DHS was evaluated by linear regression. To accommodate possible between-attendant variability we used a linear mixed-effect modelling approach. The full model investigated was of the form:

$$DHS_{ij} = \beta_{0i} + e_i + \beta_1 pDCS_{ij} + \beta_2 DUR_{ij} + \beta_3 MSW_{ij} + e_{ij}$$

which comprised the dependent variable DHS and fixed explanatory variables, pDCS, exposure duration in minutes (DUR), and treatment pressure in metres sea water (MSW). pDCS is included to rank the different hyperbaric exposures and non-hyperbaric data according to their relative decompression stress. DUR and MSW were included in the model to investigate any possible influence of hyperbaric exposure on health outcome other than via pDCS; for instance a longer treatment may cause fatigue not related to decompression stress.

Different subjects may describe their normal health status differently; this manifests as a different intercept (DHS at pDCS, MSW, DUR all equal 0) in the linear model. To accommodate this the 46 attendants were considered a random sample from a population where the intercept ($ß_0$) of the regression on the explanatory variables depends on the attendant. Subscript i denotes attendant, subscript j denotes days, and *e* denotes error.

Parameters of the regression models were estimated by maximising the likelihood. The likelihood is the joint probability density function of the observed values of the dependent variable given the respective regression model. To find the most parsimonious model, explanatory variables with non-significant parameters ($p > 0.05$) that therefore do not contribute to the model fit to the data were removed from the full model and the resulting reduced models again fitted to the data. Significant difference ($p \leq 0.05$) between nested models was evaluated by likelihood ratio test,

$$2(LL_f - LL_r) \approx X^2_{f-r}$$

where LL is the maximised log-likelihood of the model and f and r are the number of parameters in the full and reduced models respectively ($f > r$). For each model the data were examined for influential values (outliers with high leverage). Outliers were data with a standardised residual more than two standard deviations from the mean. Leverage was taken as the diagonal of the hat matrix, and values more than twice the mean were considered high.

All statistical calculations were performed using R software base package (version 1.4.1. The R Development Core Team; 2002) and the non-linear mixed effect package (version 3.1–23. Pinheiro J, Bates D, DebRoy S, Sarkar D; 2001).

Results

Daily health status of attendants was not influenced by the standard hyperbaric exposures used at the Royal Adelaide Hospital. During the modelling procedures two influential values were identified in the non-hyperbaric data and removed from all analysis (both DHS = 8). The remaining data are summarised in Table 1. There was no significant difference in DHS between the different treatment schedules or non-hyperbaric activities. The median interval between decompression and DHS was eight hours (interquartile range 5–12, n = 500).

For USN 6 the pDCS was calculated using the JAP98–1 model for each individual exposure as this schedule can be extended for therapeutic reasons and the period of attendant oxygen breathing varied. The lowest value resulted from an extended schedule with 90 minutes of oxygen breathing for the attendant, and the highest risk from a standard duration schedule with only 30 minutes of oxygen breathing. The pDCS for the other schedules were calculated for a typical exposure and do not account for small variations in descent time. The pDCS for all hyperbaric exposures was calculated as the weighted mean of the schedules in the analysed data. Schedules 10:90:30 and 14:90:30 are slightly under- and over-represented, respectively, in the analysed data compared to the actual frequency of their use during the data collection period; the weighted mean pDCS for all hyperbaric exposures calculated for the actual frequency of schedule use is 0.226%.

The results of the modelling of DHS are shown in Table 2. The full model (model 1) shows that the explanatory variables MSW and DUR did not significantly influence DHS. Removal of MSW and DUR produced a simpler model (model 2) that fitted the data equally well. As DHS is a validated measure of decompression-related health outcome we did not expect MSW or DUR to have an influence separately from their contribution to pDCS. However, in model 2 the explanatory variable pDCS did not significantly influence DHS. Removal of pDCS resulted in the null model (model 3) that fitted the data equally well and is preferred as the simplest explanation of the data. In the null model, DHS only varied between attendants and is not different between non-hyperbaric duties or any of the hyperbaric

Table 1. Data summary. Mean DHS, 95% confidence interval (CI), number of surveys (n), number of attendants, and decompression stress index (pDCS: JAP98–1) for each hyperbaric treatment schedule and normal ward duties (non-hyperbaric), and combined means for hyperbaric exposures only and for all data (total)

Schedule	Mean DHS	95% CI	n	Attendants	pDCS (JAP98–1)
Non-hyperbaric	2.4	1.8 – 3.0	24	14	0
10:90:30	2.3	2.0 – 2.5	287	40	0.02%
14:90:30	2.2	1.9 – 2.5	109	20	0.50%
18:60:30	2.0	1.7 – 2.3	78	25	0.87%
USN Table 6	2.3	1.7 – 3.0	16	10	0.46 – 3.27%
All hyperbaric	2.2	2.1 – 2.3	490	45	0.27%
Total	2.2	2.1 – 2.3	514	46	

Table 2. Model comparisons. Estimated value, standard error (SE) and significance (p) of model parameters and log-likelihood (LL) comparison of model fits to the data

Model	Variables	Parameter Estimate	(SE)	p	df	LL	Test	Likelihood Ratio	p
1	Intercept	2.8	(0.40)	<0.0001	6	-880.8			
	pDCS	37	(18)	0.0272					
	MSW	-0.04	(0.02)	0.0573					
	DUR	-0.001	(0.002)	0.5800					
2	Intercept	2.2	(0.2)	<0.0001	4	-882.7	1 vs 2	3.706	0.1568
	pDCS	14	(11)	0.2143					
3	Intercept	2.3	(0.2)	<0.0001	3	-883.5	2 vs 3	1.545	0.2137

exposures. The standard deviation of DHS between attendants was 1.3 (not shown) with 95% CI not including zero, indicating that attendants differed in how they described their normal health status.

The present modelling does not account for censoring of the data; censored data show only that the event of interest has not occurred at the time of data collection. In the present data, symptoms of DCS (and a resulting higher DHS) may have arisen after the decompression health survey was completed. However, any censoring is probably not severe as symptom onset occurs by eight hours (mean interval between hyperbaric exposure and health self-assessment) in approximately 90% of cases of DCS.[9]

During the period of data collection, three attendants were treated for symptoms of DCS (joint pain, fatigue). In each case the symptoms resolved with a short series of hyperbaric oxygen treatments. Only one of these attendants contributed a decompression health survey following the putative causative chamber dive (DHS = 11). This incidence (3/1531) was the same as the expected incidence of DCS according to the JAP98–1 model calculated from the weighted mean pDCS of all hyperbaric exposures (0.226%). This incidence is not significantly different from the incidence of 5/7197 decompressions during the preceding 12 years using these schedules (Yate's corrected Chi-square, p = 0.31). Of interest, however, is that five of the eight incidents were clustered in an otherwise unremarkable 16-month period.

Discussion

Despite a non-zero incidence of DCS symptoms, mean attendant health status is not adversely affected by the routine compressed-air exposures and oxygen decompressions used at the Royal Adelaide Hospital, being no different from that following non-hyperbaric ward duties. The overall incidence of treated symptoms of DCS amongst attendants at the Royal Adelaide Hospital of eight out of 8724 decompressions (approximately nine per 10,000) is similar to the reported incidence of DCS from other individual hyperbaric facilities, which ranges from eight to 42 per 10,000 decompressions.[1] However, approximately five DCS per 10,000 decompressions (23/49,349) is reported from a survey of 33 North American hyperbaric facilities,[1] suggesting a possible bias towards publication of positive incidence from individual facilities.

Our figures suggest the incidence of DCS in attendants may be higher than generally accepted. It is likely that there is under-reporting of DCS amongst attendants in some facilities, as such under-reporting is commonplace in many diving groups where untreated DCS probably exceeds treated DCS.[7,10] Additionally, there may be some high-risk decompression protocols in use that need to be identified and appropriately modified. For example, later revisions of the US Navy Diving Manual have twice increased the duration of attendant oxygen breathing for decompression following USN 6. All attendant decompression protocols should be subject to this sort of scrutiny.

The DHS reported by attendants was unrelated to the pDCS calculated according to the JAP98–1 model. This is contrary to what has been found for occupational underwater air diving.[7] There are several possible reasons for the present lack of association. The JAP98–1 model may be inappropriate for attendant exposures, the DHS may not be a good measure of outcome in this context or there may be insufficient variation of pDCS in the present data set.

Decompression models, like any models, may fail if applied outside the conditions for which they are tested, and there are no decompression models developed for the specific needs of chamber attendants. The JAP98–1 model was developed for underwater diving, but specifically to explain the effects of breathing high fractions of oxygen during decompression, where other models fail.[8] The JAP98–1 model was chosen since high oxygen fraction breathing is a feature of attendant decompression procedures. The choice seems reasonable since the model predicted the overall incidence of treated symptoms of DCS in these attendants. However, the JAP98–1 model is calibrated against a data set with high incidence of DCS (5.4%) and may not appropriately estimate the very low-risk attendant decompression procedures. It is interesting to note that the USN 93 decompression model,[11] which was not optimised for oxygen breathing decompression and was predictive of occupational underwater air diving outcome,[7] predicted zero incidents of DCS during the present period of data collection. This highlights the need to use appropriate models to plan attendant decompression procedures.

The DHS has been well validated for measuring decompression-related health outcome.[6] Since DCS is rare, it is not possible to validate the DHS for specific occupational groups. However, the DHS correctly identified the one incident of treated DCS amongst the present attendant data. The most likely reason that pDCS was not predictive of DHS in the present data is that the majority of the data were collected following the same three treatment schedules, which have three, low, calculated pDCS. Firstly, this decompression stress may be too low to influence mean attendant health status. Secondly, the DHS can only take integer values, and in occupational divers increased one unit for every 1% increase in pDCS,[7] whereas the majority of the present data spanned less than 1% pDCS.

Data collection is being extended to other hyperbaric facilities with the aim of acquiring data from a larger variety of decompression protocols (and pDCS) and supplementing currently under-represented schedules. More information regarding participation in this multi-centre trial is available from the authors. Such a data set will allow rational design of attendant decompression protocols.

Acknowledgments

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Effect of oxygen flow on inspired oxygen and carbon dioxide concentrations and patient comfort in the Amron™ oxygen hood

Gretel Davidson and Michael H Bennett

Key words
Hyperbaric oxygen, equipment, oxygen, carbon dioxide, performance, research

Abstract

(Davidson G, Bennett MH. Effect of oxygen flow on inspired oxygen and carbon dioxide concentrations and patient comfort in the Amron™ oxygen hood. *SPUMS J*. 2004; 34: 68-74.)
The Amron™ Oxygen Treatment Hood was tested to determine the effect of altering oxygen flow on conditions within the hood. Inspired oxygen percentage, and inspired and end tidal carbon dioxide pressures were measured as fresh oxygen flow was reduced. Temperature within the hood was also measured. Discomfort was scored by the subjects for noise, temperature and respiratory effort. Inspired oxygen percentage was well maintained at flows of greater than 20 $l.min^{-1}$. As oxygen flows fell, inspired carbon dioxide pressure increased, although there was little clinically relevant change until flows were reduced below 30 $l.min^{-1}$. End tidal carbon dioxide did not change significantly. Temperature was higher at low flows, but did not fall significantly further with flows above 20 $l.min^{-1}$. Patient discomfort scores did not change significantly, but there was a positive correlation between flow and noise, and a negative correlation between both temperature and respiratory effort and flow. We conclude that, with healthy volunteers at one atmosphere absolute ambient pressure, an oxygen flow of 30 $l.min^{-1}$ into the Amron™ Oxygen Treatment Hood provides adequate inspired oxygen concentration, with minimal rebreathing of carbon dioxide, and maintains acceptable conditions of noise and temperature.

Introduction

Hyperbaric oxygen therapy (HBOT) is used in the management of medical and surgical conditions including carbon monoxide poisoning, diabetic and ischaemic ulcers, necrotising infections and decompression illness. In multi-place hyperbaric chambers pressurised using air, administration of 100% oxygen to patients and removal of exhaled gas, without contaminating the chamber atmosphere, is achieved using either a mask fitted over the nose and mouth to supply oxygen on demand, or a hood enclosing the head and supplied with a constant flow of oxygen. Such a device may be used, for example, for patients who have undergone head or neck surgery and to whom a tight mask cannot be fitted, patients with tracheostomies, or persons who are unable to tolerate a tight-fitting mask for any other reason.

The Amron™ Oxygen Treatment Hood (Amron, California, USA) is commonly used by hyperbaric medicine units both in Australia and elsewhere. The device consists of a clear vinyl hood fitted to a plastic ring with a soft dam fitting around the neck. Oxygen is supplied through an inlet hose and the hood is exhausted through a separate outlet hose (Figure 1).

The manufacturers' advice is to supply oxygen at a rate of 25–50 $l.min^{-1}$. In our facility, patients receiving oxygen at high flows often report being disturbed by the high level of noise within the hood, and communication between the chamber attendant and the patient may be impaired by this noise. Some patients are also disturbed by the high temperature and 'stuffiness' within the hood during the treatment period. Additionally, if flows at the upper end of this range are not in fact required to safely conduct therapy and provide patient comfort, this would represent a considerable waste of oxygen.

A preliminary, unpublished study conducted in our facility determined that reducing fresh oxygen flow had little effect on inspired carbon dioxide concentration down to a flow of 20 $l.min^{-1}$. Currently in our facility, oxygen is routinely administered at 30 $l.min^{-1}$. Around Australia, of those centres using oxygen hoods, higher flows are used in most – up to 60–70 $l.min^{-1}$ in one centre.

The manufacturers were unable to provide evidence to support their recommendations, and a search of relevant literature yielded no previously published study assessing the effects of varying oxygen flow into the hood. The aim of our study was to determine the effect of reducing oxygen flow on concentrations of inspired carbon dioxide (P_ICO_2), end tidal carbon dioxide ($P_{ET}CO_2$), inspired oxygen fraction (F_IO_2) and temperature within the Amron hood. In addition, subjective information was gathered about aspects of patient discomfort regarding noise levels, temperature and dyspnoea. We aimed to determine the optimal fresh gas flow rate to ensure administration of 100% oxygen, while ensuring acceptable carbon dioxide elimination and patient comfort.

Figure 1. The Amron™ Oxygen Treatment Hood

Methods

Following approval by the South Eastern Sydney Area Health Service Eastern Section Research Ethics Committee, healthy volunteers were recruited for the study. Prior to fitting the hood, sampling nasal cannulae (Salter Labs, California, USA) were placed on each subject for end tidal gas sampling. A temperature probe (Mallinckrodt Mon-a-Therm, Mallinckrodt Chihuahua, Mexico) was attached to the inner surface of the hood. Subjects were fitted with an appropriately sized neck seal and the sampling line and temperature probe were passed under the neck seal to exit the hood (Figure 1). The gas-sampling line was connected to the gas-sampling inlet of a Datex AS/3 anaesthetic monitor (Datex-Ohmeda, Helsinki). Oxygen was administered via 22 mm tubing from a high-flow oxygen flowmeter to the inlet port, and gases were exhausted via 22 mm tubing from the outlet port via a wall-mounted suction outlet (Clemens, Australia). These arrangements mimicked the equipment used during hyperbaric exposure. Exhaust pressure was titrated against flow to maintain constant hood inflation, just as during treatment.

Subjects were requested to breathe through the nose and encouraged to read in order to reduce their awareness of their respiratory pattern. Commencing at an oxygen flow of 50 $l.min^{-1}$, tidal ventilation was monitored from the nasal sampling line for a five-minute period. Flow was sequentially reduced through 40, 35, 30, 25, 20, 15, and 10 $l.min^{-1}$. Concentrations of inspired oxygen, and inspired and end tidal carbon dioxide were recorded at the end of each five-minute period. Temperature within the hood was continually monitored with the AS/3 monitor and recorded at five-minute intervals.

Subjects were provided with a questionnaire and asked to complete each section following the five-minute period at each flow setting. Subjects were asked to record their level of discomfort on a scale of one (comfortable) to five (distressing) with regard to noise level, temperature within the hood and difficulty breathing. Space was also available on the questionnaire for freehand recording of relevant comments.

In order to confirm the observation that a steady state for the measured gas concentrations was reached within the five-minute period, a second study was completed. Further healthy volunteers were recruited and prepared as above. In this series of subjects, fresh gas flows were altered in random order. Measurements of inspired oxygen and carbon dioxide concentrations were recorded at one-minute intervals for ten minutes if a steady state was observed. If the parameters had not achieved a steady state at that time, observations were to be continued for fifteen or twenty minutes as required.

Data were assessed using Stats Direct Statistical Software Version 1.9.8 (Iain Buchan, 2001). Shapiro-Wilk W test for non-normality suggested it would be reasonable to use parametric tests to analyse data from gas and temperature measurements. Comparisons were thus made using ANOVA with Tukey correction for multiple comparisons and simple linear regression where appropriate. Non-parametric data were analysed using Kendall Rank Correlation. Comparisons were considered to be statistically significant when the p-value was < 0.05. Results are expressed as the mean with 95% confidence intervals.

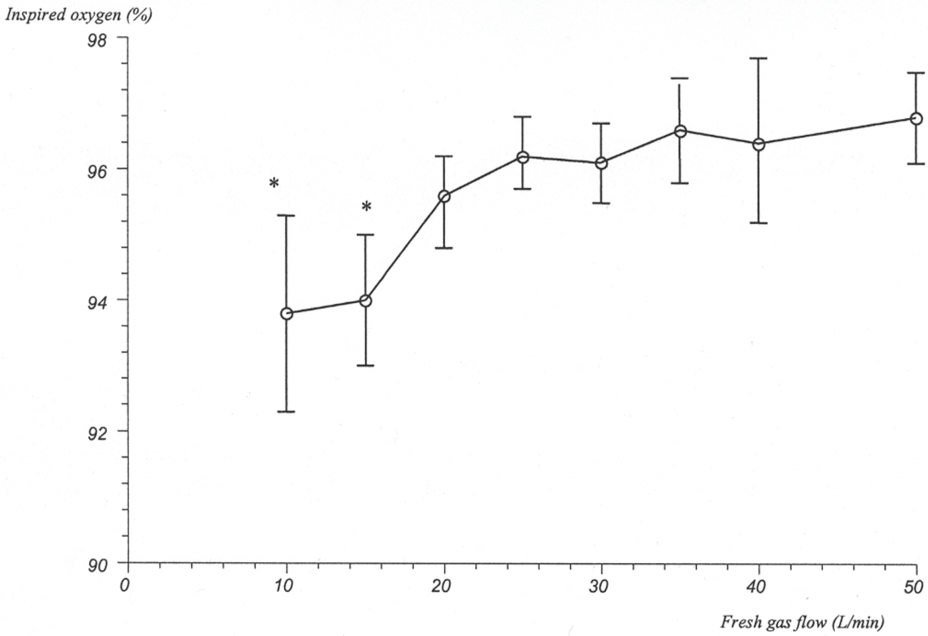
Results

Nineteen subjects were enrolled in the sequential flow phase of the study. Complete data were available on 17 subjects and partial data on the other two. Twelve of the subjects were male, and the range of body mass indices (BMI) was 21.6 to 31.7 (median 24.7). Five subjects were enrolled in the random flow phase of the study (four male), and the BMI ranged from 19.9 to 31.4 (median 24.4). Results from the random flow phase are included only in the ‘steady state’ analysis.

INSPIRED OXYGEN

Inspired oxygen concentration decreased with decreasing oxygen flow (Figure 2). On examination of the corrected

Figure 2. Mean F_IO_2 (%) with 95% CI at different fresh gas flows
***Indicates significantly lower concentration than at 50 l.min^{-1}**



multiple comparisons by ANOVA, there were significant differences between low flows (10 and 15 l.min^{-1}) and 50 l.min^{-1}, but no further significant differences when flow was 20 l.min^{-1} or above. The mean difference in oxygen concentration at 50 l.min^{-1} flow compared with 10 l.min^{-1} flow is 3.0% (95% CI 1.0 to 5.1), p = 0.0003.

INSPIRED CARBON DIOXIDE

P_ICO_2 increased in a non-linear way with reducing oxygen flow although there was no significant difference in P_ICO_2 for flows less than 30 l.min^{-1} when compared with 50 l.min^{-1}. Using a regression of $\log_{10}P_ICO_2$ against flow, this relationship is highly significant (p = 0.0007), and most of the variability in P_ICO_2 is accounted for by varying flow (r^2 = 0.87). P_ICO_2 values were never zero, even at 50 l.min^{-1} (mean 5.9 mmHg, 95% CI 5.5–6.4) (Figure 3).

At most flows, P_ICO_2 increased significantly with increasing BMI. For example, at 30 l.min^{-1} there was a significant relationship by linear regression (p = 0.002), with changes in BMI accounting for 40% of the variability in P_ICO_2

Figure 3. Mean P_ICO_2 (mmHg) with 95% CI at different fresh gas flows
***Indicates significantly higher concentration than at 50 l.min^{-1}**

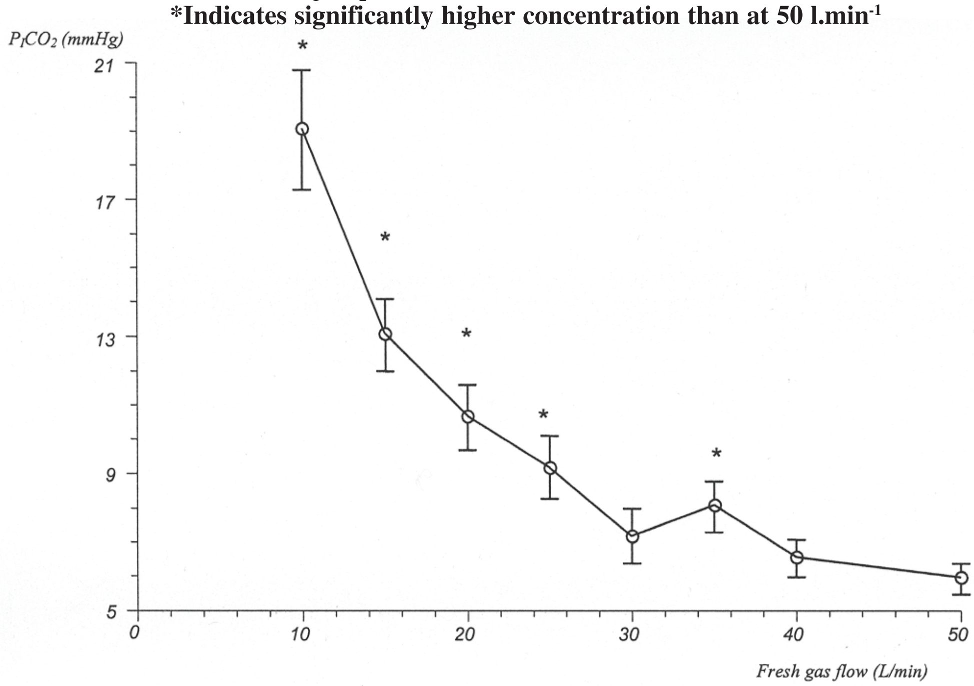
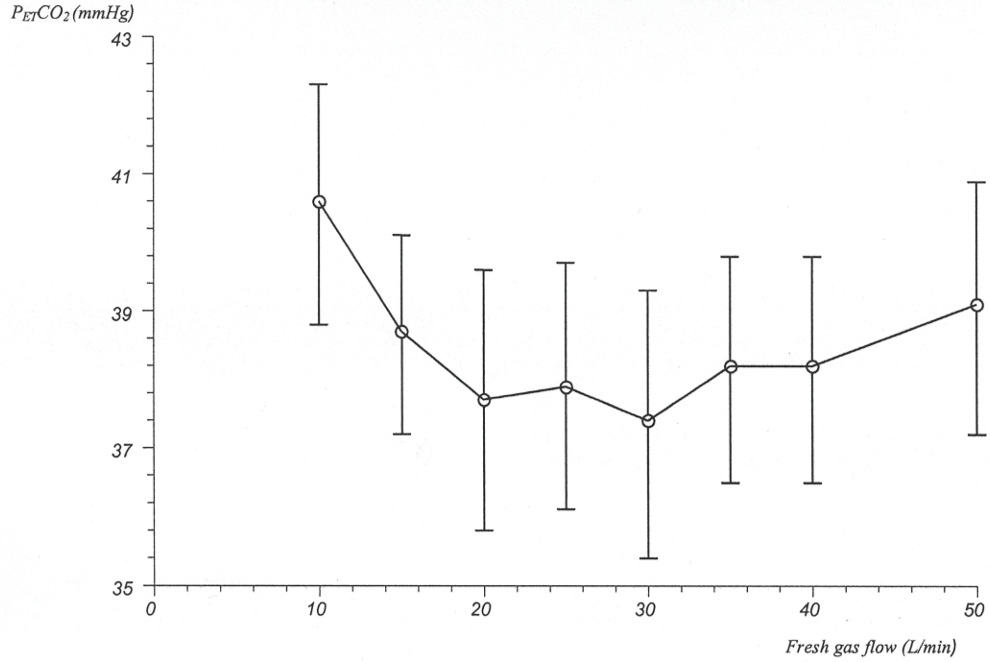


Figure 4. Mean $P_{ET}CO_2$ (mmHg) with 95% CI at different fresh gas flows



($r^2 = 0.4$). Regression suggests that P_ICO_2 will increase by 0.36 mmHg with each unit increase in BMI (P_ICO_2 mmHg = 0.36 x BMI – 1.80).

END-TIDAL CARBON DIOXIDE

$P_{ET}CO_2$ was lowest at a flow of 30 l.min^{-1} (mean 37.4 mmHg, 95% CI 35.4 to 39.3), increasing at both higher and lower flows (Figure 4). ANOVA suggests, however, that there was no significant difference in mean $P_{ET}CO_2$ at any of the flows measured ($F = 1.93$, 6 degrees of freedom, $p = 0.06$).

TEMPERATURE

Temperature measured within the hood increased significantly with reducing flows ($r^2 = 1.0$, $p < 0.0001$). Regression suggests that temperature decreases 0.07 ºC for every litre of oxygen flow (hood temperature ºC = 27.3 – 0.07 x oxygen flow l.min^{-1}). On examination of the corrected multiple comparisons, there were significant differences in hood temperature between low flows and 50 l.min^{-1}, but no further differences on comparison of flows of 20 l.min^{-1} or greater with 50 l.min^{-1} (Figure 5).

Figure 5. Mean temperature within hood (ºC) with 95% CI at different fresh gas flows

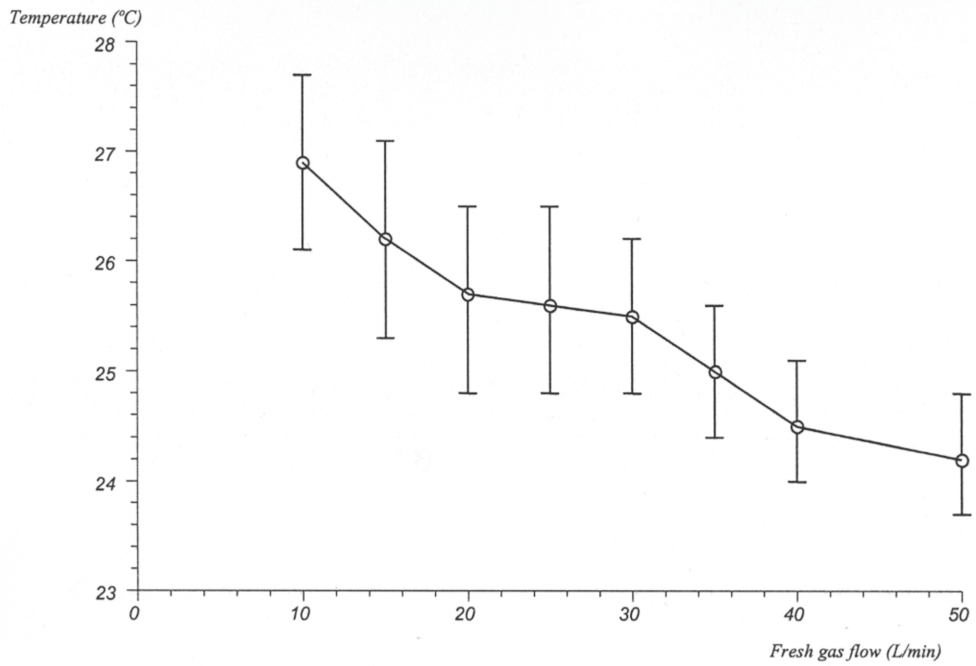
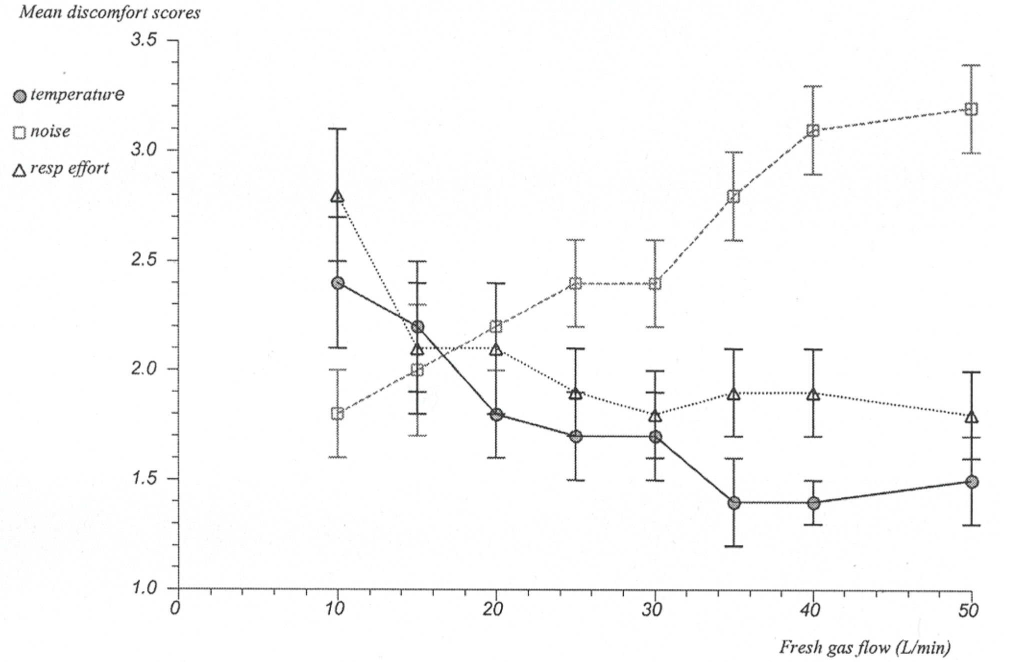


Figure 6. Patient discomfort values (with standard error) for noise, temperature and respiratory effort at different fresh gas flows



PATIENT DISCOMFORT VALUES

Over the range of oxygen flows there were no statistically significant differences in patient discomfort values for noise ($p = 0.11$), temperature ($p = 0.23$), or respiratory effort ($p = 0.48$). However, mean patient discomfort scores for noise correlated positively with oxygen flow ($p < 0.0001$), and scores for temperature and respiratory effort correlated negatively with oxygen flow ($p = 0.0002$ and $p = 0.002$ respectively) (Figure 6).

STEADY STATE

In this study, there was a statistically significant difference in the mean values for oxygen fraction at one minute compared with all other times at a flow of 20 $l.min^{-1}$. There were no significant differences in the mean values for oxygen fraction at any other times or at other flows (Figure 7). There were no significant differences in the mean values for P_ICO_2 at any of the flows tested over the ten-minute period (Figure 8).

Figure 7. Mean F_IO_2 (%) over time at different fresh gas flows

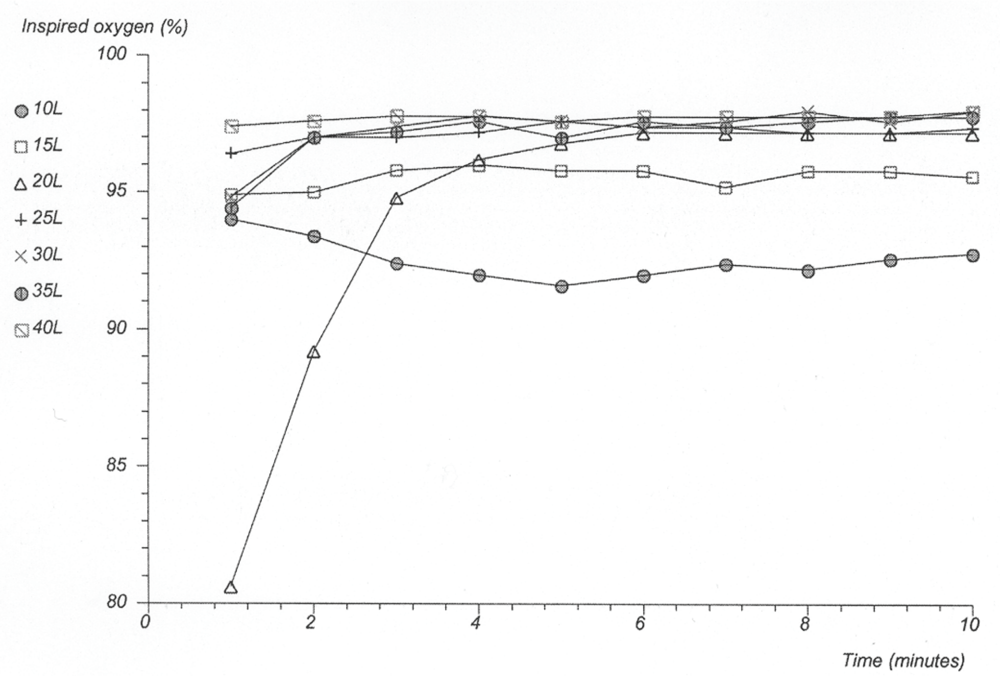
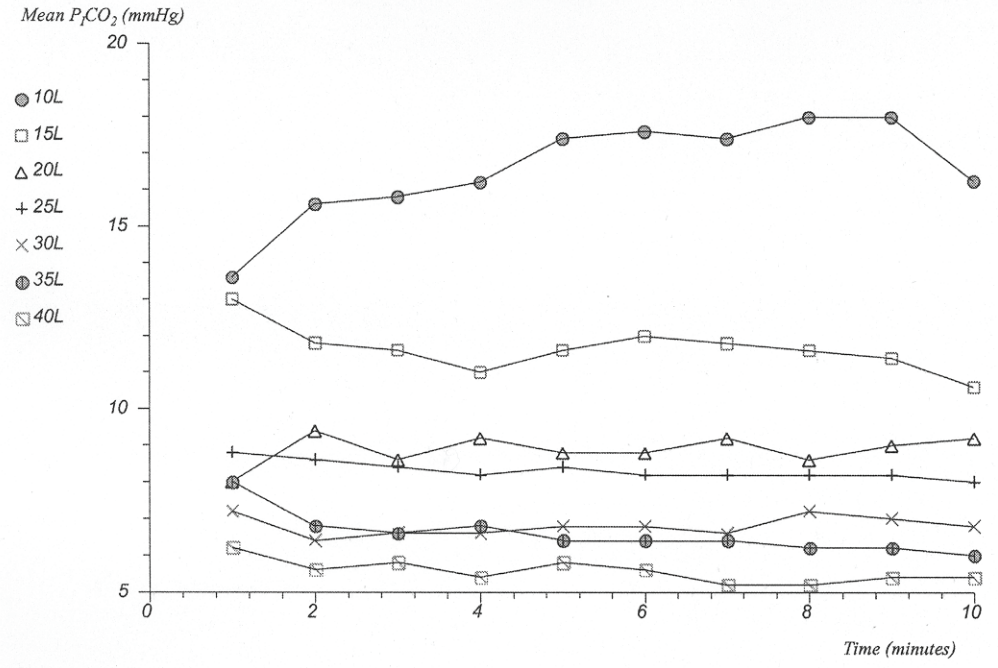


Figure 8. Mean P_ICO_2 (mmHg) over time at different fresh gas flows



Discussion

The respiratory equipment tested in this study is designed to deliver high concentrations of oxygen at elevated ambient pressure while avoiding hypercapnia. The primary purpose of this study was to test the ability of the Amron™ hood to achieve these aims at flows acceptable to patients. The manufacturers recommend oxygen flows of 25–50 $l.min^{-1}$, and although the operating procedures manual states that "*flow rates will vary with chamber, delivery system, patient tidal volume and breathing rate*",[1] this represents a wide range of possible values. A gas flow of 50 $l.min^{-1}$ at sea level (101 kPa) equates to 120 $l.min^{-1}$ at 242 kPa (14 metres of sea water), a pressure commonly employed in hyperbaric oxygen therapy. Over 90 minutes of treatment time this may considerably contribute to an institution's total consumption of medical oxygen.

Our study confirms our clinical impression that a fresh oxygen flow of 30 $l.min^{-1}$ into the Amron™ hood provides adequate inspired oxygen concentration, with minimal accumulation and rebreathing of carbon dioxide. In addition, temperatures and noise levels within the hood are maintained at reasonably comfortable levels.

A previous study found $F_IO_2 > 0.9$ in all subjects to whom oxygen was delivered via hood, as compared with oxygen delivered via oral-nasal masks.[2] Our study has confirmed this finding, with no values lower than 90% recorded at any flow, and no clinically important difference in inspired oxygen concentration for flows above 25 $l.min^{-1}$. Inspection of graphical data suggests little clinically significant difference in inspired oxygen concentration at any of the flows employed, as compared with 50 $l.min^{-1}$.

While there is a significant correlation between oxygen flow and inspired carbon dioxide concentration, at flows less than 30 $l.min^{-1}$ there is little clinically significant difference in P_ICO_2. None of our experimental conditions achieved a P_ICO_2 of zero. This finding accords with similar investigations in other clinical scenarios. For example, carbon dioxide levels have been shown to increase significantly under surgical drapes throughout the duration of ophthalmological surgery, with or without insufflation of oxygen and suction to remove carbon dioxide.[3,4] It remains to be determined what concentration of inspired carbon dioxide may be considered acceptable. One author suggests a concentration of 10 mmHg, although it is accepted that a significantly increased minute volume is required to maintain normocarbia with this level of inspired carbon dioxide.[5]

In our group of healthy subjects, increased inspired partial pressure of carbon dioxide was not associated with significantly increased end tidal (and presumably arterial) carbon dioxide tension. While these individuals were able to regulate their ventilation to maintain normocarbia, it cannot be assumed that patients with impaired respiratory reserve or at risk of carbon dioxide retention would be able to compensate.

Temperatures measured in the hood increased with reducing flows in our study and achieved a steady state after five minutes at each step. Given that HBOT treatment times are usually 90–120 minutes, however, we cannot confidently assert that temperatures will remain acceptable over a full treatment period at low flows. In clinical practice at our facility, patients rarely complain of feeling hot during treatment with an oxygen flow of 30 $l.min^{-1}$.

Inspection of Figure 6 suggests there is a point of compromise between noise, temperature and respiratory effort at an oxygen flow of approximately 15 l.min^{-1}. At flows of less than 15 l.min^{-1}, discomfort scores for temperature and respiratory effort increased rapidly. At a flow of 10 l.min^{-1}, subjects reported significant discomfort. At flows of 40 or 50 l.min^{-1}, however, subjects were disturbed by the levels of noise. Some subjects reported that enduring such levels of noise throughout a treatment period of 90 minutes could become distressing.

We recognise our study has two potential methodological flaws. Firstly, it was conducted at an ambient pressure of 101 kPa (sea level) rather than at a treatment pressure. This was primarily because of our inability to monitor gas concentrations in the chamber at pressure. We believe, however, that the relationships between flows and gas concentrations are unlikely to change at the modest hyperbaric pressures used therapeutically. Further investigation to confirm this assumption should be undertaken, and we plan to do this when suitable equipment is available to us.

Secondly, we measured outcomes following a step-wise reduction in flow, rather than randomly altering flow, on the assumption that values after five minutes at each flow would not be influenced by the previous flow setting. The finding that steady state was achieved after one minute when flows were randomly varied suggests this is a valid assumption. Given that rates of oxygen consumption and carbon dioxide production should not be significantly different under hyperbaric conditions, it is probably reasonable to extrapolate these results for application to clinical usage.

In conclusion, we recommend that an oxygen flow of 30 l.min^{-1} into the Amron™ Oxygen Treatment Hood is appropriate and can be expected to provide acceptable oxygen delivery and carbon dioxide elimination while providing reasonable patient comfort. Further studies are required to determine whether flows should be adjusted for individuals at risk of retaining carbon dioxide.

Acknowledgement

The authors wish to acknowledge the assistance of the staff of the POWH Department of Diving and Hyperbaric Medicine in the execution of this work.

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Erratum

In the editorial by Dr Carl Edmonds on diving and inner ear damage (*SPUMS J*. 2004; 34: 2-4.) the meaning of the fourth paragraph, left-hand column, on page 3 regarding the treatment of inner ear barotrauma (IEBt) was substantially changed by a typographical error. The term MEBt (middle ear barotrauma) appeared in the first sentence rather than IEBt. The first sentence of that paragraph should read:

“*The pathophysiology guides the treatment of IEBt.*”

The advice given in that paragraph does *not* pertain to MEBt. Dr Edmonds hopes that no one ever quotes this as treatment for MEBt. The Editor apologises for this error.

SPUMS Annual Scientific Meeting 2003

Risk, perception and sport – the doctor as policeman?

Michael H Bennett

Key words
Risk, safety, medicals - diving, fitness to dive, review article

Abstract

(Bennett MH. Risk, perception and sport – the doctor as policeman? *SPUMS J*. 2004; 34: 75-80.)
Introduction: The pre-diving medical examination might be approached from the point of view of a barrier to be policed, or a risk assessment exercise. Whilst the examiner as policeman is the model that has been popular in the past, many diving physicians no longer feel this is an appropriate role.
Review: This article explores the concepts of risk assessment in the context of the diving medical examination. While risk is a fixed value and potentially quantifiable, risk perception is both personal and variable. Risk may be communicated using relative risk, absolute risk, numbers needed to harm or probability. Which presentation of risk is appropriate will vary with circumstance. Using an inappropriate measure may result in miscommunication and an inappropriate response. The theoretical models of risk homeostasis and cognitive mapping are discussed in relation to scuba activity, and the influence of safety measures on actual risk are explored.
Conclusion: Risk perception and actual risk are often difficult to reconcile. Individuals are likely to assess risk in remarkably different ways, and it is very difficult to ensure risk is communicated in both a truthful and meaningful way. For any medical assessment that requires risk communication (and this certainly includes a pre-dive medical), great care must be taken. Whilst the role of the medical examiner as policeman removes the need to communicate risk accurately, this may no longer be appropriate.

Introduction

Diving, whatever form it may take, carries risk to health. Some of these risks are appreciated through 'common sense' (you can't breathe underwater), while others are more obscure and require specific education and/or training to appreciate (decompression illness). The aim of this paper is to introduce some general concepts concerning risk and risk perception, particularly in relation to the physician as part of the risk assessment process in sports activity. This paper was presented at the opening of the SPUMS ASM in 2003. That meeting was concerned specifically with the role of the physician in the risk assessment of sports divers.

Risk and risk perception are large fields of investigation. The following is nothing more than a brief introduction to what is becoming a complex area. Interested readers are referred to two of a number of good general summaries of the field.[1,2]

Specifically, the aims are to put the concepts of risk assessment in the context of the diving medical examination, define precisely what is meant by 'risk' and 'risk perception', discuss the concept of relative risk perception in the context of sporting activity and to explore how these concepts apply to recreational scuba diving. Finally, the question central to the 2003 ASM will be introduced. What is the role for the physician in this context? Are we acting as policeman or risk assessor during a routine 'fitness to dive' medical?

Risk

The term 'risk' derives from the Latin *'riskare'* meaning to navigate around a rock or cliff. The link with the sea is quite apt for our purposes. In English, 'risk' has been defined by the Royal Society as "*the chance (probability) of the occurrence of a particular adverse event or hazard*".[3]

Thus, for most purposes at least, risk can be defined as the subgroup of possible events that would be perceived as adverse. We can express risk quantitatively in a number of equivalent forms, as probabilities with values between 0 (no risk) and 1 (certainty of event), percentages between 0% (no risk) and 100% (certainty) or frequencies (10 times out of 100). Much of medical statistics in both epidemiology and clinical research is designed to produce estimates of risk values, and a full appreciation of risk theory is not possible without some understanding of both probability theory and statistical analysis. Indeed, proponents of the evidence-based paradigm for the practice of medicine would suggest that rational medical practice is not possible in the absence of such an understanding.[4]

In practice, such concepts are not difficult to master, and the interested reader is referred to the excellent publication by Sackett and colleagues.[5]

Risk perception

The perception of risk is a rather different and inexact concept. Risk perception may be formally defined as the subjective assessment of risk, and perceptions will vary between individuals and even in the same individual over time. Risk perception is therefore both personal and variable.[6] Not surprisingly perhaps, the perception of risk is poorly correlated with actual risk, and highly dependent on the way in which information is presented to the individual. Risk perception is not logical. It is very difficult for the human mind to accept that, after a run of six consecutive red numbers on a roulette wheel, the chance of a further red number is no different than the chance of the first. We all instinctively feel that a black number is 'due'.

A few examples may serve to illustrate these concepts. During 2003, a rogue sniper was infamously active in the Washington DC area. Several individuals were shot whilst in public places such as petrol stations and shopping mall car parks. There was understandably widespread concern for the safety of residents, and many individuals were reported as driving long distances to avoid exposure in such places in the Washington area. One author calculated that during this time there was a 1 in 517,422 chance ($p = 0.00002$) of being shot by the sniper, while the risk of death through a motor vehicle crash over the average extra miles travelled was likely to be appreciably higher.[7]

In Sydney, over approximately the last three years, there have been plans promulgated to site Australia's next nuclear facility at the same site as our present facility, in the southern Sydney suburb of Lucas Heights. Apart from any other potential concerns about the wisdom of this plan, numerous local residents are opposed to it on the basis of what is calculated to be a negligible increase in the risk of cancer from environmental radiation. A number of these residents are smokers. Their risk of cancer is many orders of magnitude greater than that due to any possible environmental exposure from the facility proposed. Rather than their residential address, they should be concerned with their personal habits, but their perception of the relative risk is very different.

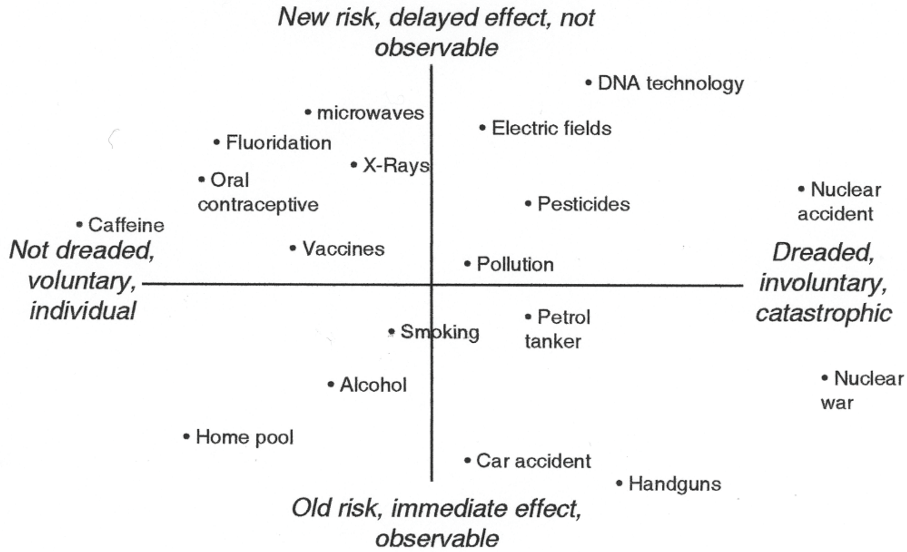
Finally, in the USA during the early 1980s, a rash of teenage suicides was reported that seemed to be associated with playing the interactive fantasy game 'Dungeons and Dragons'. In total, 131 players were claimed to have committed suicide over this period and there were wild theories expounded concerning the sinister nature of this hobby activity. One author went so far as to suggest,

> *"[Dungeons and Dragons] is essentially a feeding program for occultism and witchcraft. For Christians, the first scriptural problem is the fact that Dungeons and Dragons violates the commandment of I Ths. 5:22 "Abstain from all appearance of evil." Much of the trappings, art, figurines, and writing within D&D certainly appears evil - to say the least of it."* [8]

Parents were urged to keep their children away from the dangerous influence of known players, or they would be at grave risk of succumbing to subliminal messages urging them to take their own lives. In fact, one author has calculated that at this time, there were approximately 4,000,000 teenage players active worldwide. With an overall teenage suicide rate an unacceptable 1 in 10,000 teenagers each year, one might have expected to see 400 suicides in this group. The number of players who died (131) seemed more likely to suggest a protective effect of playing rather than a risk.[9]

Risk perception has little to do with rational interpretation

Figure 1. A cognitive map of some perceived risks[11]



of true risk and a lot to do with our view of the world, with our suspicion of those elements of science and society with which we are unfamiliar.

A number of schemes have been advanced to help us understand the way we all appreciate risk. Adams points out that we can divide risk into three categories – direct, practical risk, e.g., drowning; scientific risk, e.g., the risk of suffering DCI; and virtual, as yet unquantifiable risk, e.g., the chance of suffering a cerebral arterial gas embolism when diving following a past history of insertion of a chest drain.[10] Examining which type of risk we are dealing with may improve our ability to correctly interpret any perception we have.

Cutter has described a cognitive-mapping approach to help interpretation of relative risk perception by society.[1] Through a questionnaire sampling process, she has described a scheme for representing relative risk across four different categories (Figure 1). The further a particular risk is placed from the centre of the cross, the greater the risk. She suggests such a scheme may assist in deciding which risks most require addressing at any moment in time.

In the example given in Figure 1, the well-known risks associated with smoking have been judged as substantially less 'risky' than a home pool, or even water fluoridation. While it is not clear how useful such a construct will prove, it does at least give some insight into the particular risk perception of the individuals responding. It might be instructive for such a cognitive map of potential risks to be constructed among a sample of divers questioned about a variety of diving-associated risks. Such a map could conceivably be of use when planning a dive safety intervention.

Communication of risk in medical statistics

There are four common ways in which risk is communicated in medical scientific reports: relative risk (RR), absolute risk (AR), numbers needed to harm (NNH) and probability values (p). Each has value in communicating true risk of a particular outcome, good or bad, but can adversely affect the reader's perception of the true risk if not presented clearly. The consequences of the 1995 report of the UK Committee on Safety in Medicines illustrate the potential dangers.[12]

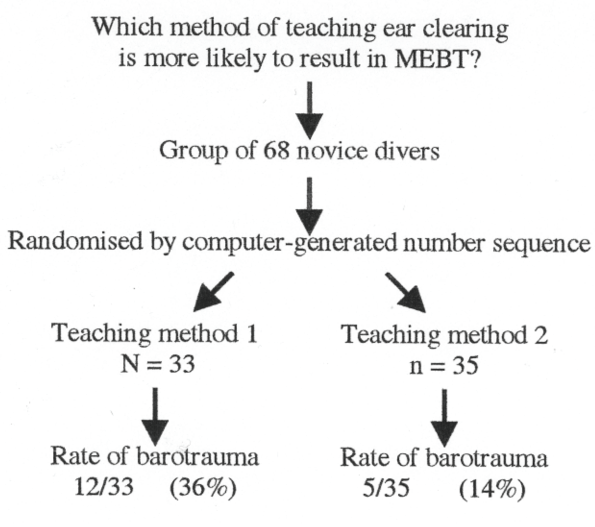
The Committee reported, accurately, that there was a 100% RR increase of significant thromboembolic disease associated with the use of the 3rd generation oral contraceptive, as compared to the 2nd generation.[13] Following a flurry of concern, many women abandoned the preparation, resulting in an estimated 8,000 extra abortions in the UK, and an unknown number of unwanted pregnancies. The AR increase was from 3 to 6 deep vein thromboses for each 1,000,000 users per year, equivalent to a NNH with the new preparation of 333,333 before one additional clot was caused. It is highly unlikely that more harm could be caused by continuing the use of the oral contraceptive pill than was caused by ceasing it. In this case, poor but accurate risk communication probably harmed the community.[12]

Consider the example in Figure 2. Let us construct a thought experiment whereby we test the hypothesis that different methods of teaching ear-clearing techniques to novice divers result in different risks of middle ear barotrauma (MEBt). We gather a sample of novice divers and randomise them to one of two methods, then measure the proportion that display MEBt.

There is a different risk of MEBt depending upon the method of ear clearing to which the individual is randomised. We might variously describe the lower risk associated with method 2 as a *relative* risk reduction of 39%, an *absolute* risk reduction of 22%, or that we would need to train five novices to avoid one episode of barotrauma (100/22). Whether this difference is important *in practice* is a matter for interpretation – let us agree for the sake of this presentation that it is. If we were selling method 2 it is likely we would prefer to use the RR reduction, and this is common practice in drug company advertising. A more rational approach might be to consider the costs of methods 1 and 2 and the severity of the outcome, before interpreting the fact that we would need to train five students to avoid one single case of MEBt.

Whether or not this difference is statistically important, otherwise known as 'significant', is similarly open to interpretation. In the example here, the risk this difference is due to random chance using a Chi-squared test for significance is 1 in 14, or 7% (p = 0.07). In general, we have abrogated our responsibility to make this latter

Figure 2.
A thought experiment concerned with the incidence of middle ear barotrauma (MEBt) associated with two different methods of teaching ear-clearing techniques



interpretation by almost universally accepting that a chance of less that 1 in 20 is 'statistically significant'– that is, when $p < 0.05$. By that convention, therefore, this experiment shows a non-significant reduction in the risk of MEBt when using teaching method 2.

This finding could be communicated to a dive training organisation, or a single prospective diver in a number of ways from: 'there is no significant difference in the chance of MEBt between the two methods' to 'there is about 40% less chance of having MEBt with method 2'. How the risk is perceived and communicated by people like dive medical examiners is likely to influence decisions profoundly, and for this reason we need to understand risk assessment and understand how to communicate it to both our patients and commercial clients.

Whenever presenting risk assessments, it is always best to be clear and unambiguous. It is useful to recall that in 1990, when asked about the wisdom of eating British beef, Sir Kenneth Calman, the Chief Medical Officer of the UK replied "*Beef is absolutely safe to eat*". By 1996, he was moved to add "*The term safe did not mean there was no risk*".[14]

Risk, benefit and homeostasis

Consider a man driving along a slippery, wet road in the pre-dawn gloom. These are challenging driving conditions and we might expect the driver would proceed with caution. The curve approaching is sharp and taking this turn at speed would be associated with some risk of a crash. Being both a reasonable man and an experienced driver, our subject is naturally inclined to take it slowly and reduce this risk as far as possible. There are many reasons to do so, apart from the fear of injury. Such an accident might injure others, e.g., pedestrians, or perhaps he has a baby on board, and will prove costly for repairs.

Nevertheless, there may be competing benefits attached to taking the curve more rapidly – he may be trying to get to an important appointment on time, want to impress his beautiful female passenger, or perhaps the sheer enjoyment of driving 'on the edge' is benefit enough. Our actions, including therapeutic decisions, are always driven by the attempt to balance risks and benefits to maximise utility.[10]

Substantially reducing the risk of all our actions across the spectrum of human activity would make for a world most would find intolerably restricting. It is unlikely any of us would be permitted to scuba dive. Evans has suggested, somewhat frivolously, that

> "*All drivers I have questioned admit that they would drive more carefully if their vehicles contained high explosives set to detonate on impact; dramatically increasing the harm from a minor crash can clearly reduce the probability of a minor crash*".[15]

Even this type of drastic constraint may not achieve the desired result, however. The principle of risk homeostasis, also referred to as 'risk compensation' or 'offsetting behaviour', suggests that most of us tend to react to safety measures by decreasing the safety of our behaviour in order to return the overall level of risk to much the same level that existed prior to the safety measure. Under this theory, we each drive to our own personal level of risk, and adjust our actual behaviour according to our perception of the risk during a particular journey.[10, 16,17]

There is some evidence for this principle in action. The death rate from motor vehicle crash (MVC) leading to head injury is the same in the USA today as it was in 1926. While the distance travelled by car per person each year has increased by a factor of 10, so has the distance needed to travel for each such fatal crash.[17] Figure 3 illustrates the risk of serious injury from road traffic crashes following the 1967 decision to change the side on which Swedes drive.[17] Prior to the change there was a 'baseline' risk. Following this radical change in the road rules, drivers perceived an increased risk and modified their driving behaviour. This actually reduced the risk of injury for the two years following the change. Gradually, however, drivers perceived the reduction in risk, further modified their driving behaviour and returned the risk to the original baseline level. Risk homeostasis was restored. Similar examples have been the introduction of compulsory seat belts in the UK and bicycle helmets in Victoria.[18]

Opponents of risk homeostasis theory suggest it is nothing more than an excuse to do nothing about safety, and the theory has been strongly criticised at several levels.[19] It is suggested that individuals are notoriously bad at risk assessment, that poor outcomes (e.g., crashes) are not sufficiently frequent occurrences for the individual to make an accurate risk assessment, and that there is very little supportive research with reliable methodology. Certainly, there are a number of studies that suggest long-lasting changes in risk on introduction of similar safety measures.[20, 21] The debate rages on.

If, however, risk homeostasis is operating in a particular environment, the question arises as to how we might re-set

Figure 3.
Risk homeostasis. The risk of serious injury on Swedish roads following the decision to change the side on which people were obliged to drive. The risk of serious injury reduced, then returned to pre-change baseline after two years (adapted from ref 17)

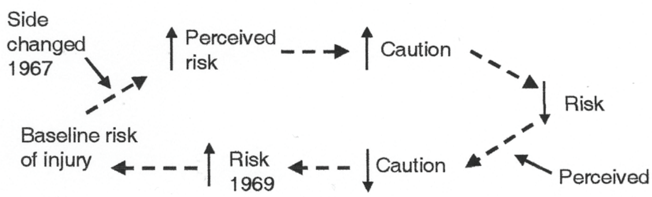


Table 1.
Injury rates for various sports. Number of injuries for each 100 player events and percent serious injury

Rugby football[23]	10.6	
Snowboarding[24]	4.0	(56%)
Soccer[25,26]	2.1	(1%)
American football[27]	1.4	(15%)
Skiing[24]	1.0	
Scuba[28]	0.01/100 tank fills	

the homeostatic mechanism in order to achieve a desired goal. The traditional approach is to punish unsafe behaviour (via the police) but some authors suggest it may be more productive to reward safe behaviour instead. The experience recently in California of offering free licence renewals to those with 'clean' licences has been associated with a 58% reduction in MVCs in the first two years.[17] Similar results have been reported from Norway and Sweden.

Risk and scuba diving

In 1997 Pedersen reported on the risk perception of a group of 444 men and women in relation to a number of potentially risky activities.[22] Interestingly for a diving readership, this group rated snow skiing as the least risky activity, followed by scuba diving, bungee jumping, rock climbing, motor cycle racing, hang gliding, cliff jumping and skydiving. Among this group, self-rated likelihood of participation was inversely related to the perceived risk. A short table of reported actual risks of injury is given in Table 1.

Experienced scuba divers would likely agree that, given appropriate instruction and training, this activity is relatively low risk when conducted at modest depth with standard equipment. Many would also accept that among the scuba diving community there are those who have set their 'risk homeostat' at a very high level. Like many activities, the risk lies not only with the nature of the activity, but the behaviour of the individual concerned.

This 'risk seeking' proportion of the population is estimated at between 10 and 20% and their behaviour has been studied in a number of ways.[29] Witte described various strategies to deal with young male drivers who attempted to 'beat' trains across level crossings in mid-west USA. She described a dysfunctional response to the threat appraisal of this activity. When an individual is requested to ask themself the questions "Is being hit by a train serious?" and "Am I likely to be hit by a train?", a typical reported response was likely to be "Being hit by a train is serious, but I can avoid the possibility by obeying the rules". For the high-risk group, the response was typically "Being hit by a train is serious, but I can beat the train because I am a great driver and have fast reflexes". Every successful crossing is a positive reinforcement of this view and further amplifies this behaviour until the almost inevitable, fatal crash.

Experienced scuba divers can probably relate these findings to a number of divers they know. Many factors have been suggested in the clinical literature to increase the risk of scuba misadventure, and it is not the purpose of this article to discuss these factors. It is interesting to note, however, what the insurance industry feels about risk and diving.

> *"The host factors that represent most risk…are poor fitness, overweight, chronic diseases, structural abnormalities of the heart and lungs and risk factors for CAD* (coronary arterial disease)*...These plus inexperience, irresponsible behavior or technical diving should alert the underwriter (to) excess risk for fatal accidents."*[30]

Conclusions

Risk perception and actual risk are often difficult to reconcile. Individuals are likely to assess risk in remarkably different ways, and it is very difficult to ensure risk is communicated in both a truthful and meaningful way.

For any medical assessment that requires risk communication, and this certainly includes a pre-dive medical, great care must be taken. The process of risk communication may be summarised in a way analogous to the practice of any evidence-based medicine as summarised in Table 2.

The role of the medical examiner as policeman removes the need to communicate risk accurately, but the easiest ways are not always the most useful.[31] To quote Adams:

> "*Attempts to criminalise self-risk are likely to be worse than useless; they are likely to redistribute the burden of risk in ways that harm innocent third parties*".[10]

Table 2.
Comparing the characteristics of good risk communication with good evidence-based medicine (EBM)

Communicating risk	Practice of EBM
Ensure both parties agree on exposure and absolute measures	Explicit questioning and use of ARR and NNH
Indicate uncertainty	Confidence limits
Give risks of alternatives	Explicit comparators
Consider all relevant outcomes	Explicit clinical outcomes
Who benefits and who pays in the event of injury or death	Cost utility, benefit and effectiveness

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Assessing and managing risk in United Kingdom scientific diving at work operations

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Key words
Risk assessment, risk management, scientific diving, diving at work

Abstract

(Sayer M. Assessing and managing risk in United Kingdom scientific diving at work operations. *SPUMS J*. 2004; 34: 81-8.)
In 1998 the United Kingdom (UK) Health and Safety Executive replaced a very prescriptive set of diving-at-work regulations with one that set minimum standards augmented through a series of risk-assessment procedures. These assessments match the potential severity of outcome resulting from a particular hazard against its likely occurrence in order to give a quantitative rating of risk. This account reviews methods of assessing risk within diving operations and discusses ways of implementing those assessments to either modify or inform diving operations as a consequence. It also details some of the generic risks assessed with the use of scuba and examines how the process of risk assessment in general is translated into effective methods for planning and executing diving operations. With a significant proportion of UK scientific diving projects being undertaken around the world, many of the aspects related to their planning will be common to operations undertaken by other diving sectors and nationalities.

Introduction

Until the early 1980s, diving at work in the United Kingdom (UK) was largely unregulated, but instead was undertaken in association with a series of industry sector codes.[1, 2] The introduction of the 1981 Diving Operations at Work Regulations (DOWR 1981) as a statutory instrument of the 1974 Health and Safety at Work etc., Act (HSW 1974) was largely a consequence of high fatality levels in the offshore sector dominated by diving operations associated with oil exploration and exploitation in the North Sea.[3] DOWR 1981 was put in place through the UK Health and Safety Commission (HSC) and implemented through its Health and Safety Executive (HSE).

Because of their origins DOWR 1981 were largely targeted at the offshore sector and were necessarily prescriptive. However, the regulations were in place to cover all diving operations at work in the UK and the prescribed approach to offshore diving operations did not always fit easily with other industry sectors. Two revisions to DOWR 1981 were made in 1985 and 1992, but for significant numbers of diving contractors, specifically journalists, scientists, archaeologists and recreational instructors diving at work, operations could only continue through the issue of exemption certificates by the HSE.

In the mid-1990s the HSE recognised that, although there could be generic regulations in place to control diving operations, there were large differences in approach and the needs of various sectors within the diving-at-work industry. Therefore, the HSE set about creating a framework under which there would be a set of generic regulations for implementing diving operations at work in the UK, complemented by sector-specific codes of practice. The codes of practice were written jointly by the HSE with bodies or groups that were representative of the respective sectors. Once accepted by the HSE these became the Approved Codes of Practice (ACoPs) for each sector.

There were five ACoPs recognised representing the Offshore, Inshore, Scientific and archaeological, Recreational and Media sectors. These codes were all much less prescriptive than the DOWR 1981 in a way that set minimum standards for each sector, and were largely self-regulated through processes of risk assessment and risk management.

Following extensive consultation the new HSE Diving at Work Regulations were formally accepted as a statutory instrument of the HSW 1974 Act in November 1997, and came into force in April 1998. The regulations were statutory instrument No. 2776 of the HSW 1974 Act and, although they came into force in 1998, are known by their 1997 acceptance date and are identified as the HSE Diving at Work Regulations 1997 (DWR 1997).[4]

The DWR 1997 are effectively goal-setting regulations. They set out, in generic terms, the roles of the diving client, the diving contractor, the diving supervisor and the diver. They outline the minimum qualification and medical requirements for a person to dive at work and describe minimum dive team numbers for specific types of diving operation. Because of their generic nature, the regulations do not give detailed or specific guidelines for how a particular operation should be conducted in practical terms and state specifically that minimum standards are unlikely to be acceptable for most diving operations. However, there are specific requirements to produce and maintain written records of the appointment of the diving supervisor, a diving project plan and a diving operation record. Specific reference is also made to the diving project plans and operation records being based on a system of risk assessment.[4]

It is the requirement to assess the risks associated with the overall diving project, the site at which the operation is to take place and the tasks within each operation that presents a framework for planning the diving operations through a system of risk management. This ensures that operations that attract a higher than accepted level of risk either do not go ahead or attract additional safeguards.

The process is also one by which information about the diving operation and the diving team is collated by the diving supervisor and imparted to all members of the diving team, ensuring good communication of the diving operation plan. Because risk assessment works best as a dynamic procedure, the process of risk management allows both on-site adjustment to the assessed risks and a process of continual re-assessment based on information gathered through the diving operation.

The UK scientific and archaeological diving sector differs from most of the other diving industry sectors in that a significant proportion of diving operations are undertaken abroad, outside UK waters. The jurisdiction of the HSE in the UK is only to a limit of 12 nautical miles from the coast, unless the diving project is either launched or operated from a UK ship (Merchant Shipping (Diving Safety) Regulations 2002).[5] Although not tested in law, it has always been assumed that a UK employer has 'duty of care' for their employees irrespective of the country in which the work takes place.

With respect to diving operations it could be argued that because an industry standard is in place within the UK, adherence to that standard would be the minimum requirement for ensuring 'duty of care'. It is recognised that the nature of overseas operations, and the conditions under which they are undertaken, makes strict compliance difficult. However, employment of the minimum standards where reasonably practicable would probably be viewed as a realistic provision of 'duty of care'.

Where conditions vary considerably from those normally encountered, the principles of risk assessment and risk management allow diving operations to be planned and executed in line with industry standards without the requirement to produce new forms of operational guidance. This account reviews some approaches to undertaking risk assessment and risk management procedures within the context of the scientific and archaeological diving-at-work sector. In doing so, it discusses methods by which diving operations can be planned based on risk assessment in ways that make allowance for potentially large-ranging differences in operational conditions.

Risk assessment and approaches to risk management in diving

The principles of assessing and managing risk are influenced by the groups for which the analysis is targeted and the risk concerns of those groups.[6] For example, fully trained and experienced sub-aqua divers, by the very nature of their profession, should have minimal concerns about prolonged submersion below the surface of water with full dependence on the mechanical delivery of breathing gases compared with an untrained office worker. For this type of reason, attempting to compare quantitative assessments of risk has its problems.[7]

Adopting a standardised methodology for assessing risk through the multiplication of the severity of the outcome of a particular hazard against the likelihood of that hazard occurring will, in the case of diving operations, always produce a numerical outcome of medium risk. This is because every diving operation carries the potential outcome of death or serious disease, but the likelihood is usually very low.

However, the very fact that diving at work is a regulated industry in many countries already indicates an acceptance that it is perceived as having a risk higher than baseline attached to it. Management of additional risks has to accommodate the basic approaches to diving at work while assessing the cumulative modifiers to the baseline risk through the environment in which the operation is conducted and the tasks employed.

For a diving industry sector with no recorded fatalities and with a low incidence of significant accidents, it could be argued that the likely most severe outcome expected while diving at work would be a case of neurological decompression illness (DCI) rather than death, even though death remains the theoretical maximum severity of outcome.[8,9] However, subjecting risk assessment to a more realistic axis of outcomes presents a more informed format on which to base risk management. Therefore, by assuming that avoidance of death in work-related self-contained underwater breathing apparatus (scuba) diving is catered for during the basic training, the main targets for risk assessment and management come in the form of reducing the chances of non-life-threatening major or minor injury.

In designing a risk management process, there are scales of factors that make up the diving operation, from those that are well known to those that are less predictable. Most scientific diving is undertaken using scuba. The level of adoption of scuba varies with other diving sectors but, as an example, it is assumed here that scuba is the predominant form of diving. Therefore, the use of scuba as the method of diving is relatively predictable.

The majority of scientific diving involves some form of sampling at a relatively small number of locations, employing relatively few methods. So, although the location and task are more variable in the type of operations undertaken, the likelihood of either the location of the diving operation or the task being repeated a number of times during a year is relatively high. However, changes to either the conditions of the location, e.g., weather, tides, surface traffic, or how the task is affected by those conditions cannot be predicted.

Therefore, the overall risk management process can be divided into four distinct approaches. The first is a generic risk assessment for employing scuba as the standard approach for most diving operations. The assessment is undertaken on a temporal scale determined by the specific operators of the diving operation, although revision on an annual basis in order to accommodate any changes in legislation and/or guidance is recommended. Effectively, this becomes a standard operational procedure.

Secondly, the location of the dive operation is risk assessed separately from the task being employed, with the assumption that the task retains a uniform level of risk (the third assessment) irrespective of the dive location, and likewise with the location risk not being affected by the task. In this way there is no requirement to continually alter the location and task risk assessments when the combination changes.

However, the lack of alteration in risk associated with changes in location and/or task change cannot be assumed in reality. So a fourth level of risk assessment analyses whether the location affects the task risk and *vice versa*, with the addition of any unpredictable variations in factors such as weather, surface traffic and dive-team membership. There is a legal requirement in the DWR 1997 to ensure that on-site, daily risk-assessment changes are noted on the diving operation record.

Generic risk assessment for scuba diving

The generic risk assessment examines the minimum requirements for undertaking a diving operation employing scuba equipment. The example of the risk assessment given below examines ten sections specific to potential risks associated with scuba:

1. Suitability of the individual diver;
    - i. minimum training/certification levels
    - ii. medical certification required
    - iii. day-by-day dive fitness of the individual.
2. Standard of equipment used and performance of that equipment;
    - i. maintenance and service requirements for equipment
    - ii. assessment of all equipment prior to a diving operation by a competent person to ensure that it is suitable, compatible and functional
    - iii. guidelines under which to terminate a diving operation if there are any concerns over equipment performance
    - iv. guidelines on the standards of breathing gases and recommended volumes and rates of supply.
3. Suitable size and make-up of the total dive team;
    - i. minimum dive team for scuba
    - ii. modification required to the basic dive team based on remoteness of location or specific tasks.
4. Standard of overall supervision of the diving operation;
    - i. requirements and duties of the diving supervisor.
5. Methods and suitability of communications over the whole operation;
    - i. suitability of communications between the diving supervisor and the dive team
    - ii. suitability of communications between the diving supervisor and third parties
    - iii. methods of indicating to other water users that a diving operation is underway, and more specific requirements if the diving operation is being undertaken in a port or harbour.
6. Adoption of safe decompression procedures;
    - i. method of calculating decompression
    - ii. any agreed limits or penalties on the chosen method of decompression calculation
    - iii. guidelines on the use of computers for deriving decompression schedules
    - iv. allowances for physical factors such as altitude and temperature.
7. Adoption of an evacuation plan in the event of an emergency;
    - i. provision of an agreed emergency plan for each diving operation
    - ii. standards of medical training and numbers/posts within the dive team that require medical training
    - iii. provision of sufficient oxygen supplies for any diving operation
    - iv. availability and content of a medical supply kit
    - v. availability of and transfer requirements to the recompression chamber nearest to the site of the diving operation.
8. Safety of diver ingress and egress from the water;
    - i. acceptability of the ingress/egress routes
    - ii. guidance on diving from boats.
9. Provision of suitable personal protective equipment;
    - i. types of protective equipment to prevent excessive environmental exposure
    - ii. additional care for areas of potential contamination risk.
10. Assessment of manual handling risks;
    - i. provision of specific manual handling risk assessment for scuba diving.

For each section the risk is identified and the actions taken to minimise the risk are outlined. Each action is qualified through reference to guidance material or, where appropriate, the regulations. In some sections the minimum requirements will be prescribed by regulation, such as minimum levels of basic training, medical requirements and the structure of the dive team. However, it is typical within DWR 1997 to prescribe only minimum requirements thereby placing the responsibility of determining the optimum requirements for the diving operation to be undertaken safely onto the supervisor of that operation. The only method by which the optimum requirements can be identified through a structured approach to dive planning is through the process of risk assessment.

Because of the requirement to maintain the scuba risk assessment as generic to all diving operations, the content is also generic and outlines only the basic principles, guidelines and reference sources for diving at work for that specific institution. In order for specific diving operations to be planned and managed, the assessment of risk needs to be more precise.

Location risk assessment

The location of the diving operation will influence greatly the basic assessment of risk for scuba diving. The HSE approved Code of Practice for scientific and archaeological diving projects[10] defines benign location conditions simply as clear water, no excessive tide or current, no trapping hazard, easy entry and exit from the water, and where the task to be performed is not arduous. There is no more guidance, except that the Code defines the minimum diving team acceptable for benign diving conditions and then states that it would only rarely be acceptable to employ the minimum dive team.

By inference, therefore, it seems likely that diving at work in the UK would rarely be accepted as being undertaken in benign conditions. The accepted method of determining the diving conditions presented by the location of the diving operation is through assessment of the risks and then re-informing of the structure of the dive team based on the overall assessment of risk.

An assessment of risk at a specific location is broken down into the following divisions.

LOCATION

The assessment gives full details of where the diving operation is to be undertaken, making full reference to the ease of travelling to and from the site. Where the location is remote, or travelling times between the site of operation and a ‘safe haven’ are substantial, this will influence how management of the risks associated with the operation is approached, and the make-up and size of the dive team.

TIDAL CONDITIONS

The location is assessed on the likelihood *versus* the severity of outcome of excessive water movements caused by tidal influences. A heavily tidal location will determine the times at which the diving operation can be undertaken in order to minimise risk. Again, the level of risk attached to the location because of tidal influences will determine the methodology of the diving operation as well as the membership of the diving team.

AIR/WATER TEMPERATURES AND WEATHER EXPOSURE

The assessment of risk has to include the conditions for the divers below water as well as the conditions for the divers and the rest of the dive team above water. Obviously, the temperature of the water in which the diver is operating will influence greatly the types of diving equipment used. However, in areas of both mild and extreme climatic change, the risk assessment should consider the additional influences of likely surface conditions and the potential consequences of change. The assessment should also consider the personnel on the surface who may be more likely to be affected. The severity of outcome may increase concomitantly with the remoteness of the location and the duration of transport between the diving location and safe areas.

UNDERWATER HAZARDS

The types of underwater hazard that could influence the risks associated with a diving operation could include underwater entrapment, no clear surface, water visibility, water depth, harmful biological life and pollution. Quantifying likelihood against severity of outcome with underwater hazards can influence greatly how a diving operation is managed.

ACCESS TO THE WATER

A number of considerations need to be made about how divers enter and leave the water. If the diving operation is shore based, there are associated issues of carrying relatively large weights of equipment over unstable or uneven ground. Shore diving also presents problems associated with retrieving divers who may be injured in some way. Diving from boats may allow the support team to be better placed to assist the divers in the water, but how the divers move into and out of the water requires assessment. Risk management associated with access can be further complicated where the route to the subsurface location of the operation site is restricted by surface objects, e.g., ice, fish-farm cages.

SURFACE TRAFFIC

Surface traffic adds to the assessment of safe access for diving operations, but also influences how safe passage to the surface can be conducted in the event of an emergency.

RECOMPRESSION CONSIDERATIONS

At present, DWR 1997 is highly prescriptive in how a diving operation should be planned with respect to emergency recompression:

- For dives with no planned in-water decompression that are less than 10 metres water depth, the legal requirement is to identify the nearest suitable, operational, two-person, two-compartment chamber within six hours' travelling time from the dive site.
- For dives of between 10 and 50 metres water depth with either no planned decompression or up to 20 minutes planned in-water decompression, a suitable two-person, two-compartment chamber should be identified within two hours' travel time.
- Where in-water decompression of greater than 20 minutes is planned, there is a requirement to have a recompression chamber at the site of the operation.

Transport of a diver to a recompression facility within the above time frames is the main factor to be assessed, and will be influenced by the remoteness of the location and the methods of transport available.

On completion of the above sections of the location risk assessment an overall assessment of risk is made. There are a number of outcomes from that assessment. The location may influence the size and members of the dive team. The location may influence how or if the task of the diving operation can be conducted safely. The overall assessment should generate an emergency protocol that states clearly how, in an emergency, the diver would be retrieved, what the on-site treatment would be, how transfer for ongoing treatment would be achieved and what the contact details for the emergency services were.

Task risk assessment

Although there is no specific requirement under DWR 1997 to assess the risk of performing a specific underwater task, it is obvious that the task will influence the overall management of the diving operation. Effectively, a risk assessment for task re-analyses the issues addressed under the risk assessment for location (location, tidal conditions, air/water temperatures and weather exposure, underwater hazards, access to the water, surface traffic, recompression considerations, etc) within the context of how the task to be carried out may alter that initial assessment.

Similar to the location risk assessment, the task assessment will inform the team size and the qualifications and experience of the team's membership. The task assessment should conclude with an overall task protocol that defines the stages within the planning and execution of the task, along with the specific personnel responsible for each stage.

Operational diving risk assessment

A significant problem associated with the process of risk assessment is that it can be viewed by operators as an administrative task rather than a dynamic tool for guiding the management of an operation. Although the DWR 1997 regulations state that every diving operation must be risk assessed, it was never the intention that this would result in numerous, repetitious and largely meaningless risk assessments. Conversely, there were concerns that the use of a single risk assessment to cover a large number of similar diving operations may result in diving supervisors overlooking day- or site-specific differences in the overall assessment.

There is a legal responsibility on the diving supervisor to review all relevant risk assessments prior to the diving operation taking place. This ensures that the person with ultimate responsibility for the safety management of the diving operation is fully aware of the risks associated with the type of diving employed, and the location and task of the operation. By providing summaries of the work to be carried out, any manpower or procedural limitations on the operation, and the protocols to employ in the event of an emergency, the site and task risk assessments provide the diving supervisor with easily accessible information covering the whole diving operation.

The DWR 1997 state that there should be an entry on the diving operation record to confirm that the diving supervisor has read the appropriate risk assessments. In order to allow for any on-site occurrences that may differ from the original risk assessment, there is also a legal requirement for the dive supervisor to note in the diving operation record any differences and how they affected the safety management of the diving operation.

At first, the level of detail required through the risk assessment procedures, coupled with the requirement to maintain the process as dynamic and useable, can appear to be imperious and, to significant sectors of the diving industry, unworkable. However, the diving operations undertaken by the diving-at-work industries tend to be predominantly repetitive either in the tasks employed and/ or in the locations dived. Therefore, by dividing the risk assessments between location and task the diving supervisor can simply construct an overall risk assessment through simple combination complemented by an assessment of any temporal change.

Simply put, if a diving group carried out seven diving tasks at each of ten different diving locations per year, then performing individual task/location risk assessments for all the possible diving operations would generate 70 evaluations. Splitting task from location and then merging the two with the addition of a brief, legally required, on-site assessment, cuts the number of evaluations to be considered from, in this example, 70 down to 17. This approach has support with the HSE, with the proviso that individual risk assessments are time limited and are revised within 12 months.

Discussion

The employment of risk assessment as the central tool for the safety management of diving-at-work operations has been operating in the UK for the past five years. During that period, the employment of risk assessment in numerous health-and-safety-at-work areas has become widespread in the UK, and it is now considered to be the main tool in the management of safety. Although there is provision in the law for revision as to how the DWR 1997 are implemented, it appears to be highly unlikely that any of the diving-at-work industry sectors within the UK will seek any change in the process of risk assessment.

The lack of prescription has permitted some sectors an added degree of flexibility to use a larger variety of diving techniques and equipment. However, the use of risk assessment, whereas presenting numerous alternatives to how a diving operation may be carried out, has increased the responsibility of those in charge of the diving operations to provide supporting qualification for the methods and approaches employed within any one diving operation.

There are many approaches to risk assessment employed in numerous different industries.[7, 11-16] The DWR 1997 do not specifically outline how risk assessment should be approached. Compared with other industries, where risk to an individual's health can be directly correlated with dose-response criteria[17], there remains debate within the diving industry as to whether risk assessment in diving can ever be much more than largely qualitative. This notwithstanding, risk analysis does provide a method for active management of a large range of diving operations, some of which may fall outside any prescriptive legislation, while permitting change on localised or time-specific scales.

If employed properly, the record of the initial analyses, in addition to any changes, provides the diving supervisor with guidance on the methods of carrying out the diving operation, in addition to any actions to be employed in the event of an incident. The maintenance of the risk assessments in association with the daily operation records provides an auditable tool for internal, top-down management as well as aiding external investigation of any incidents.

When first introduced, the process of risk assessment for diving operations appeared to be an unnecessary paper exercise in stating the obvious. However, when approached constructively by the whole diving team, the risk assessments build into a dynamic form of outlining company policy and procedures, in addition to giving the supervisor and the divers clear, written guidance as to how the diving operation is to be completed.

As stated above, this approach to the safety management of diving operations is a legal requirement only for diving groups defined as 'at work' and for that work to be carried out within 12 miles of the UK coastline. Many UK scientific diving operations occur outside this limit in addition to the hundreds of thousands of recreational dives that occur on an annual basis worldwide. The obvious question is whether or not a legal requirement for at-work divers has any relevance to working dives abroad or the leisure diving industry.

WORKING ABROAD

The question of scientific divers from the UK working abroad has always presented the employers of those divers with a fairly basic choice. The first option is to effectively dismiss the relevance of UK legislation for diving operations not enforced by the UK HSE and to allow the scientists to adopt their own practices. The vast majority of UK scientific diving occurs within the 10–29 m depth range, is based on recreational qualifications and techniques, and is carried out predominantly using equipment intended primarily for use by the recreational sector.[9]

There will, therefore, be an element of the at-work sector who will simply adopt diving practices based on recreational approaches. There are notable exceptions to this. The employees of the UK Natural Environment Research Council, which include those of the British Antarctic Survey, have a policy of adhering to UK regulations for all diving operations worldwide where it is reasonably practical. The main reason for this is that the UK regulations are considered to be an accepted industry standard.

The UK employer of those who are employed and paid in the UK will have a duty of care to ensure that those employees are working to health and safety standards that adhere to an industry standard. Therefore, it could be argued that, by dismissing the relevance of UK legislation to an employee working abroad, the employer is open to litigation through their dereliction of duty of care.

Because the HSE regulations do not have legal status outside UK territorial waters, the HSE themselves cannot prosecute the employer. Any prosecution would have to be a civil action most probably brought by the diver themselves or the family of that diver. Until such a civil action is brought, a clear legal definition of the limits of duty of care as they relate to diving-at-work operations abroad remains lacking.

RECREATIONAL DIVING

The application of risk management and risk assessment in the recreational sector is likely to depend on the level of organisation related to that diving operation. Theoretically, the application could be considered at three levels. Firstly, at the purest form of recreational diving where the divers entering the water are doing so under their own control, any assessment of risk is likely to be in the form of the application of common sense based on the divers' own knowledge of their own abilities. It is highly unlikely that any written assessment of risk will be carried out proactively, although comments written retrospectively in diving records may inform future dives.

The second level of recreational diving is where there is an element of control and guidance coming through a recreational diving club that may be connected with a national or international association. In this case, it can be argued that payment of a membership fee by the individual to the club and/or association should guarantee a certain level of control associated with the organisation of a diving event. This could take the form of club members being allocated the task of supervising dives.

That supervision will require assessment of the diving site as appropriate for the qualifications and experience of the divers, or *vice versa*, and that the structure of the diving group in the water properly reflects the relative experience levels of those divers. The supervising person will also have to make decisions as to local changes in conditions in a similar way to a diving-at-work risk assessment being revised because of on-site and/or on-the-day changes.

Although this second level in the structure of recreational diving will carry a higher degree of organisation, it is still unlikely that written forms of risk assessment could be easily incorporated into an amateur club situation. The payment of membership fees and charges associated with the real costs of the diving operation will provide only a nominal level of guidance to the diver. It is unlikely that national inspectorates or legislators would wish to become involved significantly with a sector where individuals are not being paid and are thus assumed to have minimal professional knowledge.

The third level in recreational diving is where the diving is managed by people at work, and is controlled by commercial bodies that charge fees for these managed dives. In this case, the divers who are paying for the organised diving should expect a level of care and control above that assumed in unorganised or organised amateur diving. It is also possible that, because these operations are defined as commercial, there could be some form of statutory regulation attached to these diving operations.

Equally, because someone within the diving operation is being paid by customers, in the event of a serious incident, the operators of this level of recreational diving would be defined as professionals and could be liable to prosecution by statutory organisations. At this level, therefore, it would appear appropriate for commercial operators of recreational diving to adopt some form of risk assessment or management in order both to reduce the likelihood of incidents but also to provide evidence of a properly managed operation in the event of an incident occurring. In effect, this is already adopted worldwide by a number of professional organisations.[18]

Because of the trends in recreational diving, it is most likely that a company will have researched or have available to it a finite number of dive sites. Each dive site over the course of a year or diving season, will probably be dived repeatedly by the same company and the same professionals. Therefore, there will be a high level of local knowledge already existing about the site in question. In addition, many dive operators will have visual representations of the dive site in order to aid the briefing of the dive groups. Some of these visual aids will clearly identify the area in which the dive will take place plus any underwater hazards.

Although there may not be a regular assessment of diver competence undertaken by recreational companies, there appears to be a trend of introducing the customer divers to dive sites with lower risk potentials at the beginning of a series of dives. Once the diving professional has had an opportunity to assess the overall competence of the divers under their control, this may inform decisions made later during the series of dives as to the appropriateness of future dive sites. However, in the commercial operation of recreational diving, it is often this assessment of customer competence that appears to be lacking in the written form.

If a professional diving instructor or guide were expected to make a written record of the divers' qualifications and assess their competence as individuals or the group as a whole, this would aid in making decisions for dives later in the series. It would also provide evidence of an assessment process. There is no requirement for this record to be particularly detailed. A simple printed diving slate could provide a *pro forma* approach whereby the most common diving qualifications are listed, and the diving professional only has to record the numbers of those qualifications present in the group. Following the initial dive of a series, the professional should be able to rate the group, or parts of the group, as very competent, competent, lacking competence in some areas, or incompetent. That assessment would inform either the locations of future dives in the series or the structure of the group itself.

The adoption of risk assessment for the management of safety in UK scientific diving-at-work operations has been a welcome development following the over-prescriptive regulations for UK professional diving in the past. It is believed that the approaches to risk assessment set out for diving operations in the present account are relatively straightforward and could be adopted by other nationalities and diving industry sectors, as well as UK-employed scientists diving for work outside UK waters. If implemented correctly, the process of risk assessment provides a clear record of the decisions made in the control of diving operations, while also improving safety through better guidance for the divers and increased responsibility being placed on the person supervising the operation.

Acknowledgement

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Dive safety and risk management: never let your guard down

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Key words
Risk, safety, scuba diving, training

Abstract

The vast majority of people who scuba dive do so without negative consequences. However, because of the probability of various injuries and risks involved, we must realise that accidents and injuries will occur despite best practices. There is no room for complacency in the world of prudent risk management for recreational scuba-diving practice.

We use the word 'safe' quite loosely in our everyday lives. However, how we determine what is and is not safe is not as widely discussed. Lowrance defined safety as a judgment of acceptable risk, and risk as a measure of the probability and severity of harm.[1] Nothing in life is risk free and activities are judged safe only when their risks are judged acceptable. As there are degrees of risk, so are there degrees of safety. Determination of how safe things are requires two activities:

1 measuring risk, which is an objective scientific activity
2 judging the acceptability of that risk, which is a personal and/or social value judgment.

Gauging risk, therefore, is a matter of estimating probabilities. This approach assesses the overall chance that an untoward event will occur, but not a specific event. For example, gauging risk by estimating probabilities can determine the likelihood of decompression illness occurring for any given dive profile; however, this approach is limited in that it cannot predict which divers will have decompression illness. The same can be said of air embolism, drowning and diver fatality.

Scuba diving is a reasonably safe activity and is categorised as such based on the concept of acceptable risk. Acceptable risk is defined by several factors, including prevailing professional practices, reasonableness and the highest practical protection and lowest practicable exposure. Adhering to standards and always being safety conscious when diving or supervising others who are diving, helps decrease the probability of an accident or incident from occurring, although it does not eliminate the probability altogether.

A disciplined adherence to effective risk management principles assists divers and dive professionals by increasing safety and minimising risks to oneself and any divers for whom one is responsible. In addition, various personal and social value judgments affect the perception and reputation of any given activity. As previously mentioned, safety is the degree to which risks are judged acceptable. Recreational scuba diving is largely viewed by the non-diving public as a high-risk activity. In all likelihood, this view stems from diving's poor safety record in its infancy in the 1950s and 1960s, and the fact that it is an activity experienced by a minority of the total population. So when things go wrong and a diver dies while scuba diving, it often makes front-page news in local papers.

It is difficult to define precisely what is considered acceptable risk for all involved groups. Consider for a moment how the definition of acceptable risk might be defined differently for the following groups: novice divers, experienced divers, dive operators, certification organisations, equipment manufacturers, insurance carriers, the legal profession, divemasters, instructors and the lay public. As mentioned previously, risk depends on the probability and severity of the injury, so the likelihood of a diver suffering an ear squeeze, near drowning, air embolism, decompression sickness or a fatality all vary both in probability and in severity. The skill and experience level of the individual involved, a novice or instructor, also affects the insight and ability that person has in accepting a risk. Formalised and modern systems of diver education, along with various statements of understanding, waivers and liability releases combine to present to an individual that diving has an element of risk, and that the severity of that risk can have catastrophic consequences, however unlikely. In my experience, informing a diver of this is in the best interest of the individual and the professional, and is both ethical and moral. In short, it is the right thing to do. Intelligent people make the personal choice to accept these risks on their own.

The vast majority of people who scuba dive do so without negative consequences. However, because of the probability of various injuries and risks involved, we must realise that accidents and injuries will occur despite best practices. It is incumbent upon each of us, whether we are divers or dive professionals, to act, teach and supervise others in a manner that never compromises the high standards that modern, recreational, scuba-diving practices have established. It is also important that we all exercise prudent and wise judgment in every environment and circumstance and that we always put the safety and wellbeing of those we dive with, supervise or train above all else. There is no room for complacency in the world of prudent risk management for recreational scuba-diving practice.

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Risk management in recreational diving: the PADI approach

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Key words
Risk, safety, scuba diving, training, PADI

Abstract

(Nimb HC. Risk management in recreational diving: the PADI approach. *SPUMS J*. 2004; 34: 90-3.)
The activity of scuba diving, whether in the context of an instructional class or recreational diving, contains some inherent risks. Water depth, limited visibility, cold, adverse weather conditions, dangerous marine life, buddy separation or diving under the influence of alcohol or drugs all represent risks of harm that may potentially be realised. It is imperative that these risks are recognised, understood and appreciated by the provider (dive centre, dive training organisation, instructor or dive master) and the consumer (certified diver or diver student). As dive educators we have a responsibility towards providing divers with safe diving experiences. To this end, we must educate our dive professionals accordingly. In other words, risk management begins with us – the providers.

Introduction

It is only natural that the question of 'risk' in diving in medical terms automatically concerns the physical eligibility of an individual to undertake diving. The 2003 SPUMS Conference focused on the diving medical, the associated risks and how these risks can be managed. We are, of course, aware that medical risk management is part of a multitude of types of risk management necessitated by the inherent risks of diving. The previous year's conference further explored one area of risk that, though resulting in medical complications, was initiated by inappropriate diving practices, in this case by inadequacies in the selection and the use of various types of diving equipment.[1]

There are numerous fun and interesting recreational activities available to us, and though different in their designs and objectives, they all have two specific things in common. Firstly, each activity carries certain risks; and secondly, effective risk management helps reduce those risks to manageable levels, to a level where we can say 'OK, I can deal with that. Let's do it!' Effective risk management has done exactly that for recreational diving, which in its infancy was widely regarded as a 'dark and dangerous' activity.

In spite of vastly enhanced risk management, however, people still get hurt and we still, regrettably, experience diving fatalities. The medical community is doing its share to enhance diver safety whilst other sectors of the dive industry do likewise through different procedures. Richardson discussed earlier the rationale for risk management from a diver educator's standpoint and how structured diver training can help reduce risks to manageable and acceptable levels.[2] With that in mind, this paper reviews the measures the Professional Association of Diving Instructors (PADI) has introduced to enhance effective risk management in recreational diving and how they are distributed.

Rationale for risk management in recreational diving

WHAT IS A RISK?

A risk is the chance of something happening as a result of a hazard or threat, which will impact on your business activity or planned event. Risk arises out of uncertainty. It is measured in terms of the likelihood of an event happening and the consequences if it does happen.[3]

The associated risks, divided into two main categories, safety and commercial, identify appropriate risk management. Safety risks relate primarily to medical considerations, diver inexperience, absence of appropriate emergency medical systems and rescue procedures, and violation of diver training standards and safe diving practices. Commercial risks typically involve loss of business opportunities from negative perceptions of diving, financial losses from claims, lawsuits and inappropriate insurance cover, loss of continued association with a reputable diver-training organisation and inappropriate government legislation.

The primary concern is diver safety. Safety precedes all other considerations. Effective risk management strives to keep the diving public out of harm's way whilst ensuring diving remains an attractive and enjoyable activity. PADI has over the years developed several important tools available for dive professionals and divers to enhance safety through effective risk management.

Risk management: the PADI approach

Diving consumers expect to have safe and enjoyable dive experiences. Effective risk management tools and techniques make this possible and practical. Some prominent tools we have developed include:

- dive training standards
- safe diving practices

- quality management
- risk management seminars and member forums
- educational consultancy
- legal support
- insurance schemes and
- involvement in government legislation.

The issue of medical examinations will be discussed in the next issue, and will not be considered in any detail in this paper. However, to emphasise that medical considerations are regarded as indispensable in proper risk management, the Association has a self-imposed medical screening process, identified internationally through application of the Recreational Scuba Training Council's (RSTC) medical examination guidelines.[4]

Diver training standards

Our philosophy of diver training is based on a systematic approach through a modular instructional system. This approach helps the student diver achieve the intended learning outcomes described in a specific set of objectives. The associated training standards present the foundation on which the system has been built. These standards are based on considerations for student diver safety, student diver learning and prudent instructor conduct.

An instructional system provides excellent risk management for several reasons:

- Diver safety: the system has been thoroughly researched, in theory and in practice;
- Training efficiency: time sensitive; globally applied to local conditions;
- Legal protection: burden of proof of the system's validity shifts to the system developers;
- Achievement of learning outcomes: measurable objectives;
- Validated through field tests: developed by divers for divers;
- Accommodation of various learning styles: performance based; conforms to the needs of the student.

Through the Instructor Development Course (IDC), candidates learn about the advantages of adhering to an instructional system and its associated standards. For the dive professional, following prescribed training standards is the single most important step in risk management.

All standards and regulations are, of course, as appropriate and viable as the individual imposing them. Training standards apply to a variety of situations but the dive professional must ultimately apply sound judgement, based on many variables, including diving conditions, training objectives, divers' experiences, location of emergency medical services and so on. Specific standards and safe diving practices, combined with sound judgement and application, make for effective risk management.

Safe diving practices

As a diver-training organisation we are particularly concerned with the needs of the diver professional, the student diver and the diver. In other words, safe diving practices apply to all divers. We receive inquiries from all categories of divers requesting advice on safe diving practices in a multitude of situations. Our association with a variety of organisations, such as SPUMS, Diver Alert Network, RSTC and many local diving federations, has enabled us to establish that we are regarded as a prudent organisation with acceptable safe diving practices. These practices are taught extensively throughout the diver training programmes, thus providing all divers with a tool for effective risk management.

Quality management

The ability to recognise dive professionals for a job well done, manage the quality of an instructional system and enhance diver safety is considered indispensable in risk management. Quality management, assurance and recognition programmes, in place since PADI was established over 36 years ago, are applied proactively to meet these objectives.

The 'Recognition of Excellence Program' acknowledges members who excel in their work. We recognise their efforts in writing, based on input received from their student divers as well as through field observations by regional managers. In the past 12 months, over 175 certificates of recognition were issued to members in the Asia-Pacific region alone. The certificates are a reminder and an encouragement to dive professionals to strive for excellence.

To help members manage risks through a consistently high level of quality dive training and diver services, our Quality Management Department (QMD) monitors diver training courses for quality control. Of particular use is a wide distribution of 'Course Evaluation Surveys' (CESs), which are routinely, and at times selectively, sent to student divers having completed a diving course. The CES contains specific questions pertaining to the level of training completed. Any indications of possible non-compliance with our standards will result in an inquiry. Other types of written complaints may also form the basis for further inquiries. All inquiries are conducted in confidence and according to standardised procedures, based on equal application and process.

In 2001, PADI America's QMD mailed 140,000 CESs (one in four divers), of which 32,200 (23%) were returned and reviewed. The review resulted in 2,200 inquiries being initiated. The vast majority of inquiries expose simple misunderstandings that are quickly and successfully addressed. Few require further investigation and even fewer result in re-training, suspension or expulsion. In order to protect the public from any further harm, the names of suspended or expelled members are published in the in-house quarterly, *The Undersea Journal*. In addition, the names of expelled members are forwarded to other training organisations.

Risk management: member forums and seminars

PADI regularly distributes information on risk management via publications, annual member forums and dedicated risk management seminars conducted worldwide. These seminars, which are 'living' programmes, are designed in such a way as to allow for local adaptation, but at the same time ensure their validity. For instance, risk management issues in Taiwan and Korea differ from those in Australia and Indonesia. In general, topics include medical considerations, why diving incidents happen, negligence, accident and liability insurance, legal considerations and a review of specific situations. Several seminars include widely popular 'mock' court proceedings over theoretical diving incidents, not unlike the Pugwash scenario.[5] Risk management seminars have been conducted throughout Asia-Pacific since March 2000 (45 seminars with a total of 1,700 members in the audience) and continue in high demand. The seminars are supported by our insurance broker who often participates actively in them, adding an important element to the message of risk management.

Educational consultants

Educational consultants are employed worldwide and play an important role in fielding questions from members and non-members alike. Questions focus on training standards, different training situations, safe diving practices and diving opportunities. During the IDC, candidates learn about this important service and how it may benefit their daily activities. PADI Asia-Pacific currently employs five educational consultants of which three also function as instructor evaluation (IE) examiners, an important addition to their responsibilities that allows for close interaction with other members.

Legal risk management[5]

A legal risk is the possibility of a legal decision that requires the dive professional to pay another party to compensate for damages caused by the dive professional's action or inaction. Our Legal Department serves several purposes to ensure the legal validity of the diver training system. Legal advice to members is limited to referrals to the appropriate profession, much like the policy on medical advice. Throughout the IDC, candidates learn to apply training procedures that are commonly referred to as 'defensive teaching', i.e., following a set of recommendations directly related to legal risk.

Insurance in risk management

In certain geographical areas, instructors, dive masters and assistant instructors are required to carry professional liability insurance. In spite of this not being a worldwide requirement, it is strongly recommended at all times. For instance, instructors conducting diver training in Australia are required to carry liability insurance whereas those in New Zealand and Thailand are not, although many have chosen to do so. We live in an increasingly litigious climate that imposes risk for high legal costs. A legal defence can be very expensive, even if the dive professional wins. The liability insurance provides cover for such expenses.

Other insurance schemes are in place to support risk management for PADI members. Student divers may be insured through the 'Student Protection Program', certified divers through the 'Protection Program', and several insurance schemes are available to dive centre, resort and boat owners. We recommend that all members, regardless of their level, carry appropriate insurance.

Involvement in government legislation

Members benefit from PADI's direct involvement with government bodies responsible for introducing legislative measures. The Association supports appropriate legislation and endeavours to render assistance and advice whenever required, and this involvement helps members adhere to local laws and requirements. We have been actively involved in legislative matters in several countries, including Australia, Malaysia, New Zealand, Singapore, Korea, UK, France, USA, Germany, Spain etc.

Implementation and outcomes

How well are all of these measures implemented, and what are the ensuing results? Our direct contact with the market through our various seminars, programmes and direct field observations, forms the basis for strong evidence that the vast majority of members apply prudent risk management procedures. Successful implementation of risk management procedures is, of course, ultimately reflected in diving incident statistics that vary from region to region, country to country. From statistics available, and when compared with the number of dives undertaken daily, it is apparent that the safety record has improved greatly over recent decades, and will continue to do so. Risk management plays a substantial role in these improvements.

Conclusions

We cannot avoid risk altogether, but we can strive to reduce risk to manageable levels. Once the diver has satisfied medical prerequisites, there are many opportunities for the dive professional to further enhance the diver's safety. The primary and most important need for risk management is to keep divers safe by preventing incidents from happening. This must be reflected in everything dive professionals and divers do. Reducing risks helps ensure that recreational diving remains a fun, attractive and reasonably safe activity.

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Errata

SPUMS Diplomates

We have been advised of a number of errors in the diplomates list held by the Society and published in the last issue of the journal (*SPUMS J.* 2004; 34: 47.). Would all diplomates please check their entry for errors and forward a copy of their diploma to the Secretary so the records may be corrected. A revised list will be published.

Dr Simon Mitchell

In the article by David J Doolette and Simon J Mitchell "*A biophysical basis for inner ear decompression sickness*" (*SPUMS J*. 2004; 34: 15-21.) reprinted with permission from *J Appl Physiol*. 2003; 94: 2145-50, copyright The American Physiological Society, Dr Mitchell's biographical note did not identify that he was a consultant in the Department of Diving and Hyperbaric Medicine, Prince of Wales Hospital, Sydney, at the time of writing.

Book Review - NOAA Diving Manual

The *NOAA Diving Manual* reviewed in *SPUMS J*. 2004; 34: 53-4 was previously reviewed by John Pennefather in *SPUMS J* 2002; 32: 26-7. The two reviewers' opinions do not differ in any important way.

The world as it is

The first Broome recompression chamber 1914–2004

Susan Thurston

Key words
History, pearl divers, hyperbaric facilities

Abstract

(Thurston S. The first Broome recompression chamber 1914–2004. *SPUMS J*. 2004; 34: 94-100.)
The history of the use of recompression chambers (RCCs) in Australia has not been well described. Probably the first records of the use of a RCC were over 88 years ago, when a pearl diver with spinal decompression sickness (DCS) was successfully treated in Broome, Western Australia. At that time Broome was supplying 75% of the world market of mother-of-pearl shell, used for the manufacture of buttons. After the introduction of compressed-air diving in the late 1800s, many divers suffered from 'diver's paralysis' (DCS). CE Heinke and Co, a British diving equipment manufacturer, in 1914 donated a RCC of their own design and patent to the pearling industry in an attempt to reduce the high death and injury rate that was occurring amongst the pearl divers. This paper presents the history of the first Broome RCC.

Introduction

While there are many historical references to the use of recompression chambers around the world, there are few on the early history of recompression treatment in Australia. The earliest documentation I have found regarding the use of a recompression chamber (RCC) is for a pearl diver who was successfully treated for spinal decompression sickness (DCS) in February 1915 at Broome, Western Australia.[1] There are also several references to a RCC at Thursday Island, Queensland, around the same time, but I have not been able to verify this.[2-5] Two references state there had never been a RCC at Thursday Island.[6,7]

Pearl divers were essentially gatherers of mother-of-pearl (MOP) shell. The odds of finding a naturally occurring pearl in the shell has been estimated to be one in 1000.[8]

During the mid 1860s, when the North West of Australia was being explored to establish sheep and cattle properties, the local aborigines were noticed to be wearing large MOP shells as decoration. MOP shell was found to be plentiful and easily gathered at low tide along the beaches and an industry was born.[4,5,9,10]

By the 1880s, Australia was supplying 75 per cent of the world MOP shell harvest, and the then tiny town of Broome, North Western Australia, became known as the 'Pearl Capital of the World'. In 1889, the Eastern Extension and China Telegraph Company completed the laying of a transoceanic telegraph cable, coming ashore at what is now known as Cable Beach. This cable linked the isolated town directly with England, via Singapore, India, Aden, Egypt, Malta and Gibraltar, allowing Broome access to London market updates of the latest MOP shell prices in just a few hours.[3,4,8]

In 1912, the price of MOP shell was high, paying £264 per ton. In that year, 1,596 tons of MOP shell were exported from Western Australia, with a value £421,609.[12] This converts to over $31 million in today's currency.[13] Up to 80% of MOP shells collected in Australia were used for manufacturing buttons mainly in Britain, Europe and, by the early 1900s, the USA.[4,5,8,11]

Pinctada maxima is unique to the regions of Northern Australia and is the largest MOP oyster in the world, growing to 15–20 cm span across the shell. It can be found from shallow waters exposed at low tide to a depth of 80 metres. The large size of the *Pinctada maxima* is attributed to the great tidal flows in this region, providing the filter-feeding oyster plentiful access to nutrients.[4,5,8] In Northern Australia, tidal variations have been recorded as great as 10 metres.[8] At Broome, the average tidal range is 7 metres, which results in the unusual sight of the sea being up to two kilometres from the high tide line twice a day.[9]

Pearl luggers

The pearling lugger was a small ketch-rigged wooden boat commonly 16–17 metres in length, often built locally in Broome. Their flat-bottomed hulls allowed them to sit upright on the sand or mud flats during low tide. There were 300 to 400 pearling luggers registered in the North West of Western Australia between the years of 1910 and 1917.[8,12,15]

Cyclones

North Western Australia has a tropical cyclone season, known locally as the 'wet' season. This runs from October to May although most of the storm activity occurs from December to March. Tropical cyclones (known as 'typhoons' in Asia and 'hurricanes' in the Atlantic and Eastern Pacific areas) can be destructive, especially on small sailing ships.[16] During one storm in March 1899, 307 people died.[4]

The pearl divers

Local aborigines were used to gather MOP shells from the beaches at low tide and were also 'encouraged' to work as free divers. They were reported to be excellent free divers.[3,5,10] In 1868, compressed-air diving, using copper-domed helmets, canvas suits and lead-weighted boots, was introduced to the pearling industry of Western Australia.[5] Compressed air was supplied by a manual pump, usually operated by relays of two deckhands.

Up till that time compressed-air diving had been used mainly for engineering and salvage work over a fixed location. Initially, it was not a success in the pearling industry due to the large tides with current flows up to 12 knots.[4,8] Eventually, a successful system was devised in which the pearl lugger drifted with the tide, with the diver trudging along the seabed. The lugger would then sail back against the tide, turn and drift back down to cover an area that may be rich in shell.[2-4,6-8]

The aboriginal people were not proficient with the cumbersome, claustrophobic copper helmets and canvas suits. However, the people of Asia showed aptitude for this form of compressed-air diving. Japanese divers proved to be the best, and for many years dominated the diving side of the industry.[4,5,8,9] In 1912, a group of ex-Royal Navy divers was employed in an attempt to break the monopoly that the Japanese divers had in the pearling industry, in what came to be known as 'The White Divers Experiment'. This trial ended disastrously with many of the English divers dead or suffering spinal DCS. This sad saga is well described in several publications.[4,5,8,11]

Empirical diving

> *"In the old days Broome and T.I.* (Thursday Island) *were pitiful with the wrecks of fine men who had suffered the bends because the art of staging was not then thoroughly understood".*[2]

In 1905, the first scientific research into the effects of compressed air diving was conducted by John Scott Haldane, Arthur Boycott and Lieutenant Guybon Damant. The results were published as the Admiralty Diving Tables (staged decompression tables).[4,8,11] By then, the pearl divers had evolved their own empirical system of diving with compressed air, which was passed on from one diver to the next.[4,5,8,9]

This method of diving was kept a closely guarded secret and exact bottom times and ascent rates were not recorded. What is believed to have occurred is that after each drift with the tide, lasting probably an hour, the diver would return on board and, with only the helmet removed, sit quietly having a cigarette. This respite would last for about 15 minutes or so as the lugger sailed back up against the tide. He would then repeat his underwater trawl for shell. Diving would continue from dawn to dusk for six days a week during the 'dry' season. There are several suggestions that some 'staging' occurred on the last dive of the day.[2,4,8,9] At the end of the day the diver would sit very still as his diving gear was removed. Only after an hour of minimal motion and no occurrence of pain or niggles would a diver then go to his cabin to eat and *"fall into his bunk exhausted"*.[2,4,5,7,8,14]

The working depth was usually not more than 20 metres, that being the length of the umbilical from the hand-driven air pumps.[5] Deeper diving was being done as described in 1911 by Francis Rodriguez, pearl diver and owner of the Continental Hotel, Broome:[17]

> "*I have personally been to 30 fathoms* [55 metres] *with four men on the pump and if I had two more, making six men on the pump, probably would have reached 40 fathoms* [73 metres]".[18]

The divers were sceptical about the Admiralty Tables, particularly the Japanese. They continued to use their own methods of decompression, and were said to be stoic about their chances of 'diver's paralysis'. The Japanese divers have been quoted as saying "If its not my time, its not".[2-4,8] Between 1900 and 1917, there were 145 deaths attributed to 'diver's paralysis'. Many more died from drowning (particularly during cyclones), shark and crocodile attack, umbilicals caught on coral, other diving equipment mishaps, beriberi and other ailments.[2-5,8,15]

Japanese cemeteries in Broome, Cossack, Darwin and Thursday Island have grave sites marked with sandstone tablets of the region. These cemeteries have been described as a "forest of headstones".[2] There are over 700 grave stones in Broome's Japanese Cemetery alone.

Diving equipment

The two main manufacturers of diving equipment at that time were CE Heinke & Co and Siebe & Gorman Ltd. The founders of both companies were German immigrants who settled in England in the early 1800s, and initially the factories were less than a kilometre apart in Central London.[19] After more than 100 years of rivalry, Siebe & Gorman Ltd finally bought out CE Heinke & Co in the early 1960s. After the takeover, unfortunately, few records remain of Heinke & Co's achievements and activities,[5,19] which makes sourcing for information on this company challenging.

The importance of the pearling industry to these two companies is demonstrated by the visit of Mr Frederick Sprang, the then General Manager of CE Heinke & Co, to the two main pearling centres of Australia (Thursday Island and Broome) in 1911.[20] James Davis, brother of Robert Davis the General Manager of Siebe & Gorman Ltd, was the Broome representative of this company in the early 1900s until he died in 1912 when the *Koombana* (the fortnightly steamer from Fremantle), was lost in a cyclone.[11]

In December 1913, Mr Sprang wrote a letter to Mr Arthur Male, Chairman of the Master Pearlers Association, which was printed in the *Nor'West Echo*, Broome's bi-weekly newspaper, stating that CE Heinke & Co were planning to send a recompression chamber to Broome.[21] In May 1914, Mr Sprang sent further correspondence (again quoted in the *Nor'West Echo*):

> "*I wish to bring to your notice a cylindrical chamber that I am having made under my own patent for the purpose of saving lives and alleviating the suffering of divers, who, by remaining too long under water, or by going too frequently, contract paralysis…from experiments and actual experience, one may say that recovery is assured. My desire is to send this first chamber out to Broome free, that it may be used for the relief of divers and at the same time serve to demonstrate its utility and value to pearlers*".[18]

Patent

Frederick Henry Sprang, Submarine Engineer, of 87 Grange Road, Bermondsey, London (the new CE Heinke & Co premises) applied for a British patent for a "re-compression apparatus" on 23 December 1913 and was accepted 10 December 1914 – patent number 29,625. (Figure 1).[23] A small recompression chamber (2.74 metres long and 66 cm internal diameter) was proposed. This could be used for recompression treatment as well as a back-up air reservoir for divers on luggers that had engine-driven compressors. A pulley system converted the chamber to an air reservoir by pulling a second, high-pressure door against the bolted, outer low-pressure door. It was designed to withstand a pressure of 250 psi (1723 kPa).[22,23]

There was a pressure gauge and "*connections and valves for regulating the admission and exhaustion of air to and from the interior and thus controlling the pressure and ensuring ventilation when the chamber is occupied.*" On the outside door of the chamber, two small round "*scuttle windows*" 12.7 cm in diameter, were "*strongly glazed to resist internal pressure*". One window was for "*casting a light upon the head of the occupant who is introduced into the chamber feet foremost*". There was a handle for turning an "*appliance to rub over the internal surface of both windows, so as to remove the moisture or mist which is liable to accumulate upon the glass*". An air lock was bolted into the door "*through which food, stimulants, etc, could be passed to the patient without affecting the air pressure inside*". The air lock was a simple box-like structure measuring 18 cm by 28 cm the pressure in which could be equalised using a valve on the outside door (Figure 2).[22,23]

Mr Sprang's initial offer to send the chamber to the Broome hospital was declined, the reason cited being that the hospital did not have a local board of management.[21] The Master Pearlers Association then stated they "…*were prepared to take charge of the plant and to provide housing accommodation…The association has not been slow in taking action as was evidenced by their recent application to the local council for a portion of Bedford Park which was readily granted*".[22]

The chamber arrived in Broome in October 1914 and was set up in a corrugated iron building in Bedford Park (Figure 3). It was situated near the Continental Hotel, as this was the only place in town to have electricity at that time. The rest of the town was lit mainly with gas lights.[24]

Perhaps due to the 'wet' season, when little diving was conducted, the first diver was not treated until February 1915. This was enthusiastically reported in the *Nor'West Echo,* February 1915.

> "*A Japanese diver was paralysed on 15th February in 20 fathoms* [36 metres] *of water and brought to Broome*

Figure 1.
British Patent Nº 29,625. Diving - apparatus. Sprang, F.H., 87, Grange Road, Bermondsey, London. (Classes 68 (ii), 81 (ii), and 123 (i).) Courtesy of Patents Information Unit, Leeds City Council, England

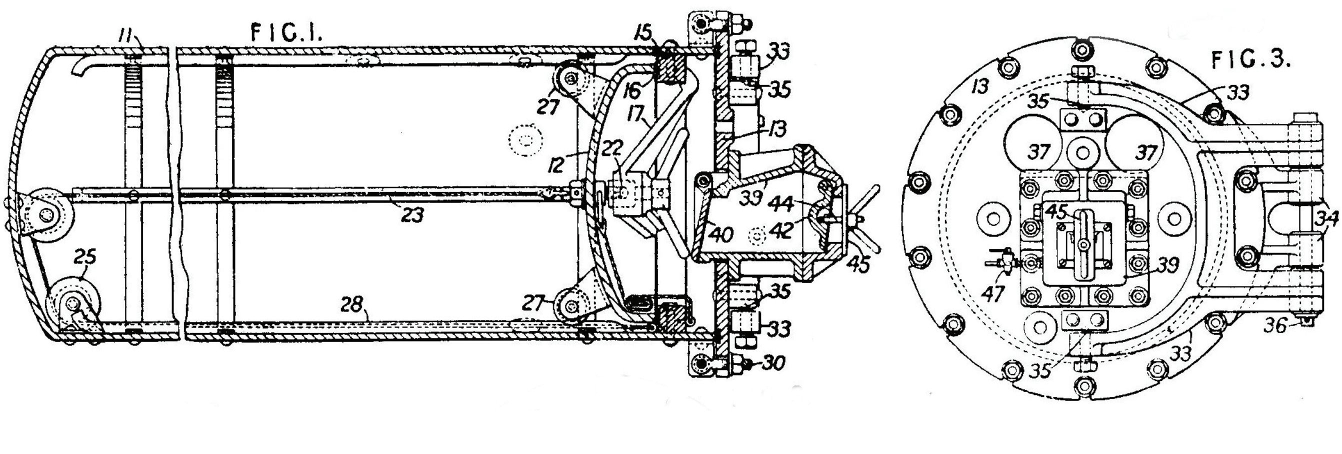

Figure 2.
Broome recompression chamber. Photo courtesy of Broome Historical Society

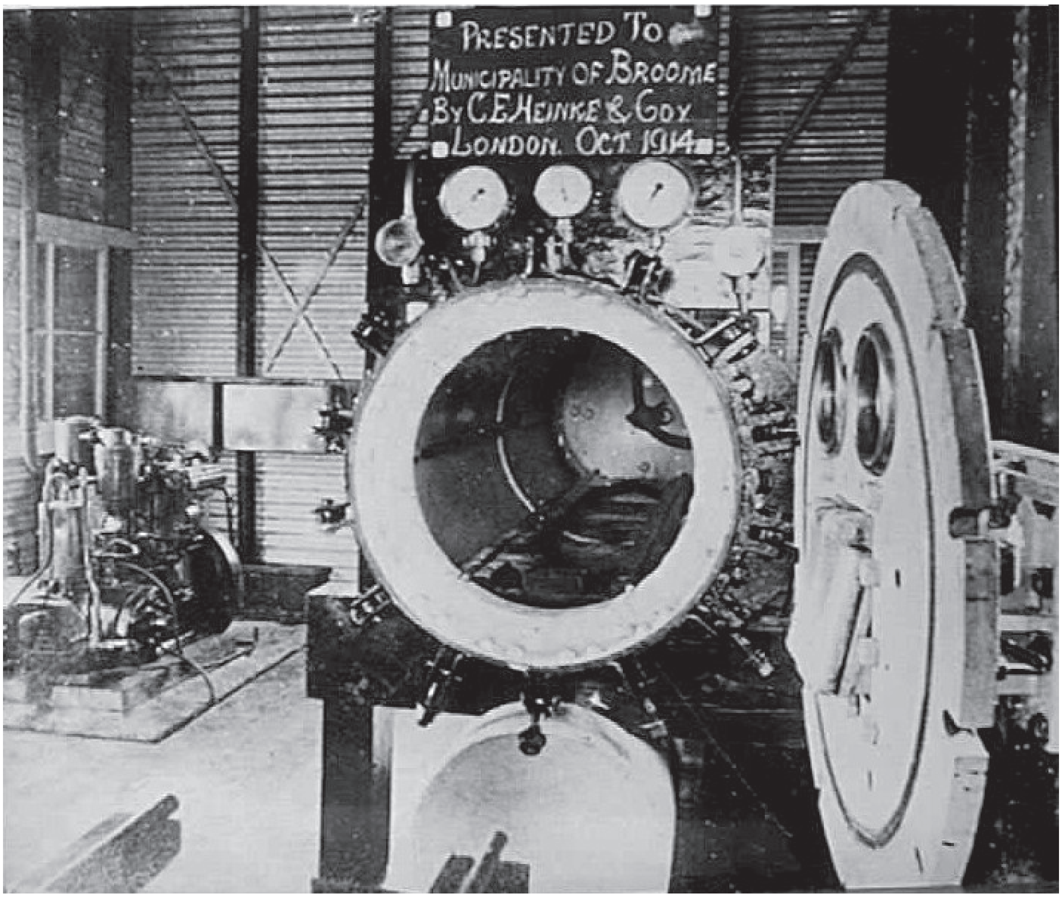

Figure 3.
Broome recompression chamber. Photo courtesy of Broome Historical Society

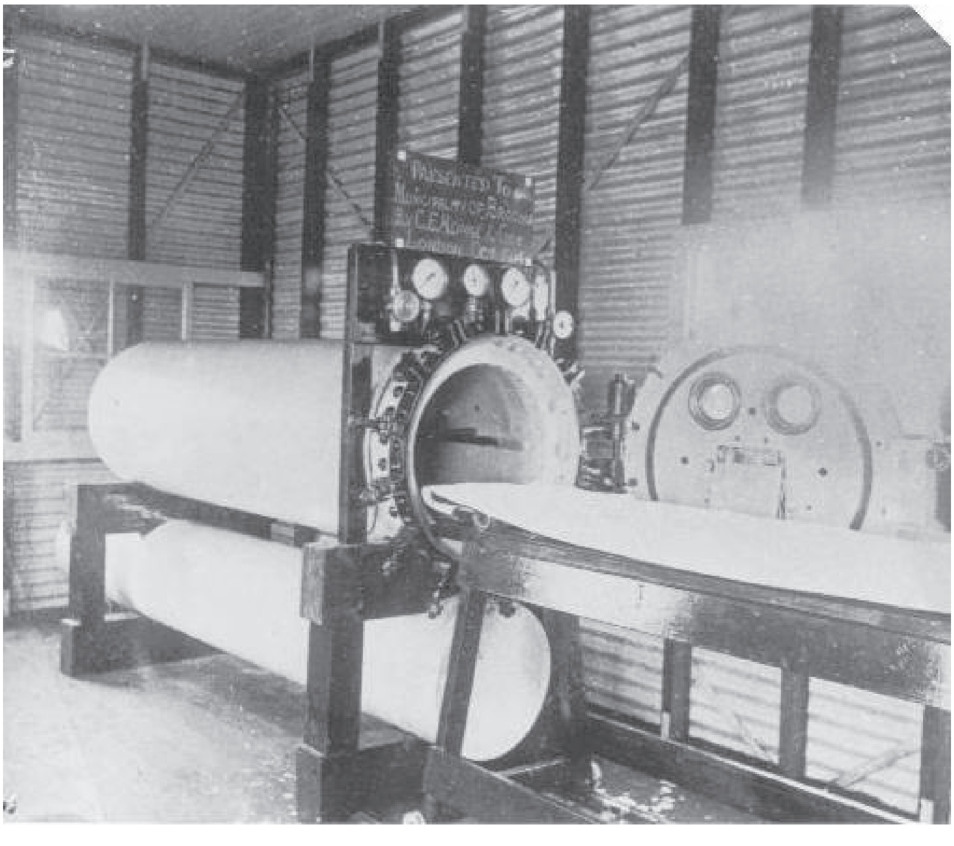

Figure 4.
Treatment table used for recompression chamber, Broome 1915

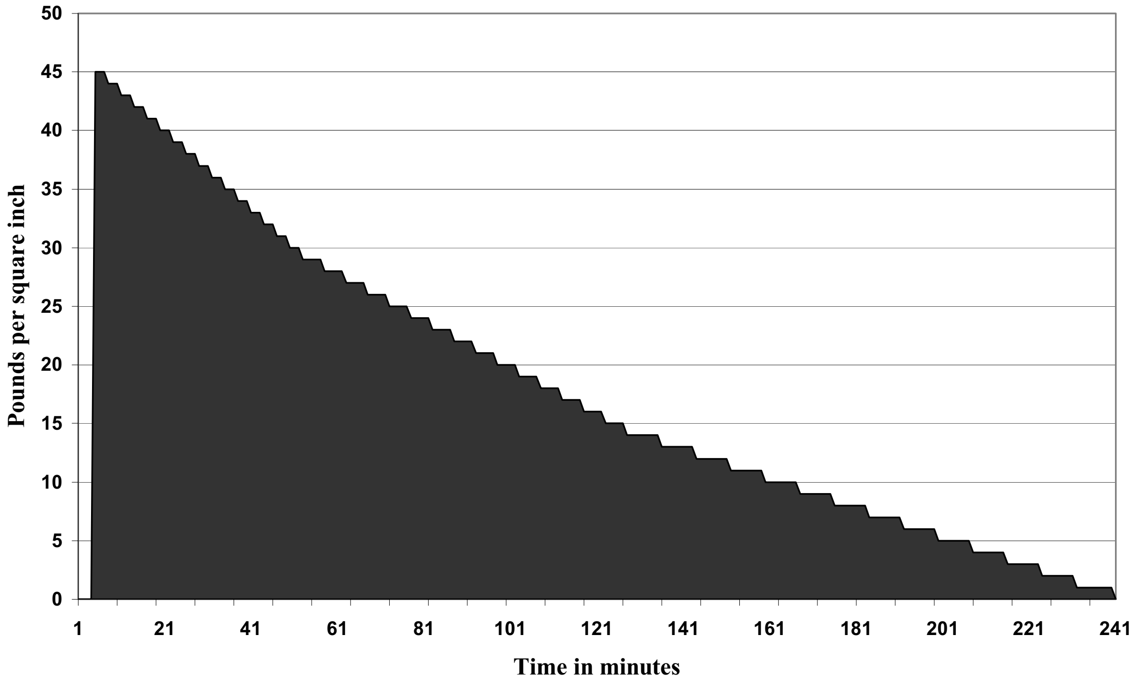

Figure 5.
RCC in Bedford Park 1990 showing deterioration. The Continental Hotel can be seen in top right-hand corner. Photo courtesy of Dr Harry Oxer

on the 19th and immediately taken to the chamber. Treatment commenced in the presence of Drs Smythe Yule and Y Harada, the Mayor, councillors, Major Wood, other representative townspeople and a number of divers. It is intended to attach a telephone to the chamber, so that conversation may be carried on with the patient while he is being treated. An electric light will also be installed to help treatment at night. Both doctors examined the patient, and declared him paralysed from the hips down, no feeling existing in any of those parts".[1]

Treatment table

A treatment table was supplied with the RCC, designed by Mr Sprang and Lieut. G. Damant from the Royal Navy.[1] Mr Sprang was quoted as saying:

"*Doubtless you, long ago, read the report of the admiralty upon diving, and saw therein the prominent part that Lieut. Damant took in all test and trials, both underwater and in compression chambers."*[22]

"*Mr V. B. Knott* [CE Heinke & Co engineer trained at their London Factory[15]] *then took charge of the plant and diver, wheeled the patient into the chamber on a travelling stretcher designed by Mr Knott. The door being securely closed, air was turned on to 45 lbs per inch and staging proceeded with from that point to zero. Great care was taken as the effectiveness of the process depends upon the success of the experiment. The staging was: 45 lbs to 30 lbs - 1lb every 3 minutes, 30lbs to 15lbs - 1lb every 5 minutes, 15lbs to zero - 1lb every 8 minutes, the total time for treatment was 240 minutes."*[1] (Figure 4)

"…A large number of people were present to witness the release of the diver at 7.30. He came out smiling, and stated feeling had returned to the paralysed partes. He was able to stand upon his feet. Within two days he was able to walk without the aid of a stick and it is confidently anticipated he will be able to return to work early next week."[1]

Most divers were treated with a single treatment but several with severe spinal DCS were treated twice with the same table but showed little improvement.[10]

Records reveal nine divers died in 1912. Around this time, the introduction of engine-driven air compressors allowed greater depths to be reached.[4,5,8,9,11] The death rate of divers increased to 29 in 1913 and 33 in 1914.[11,12] In 1915, 21 divers died and nine divers were treated in the RCC. In 1916, 19 divers died and nine divers were treated.[11,12]

Pearling industry, 1914 to present

At the outbreak of World War One in 1914 there were about 300 pearl luggers based at Broome and the population was over 3,000. Within a few months, however, the fleet numbers had halved as men enlisted and the war in Europe severely

Figure 6.
RCC and author, Broome Historical Society Museum, May 2003

curtailed the MOP market. After World War One, the price of MOP shell collapsed until the industry found new markets in America, where more than 50 per cent of all shell harvested went during the 1920s and 1930s. This recovery lasted until the 'Great Depression' of 1929. After the outbreak of World War Two only 73 luggers remained. Workers were once again scarce because of the heavy reliance on Japanese pearl divers, who were now interned in prisoner-of-war camps or had returned to Japan, and enlistment of most of the pearling industry's labour pool. By the early 1950s, the MOP shell industry made a recovery but, by then, the invention and marketing of the plastic button reduced demand for the MOP shell. As an industry, MOP shell harvesting was virtually abandoned.[4,5,8,9] Now, however, the town of Broome is once again thriving, this time with tourism and the cultured pearl industry.[8]

The RCC's final years

Records of how long the chamber was used have been difficult to source. The chamber and its corrugated shed were moved to Broome District Hospital in 1925.[25] There is a reference to the chamber being used in 1954.[2] In the early 1970s, a local man interested in Broome's pearl diving history was told of the chamber. After a long search he found it dumped at the Broome rubbish tip.[8] The chamber was rescued and put on display in Bedford Park, along with other relics of Broome's history (Figure 5). It was located in close proximity to where it was originally used nearly 60 years before. Nearby, an engine also on display bears the inscription "*This motor operated the decompression chamber donated by Heinke & Co of London, used in the treatment of divers' paralysis*".

By 1990, the chamber was showing significant signs of deterioration, and the Broome Historical Society requested the Maritime Museum in Fremantle undertake restoration work. In December 1991 the renovated chamber was returned to be displayed at the Broome Historical Society Museum along with other memorabilia of Broome's remarkable history (Figure 6).[12]

Acknowledgments

The author thanks Dr Robert Wong and the Fremantle Hospital Hyperbaric Trust Fund for assistance to attend this conference, the staff at the Broome Historical Museum, Paul Cookson of the Pearl Producers Association, Bob Ramsay of SEAP Historical Diving Society and Dr David Davies for their assistance, encouragement and advice.

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Sue Thurston was awarded the SPUMS Prize for the best presentation by an HTNA member at the Hyperbaric Technicians and Nurses Association Conference, Hobart, Tasmania, August 2003.

Freediving in cyberspace

Nigel McKie

Key words
Freediving, breath-hold diving, record, general interest

Abstract

(McKie N. Freediving in cyberspace. *SPUMS J.* 2004; 34: 101-3.)
The international organisational governance of the extreme sport of breath-hold diving and the associated criteria relating to the various disciplines were investigated on the world wide web. The universally accepted descriptive term for this activity is 'freediving'. The umbrella organisation is the International Association for the Development of Apnea, which promotes freediving, both competitive and recreational, and encourages the safe practice of the sport. Various web sites around the world were explored, the different disciplines defined and the current world records for each listed. Freediving is a potentially dangerous activity, and the web sites visited all carry warnings regarding safety.

Introduction

Having previously written to the *SPUMS Journal* about breath-hold diving records, and Tanya Streeter in particular, the author thought it would be appropriate to investigate a little more deeply the national and international organisational governance of this extreme sport and the criteria relating to the various associated disciplines. This proved to be a fascinating journey that may be of interest to fellow SPUMS members.

A two-page feature on Tanya Streeter in the United Kingdom (UK) *Sunday Times*, on 28 December, 2003 provided a reference to the British Freediving Association (BFA) so this seemed like a good place to start. As will become obvious, the first take-home message is that the universally accepted descriptive term for this activity is 'freediving'. The author recommends that, in future, SPUMS standardises by using not only this generic term but all of the others used by the sport's afficionados for its various disciplines.

UK freediving web site

The BFA web site was set up in 1999 to represent the sport of freediving in the UK.[1] Each page on the web site includes a disclaimer highlighted in red text which states that,

> *"Freediving is a potentially dangerous activity. This web site exists only to provide general information about freediving and does not constitute any form of instruction. Individuals interested in freediving are strongly encouraged to undertake a course with a qualified instructor and to never freedive alone. The BFA accepts no liability for injury or death resulting from the use of information on this web site."*

Various topics are accessible on the web site under the following main headings:

- About Freediving (which includes a section on physiology)
- The BFA
- UK Freedivers
- Instruction/Courses
- Competitions
- Records
- Links
- Contact Us

The BFA is the UK representative of the International Association for the Development of Apnea (AIDA). The objectives of the BFA are "*to promote freediving, both competitively and recreationally, and to encourage the safe practice of the sport*". In addition, the BFA is the sole body that selects UK teams for international competitions and ratifies any UK record attempts according to the rules specified by AIDA UK.

AIDA

AIDA is an acronym based on the French, Association Internationale pour le Développement de L'Apnée. AIDA is, in its own words,

> "*the worldwide sportive Federation which manage and overview since 1992 the recognition of records, the organisation of competitions and the elaboration of education standards of Freediving*".[2]

Clarification of the different disciplines within this sport was one of the main areas of interest to the author. According to the web site html 'Disciplines', AIDA recognises only eight categories as official disciplines for world records and competitions, and it considers that other kinds of 'similar' or 'different' categories could only be considered 'demonstration categories', without any sanctioned world record. It should also be noted that men's and women's records exist for each category.

AIDA definitions and world records

The following are the AIDA discipline definitions and world records taken verbatim from its web site on 23 May, 2004.

Static discipline

STATIC APNEA (STA)

"*The freediver holds his breath for as long as possible with his respiratory tracts immerged, his body either in the water or at the surface. Performances can be done and recognized in both pool or open water (sea, lake, river, etc*)."

Women: Annabel BRESINO (USA) - 6' 21"
13/11/2003 - Pool - Kona, Hawaii (USA)
Men: Martin STEPANEK (Czech Republic) - 8' 06"
03/07/2001 - Pool - Miami, Florida (USA)

Dynamic disciplines

DYNAMIC APNEA WITHOUT FINS (DNF)

"*The freediver travels in a horizontal position under water attempting to cover the greatest possible distance. Any propulsion aids are prohibited and performances can only be recognized in pools with a minimum length of 25 metres*."

Women: Renate DE BRUYN (Netherlands) - 104m
25/04/2004 - 25m pool, Huy (Belgium) - subject to anti-doping test result.
Men: Stig Aavall SEVERINSEN (Denmark) - 166m
19/07/2003 - 25m pool, Aarhus (Denmark)

DYNAMIC APNEA WITH FINS (DYF)

"*The freediver travels in a horizontal position under water attempting to cover the greatest possible distance. Any propulsion aids other than fins or a monofin are prohibited. Performances can only be recognized in swimming-pools with a minimum length of 25 metres*."

Women: Natalia MOLCHANOVA (Russia) - 155m
25/04/2004 - 50m pool, Moscow (Russia) - subject to anti-doping test result.
Men: Peter PEDERSEN (Denmark) - 200m
18/07/2003 - 50m pool, Randers (Denmark)

Depth disciplines

CONSTANT WEIGHT (CWT)

"*The freediver descends and ascends using his fins/ monofin and/or with the use of his arms without pulling on the rope or changing his ballast; only a single hold of the rope to stop the descent and start the ascent is allowed*."

Women: Mandy-Rae CRUICKSHANK (Canada) - (-)78m
21/03/2004 – Sea, Grand Cayman (Cayman Island, British West Indies)
Men: Herbert NITSCH (Austria) - (-)95m - 04/09/2003
Lake, Dellach, Millstätter See (Austria)

CONSTANT WEIGHT WITHOUT FINS (CNF)

"*The freediver descends and ascends under water using only his own muscle strength, without the use of propulsion equipment and without pulling on the rope*."

Women: Mandy-Rae CRUICKSHANK (Canada) - (-)41m
01/09/2003 - Sea, Vancouver, BC (Canada)
Men: Stig Aavall SEVERINSEN (Denmark) - (-)61m
28/09/2003 - Sea, Mochima National Park, Puerto la Cruz (Venezuela)

FREE IMMERSION (FIM)

"*The freediver dives under water without the use of propulsion equipment, but only by pulling on the rope during descent and ascent. Performances can be done head first or feet first during the descent*."

Women: Annabel BRISENO (USA) - (-)71m
15/11/2003 - Sea, Kona, Hawaii (USA)
Men: Martin STEPANEK (Czech Republic) - (-)102m
23/03/2004 - Sea, Grand Cayman (Cayman Island, British West Indies)

VARIABLE WEIGHT (VWT)

"*The freediver descends with the help of a ballast weight and ascends using his own strength: arms and/ or legs, either by pulling or not pulling on the rope. Freedivers descended head first with the older sleds but with the modern sleds, the descent tends to be feet first*."

Women: Tanya STREETER (USA) - (-)122m - 19/07/ 2003 - Sea, Providenciales, (Turks and Caicos)
Men: Patrick MUSIMU (Belgium) - (-)120m
12/11/2002 - Playa del Carmen (Mexico)

NO LIMIT (NLT)

"*The freediver descends with the help of a ballast weight and ascends via a method of his choice which could include an inflatable balloon, diving suit or vest*."

Women: Tanya STREETER (USA) - (-)160m
17/08/2002 – Sea, Providenciales (Turks and Caicos)
Men: Loïc LEFERME (France) - (-)162m
20/10/2002 – Sea, Nice (France)

The international hierarchical structure of AIDA is somewhat complicated. AIDA is made up of 32 national AIDA 'Members' who appear to take precedence over the

27 national AIDA ‘Contacts’. Fully constituted national ‘Members’ include named national representatives and national consultants, whereas fully constituted national ‘Contacts’ have two named contacts. There is no indication on the AIDA web site as to what is meant by the term national representative, national consultant or national contact. At the time of writing, the BFA, which is the UK national AIDA Member, has a nominated national representative and a national consultant.

And for those of you who have been unable to get Verdi’s slave girl of Amneris, the King of Egypt’s daughter, out of your minds since I first mentioned AIDA, yes, indeed there is an AIDA Egypt, which is one of the national AIDA Contacts with a nominated contact #1!

South Pacific region

What about representation in the South Pacific region? The only national AIDA Member state I could identify was that of Fiji, with a national representative but no national consultant. Australia is a national AIDA Contact with Sacha Dench of Freedive Australia being the first contact, and Scott Laverty of HMAS Penguin being the second contact. Their e-mail addresses are <sacha@freedive.com.au> and <scott.laverty@defence.gov.au> respectively. New Caledonia (AIDA France) and New Zealand are also both national AIDA Contacts each with a nominated contact.

The final port of call was the ‘Enter Freedive Australia’ web site.[3] However, this could not be accessed until the WARNING - DISCLAIMER gate had been cleared. This cautioned, like the BFA, that Freedive Australia accepts no liability for the various potential adverse outcomes associated with the interpretation, application, or instruction of any information presented within the web site.

The Freedive Australia web site has a selection of accessible topics under the following main headings:

- Training
- Why Freedive?
- Gear
- Adventures
- Meet the Experts!
- News
- Freediver Fun
- Message Board

In exploring the options, it was noted, in particular, that most of the data on the current world records page of the ‘Freedive News’ section were out of date, as compared with the data shown on the equivalent AIDA web page. For children you can go to ‘Amphibians with Attitude’, the Freedive Australia “*cool new marine studies programme and holiday for kids*”.

Finally, when passing through the WARNING - DISCLAIMER gate one comes across an additional barrier not mentioned earlier. This is the EXTRA WARNING, an absolute pièce de résistance, which reads as follows:

> *“Young adult males are the most likely to suffer from shallow water blackout, the most common freediving accident and are expressly asked NOT TO BE DICKHEADS and to respect their own limitations. Always dive with a competent and alert buddy”*

Now that is what I call a good, old-fashioned, in your face ockerism, or WYSIWYG in cyberspeak!

References

1 British Freediving Association. <www.britishfreediving.org>.
2 Association Internationale pour le Développement de L’Apnée (AIDA). <www.aida-international.org>.
3 Freedive Australia. <www.freedive.com.au>.

Nigel McKie, FAFOM,
Helston, Cornwall, United Kingdom
E-mail: *<nigelmckie@helston.fsbusiness.co.uk>*

Letter to the Editor

Dear Editor,

I am researching the history of recompression chambers (RCCs) in Australia. Based on my research to date, Australia’s first chamber was a Heinke chamber that came to Broome, Western Australia in 1914.[1]

A variety of RCCs were used during the next 50 years, mainly for the treatment of decompression illness using air tables. It was not until the mid-1960s that a chamber was purpose built for the use of hyperbaric oxygen therapy, and installed at the Prince Henry Hospital, Sydney.

To assist with my ongoing research, I welcome any contributions of information on chambers, their use and the people involved.

Sue Thurston,
Clinical Nurse Manager,
Department of Diving and Hyperbaric Medicine,
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Western Australia 6959
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Fax: *+61-(0)8-9431-2235*
E-mail: *<susan.thurston@health.wa.gov.au>*

Reference

1 Thurston S. The first Broome recompression chamber 1914-2004. *SPUMS J*. 2004; 34: 94-100.

SPUMS notices and news

South Pacific Underwater Medicine Society Diploma of Diving and Hyperbaric Medicine

Requirements for candidates

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

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

Additional information

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

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

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

The Academic Board reserves the right to modify any of these requirements from time to time.

The Academic Board consists of:
Dr Chris Acott, Education Officer, Professor Des Gorman and Associate Professor Mike Davis.
All enquiries should be addressed to the Education Officer:
Dr Chris Acott,
30 Park Aveneue
Rosslyn Park
South Australia 5072
Australia
Email: <cacott@optusnet.com.au>

Key words
Qualifications, underwater medicine, hyperbaric oxygen, research

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Minutes of the SPUMS Executive Committee teleconference, 9 March 2004

Opened: 1915 hr EST
Present:
Drs R Walker (President), G Williams (Immediate Past-President), C Meehan (Secretary), M Davis (Editor), A Patterson (acting Treasurer)
Apologies:
Drs M Bennett, S Mitchell, D Walker (committee members), D Doolette (Education Officer), D Smart (ANZHMG Representative)

1 Minutes of the previous meeting (25 October 2003)

Moved that the minutes be accepted as a true record, after minor corrections
Proposed, Dr R Walker, seconded Dr G Williams

2 Matters arising from the minutes

2.1 Improving our Internet cost effectiveness
Dr R Walker has information about a company that offers internet solutions including secure transactions and additional functionality. Dr Walker will obtain a full description of services offered, with a quote.

2.2 Update from Editor, Dr M Davis

A list of successful diplomates will appear in the March journal as planned.

There is a need to streamline the handling of mail to the SPUMS St Kilda address. It was suggested that all the mail to this address be directed to Steve Goble, the Administration Officer. He would sort the mail and forward on as required. Dr Davis will contact the College and Steve to inform them of this process.

There was a question regarding advertising in the Journal. A large proportion of this is regarding courses. There was some discussion as to whether there should be a charge for future advertising.

2.3 Revision of Society Rules and the constitutional changes required

The name of the Journal will change to "*Diving and Hyperbaric Medicine. The Journal of the South Pacific Underwater Medicine Society*".

Further changes to the wording in the constitution were discussed and notice was given to the Secretary for discussion of the changes at the AGM.

2.4 Dr Bennett was not available to give an update on the UHMS

2.5 Dr Doolette was not available to give an update.

It was noted that Dr Doolette had notified the Committee of his resignation as Education Officer, effective 1 March. There was some discussion as to a suitable and willing replacement. Dr R Walker will discuss suitable hand-over time with him. Other members of the Academic Board will have to keep it going until a suitable replacement can be found.

2.6 Update from ANZHMG Dr D Smart, not present

2.7 Update on replacement of Dr J Knight as the SPUMS representative on the Occupational Diving Committee

Dr David Smart will take over this position.

2.8 E-mail from Larry "Harris" Taylor

This seems to be an offer to contribute and maintain (validate once a month) a list of valid web links. Dr C Meehan will find out further details.

2.9 University of Auckland courses

Dr Mike Davis gave an update on the new University of Auckland PGDipMedSc - Diving and Hyperbaric Medicine course. It will commence second semester 2004.

2.10 CME points

Clarification of the position of the various colleges is being sought. At present, the conference is approved by RACGP and ANZCA. Annual approval is necessary for these.

3 Annual scientific meetings

3.1 2004 ASM Noumea, given by Dr Williams

3.2 2005 ASM will be at Coco Palm Resort and Spa, Maldives. Dr Meehan is the Convener.

3.3 NZ has been mentioned as an area for a future ASM.

4 Treasurer's report

Update on candidates for the position of Treasurer.

Dr Andrew Patterson will attend the meeting. He has officially agreed to stand in until the AGM. Nominations for the position will then be called for.

The Treasurer reports that the accounts are with the auditor. It is necessary to get a breakdown of costs of producing the Journal in order to finalise a budget.

5 Correspondence

None received

6 Other Business

None raised

Closed: 2045 hr EST

SPUMS Annual Scientific Meeting 2005

Preliminary Notice

2 – 9 May
CocoPalm Resort and Spa
Dunikolhu Island, Baa Atoll
The Maldives

Theme: Evolving Diving Practices

Principal Guest Speaker:
Michael A Lang
Marine Sciences Program and Scientific Diving Officer
Smithsonian Institute, USA

Conference Convenor: Dr Cathy Meehan,
McLeod Street Medical Clinic,
67 McLeod Street,
Cairns, Queensland 4870,
Australia
E-mail: <cmeehan@ozemail.com.au>

In memoriam

It is with immense regret that the Society has heard of the recent death of Dr Tony Slark after a brief illness. Tony was a Life Member and Past-President of the Society. The President extends the Society's deepest condolences to his wife, Eileen, and her family in their loss.

Slark A. Doctor to the divers. *SPUMS J*. 2003; 34: 145-8.

ANZ College of Anaesthetists Certificate in Diving & Hyperbaric Medicine Examination

Applicants who did not meet the criteria for the award of the Foundation Certificate in Diving & Hyperbaric Medicine of the ANZ College of Anaesthetists by 30 June 2003 are advised that they may be eligible to present for the examination for the Certificate.

The criteria for examination are:

1 Possession of a specialist qualification registrable in Australia/New Zealand
2 Possession of DipDHM
3 Minimum of 6 months' experience in anaesthesia
4 At least 12 months' *full-time equivalent* experience in diving and hyperbaric medicine in a hyperbaric department (accredited or to be accredited by ANZCA)
5 Currently working in diving and hyperbaric medicine

Trainee registration (one-off fee): $300.00
Examination fee: $500.00
Annual fee for certificate holders: $100.00
The interim regulation expires on 31 December 2004, after which time all candidates must meet the requirement of the SIG Workbook and the requisite training time.

Intending candidates are requested to contact Ms Helen Morris at ANZCA for further information:
The Australian and New Zealand College of Anaesthetists
'Ulimaroa', 630 St Kilda Road
Melbourne, Victoria 3004, Australia
***Phone:** +61-(0)3-9510-6299*

ANZCA DHM Certificate Examination

Please be advised that dates for the 2004 Inaugural DHM Certificate Examination have been confirmed as follows:

Closing Date for Applications - 9 August
Written Examination - Week commencing 11 October
Oral Examination - 29 October

Written papers will be taken at ANZCA-accredited DHM centres, under the supervision of Departmental Directors. The Oral Examination will be held at ANZCA House in Melbourne.

The exams will be coordinated by Ms Cherie Wilkinson, Manager of Trainees and Examinations. Registration forms and examination application forms should also be forwarded to Ms Wilkinson.

Please do not hesitate to contact me if I can be of any further assistance.

W R Thompson
Chair, Courses Subcommittee

Diving-related fatalities document resource

All the coronial documents relating to diving fatalities in Australian waters up to and including 1998 have now been deposited by Dr Douglas Walker for safe keeping in the National Library of Australia, Canberra.

These documents have been the basis for the series of reports previously printed in this Journal as Project Stickybeak.

These documents will be available free of charge to bona fide researchers attending the library in person, subject to the stipulation that the researcher signs an agreement that no identifying details are to be made public.

Accession number for the collection is: MS ACC 03/38.

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

SPUMS Journal CD

The SPUMS Journal, volumes 1-30, is available on CD.

To read and print these documents Adobe Acrobat Reader (version 3 or later) is required. This may be downloaded free of charge from the Adobe web site <www.adobe.com>

The CD is available to members for Aust $25 (incl. GST or overseas mailing). The cost to non-members and institutions is Aust $90 inclusive. Supplies are limited.
Cheques or money orders should be made payable to: 'South Pacific Underwater Medicine Society'.
Credit card facilities are not available for this.

Contact: Steve Goble, Administrative Officer
E-mail: <stevegoble@bigpond.com>

Articles reprinted from other journals

Longitudinal study of childhood wheezy bronchitis and asthma: outcome at age 42

Elisabeth Horak, Anna Lanigan, Mary Roberts, Liam Welsh, John Wilson, John B Carlin, Anthony Olinsky, Colin F Robertson

Longitudinal studies have reported that asthma in childhood has a good prognosis. However, most of these studies have not taken into account the severity of childhood symptoms.[1] The Melbourne Epidemiological Study of Childhood Asthma recruited children at age 7 years and followed them up through adolescence to adulthood.[2-5] This report describes outcome at age 42 years in relation to symptoms in childhood.

Participants, methods, and results

In 1964, 401 children (295 with asthma and 106 controls) were randomly selected from a total of 30,000 7 year olds living in metropolitan Melbourne. A further 83 children with severe asthma were included from the same cohort in 1967, at age 10.[2,3] Original data were available for 479 participants.

At recruitment, 105 children were classified as controls (children who had never wheezed); 74 had mild wheezy bronchitis (<5 episodes of wheezing associated with respiratory tract infection); 104 had wheezy bronchitis (=5 episodes of wheezing associated with respiratory tract infection); 113 had asthma (wheezing unassociated with respiratory tract infection); and 83 had severe asthma (onset of asthma symptoms before 3 years of age, persistent symptoms at age of 10, and barrel chest deformity or ratio of forced expiratory volume in one second to forced vital capacity 50%).

At each review from the age of 21, participants were classified as follows: no recent asthma (no wheeze in past three years); infrequent asthma (wheezing in past three years but none in past three months); frequent asthma (wheezing in past three months, but less than once a week); or persistent asthma (wheezing in past three months, more than once a week).

Fifteen of the original cohort had died at follow up, one from asthma. Of the remaining 464, 403 participated in the current review, giving a continuing participation rate of 87%. In all, 267 participants attended the laboratory for measurement of lung function. We calculated mean values of lung function using standard two sample t tests and confidence intervals of the mean by standard methods.

The table shows the clinical expression of asthma at age 42 according to severity of disease at recruitment. The distribution of severity at age 42 has not changed from that at age 35.[5] The proportion of cases with no recent asthma has increased steadily from 20% at age 14 years to 40% (126/317) at age 42.

Lung function was similar to that of controls in participants who had had wheezy bronchitis in childhood. Participants who had had asthma aged 7 had reduced lung function at age 42.

Comment

Our study shows that the pattern of asthma during childhood predicts outcome. Most children with persistent asthma had continuing symptoms into adult life and reduced lung function. However, children who had intermittent symptoms associated with respiratory tract infections generally had complete resolution of symptoms in adult life. The small number of participants who still had mild, intermittent symptoms at age 42 had normal lung function. This good outcome was achieved despite the fact that anti-inflammatory treatments were not available for most of their childhood.

References

1 Ahmed IH, Sanet JM, The natural history of asthma. In: Murphy S, KelIy HW, eds. *Pediatric Asthma*. Vol 126. New York: Marcel Dekker; 1999. p. 41-69.
2 Williams HE, McNichol KN. Prevalence, natural history and relationship of wheezy bronchitis, and asthma in children: an epidemiological study. *BMJ*. 1969; iv: 321-5.
3 McNichol KN, Williams HB. Spectrum of asthma in children. I Clinical and physiological components. *BMJ*. 1973; iv: 7-11.
4 KelIy WJ, Hudson I, Phelan PD, Pain MC, Olinsky A. Childhood asthma in adult life: a further study at 28 years of age. *BMJ*. 1987; 294: 1059-62.
5 Oswald H, Phelan PD, Lanigan A, Hibbert M, Bowes G, Olinsky A. Outcome of childhood asthma in mid-adult life. *BMJ*. 1994; 309: 95-6.

Horak E, Lanigan A, Roberts M, Welsh L, Wilson J and 3 others. Longitudinal study of childhood wheezy bronchitis and asthma: outcome at age 42. Reprinted with kind permission from *BMJ* 2003; 326: 422-3.

Key words
Asthma, children, health surveillance, research

A Longitudinal, Population-Based, Cohort Study of Childhood Asthma Followed to Adulthood

Malcolm R Sears, Justina M Greene, Andrew R Willan, Elizabeth M Wiecek, D Robin Taylor, Erin M Flannery, Jan O Cowan, G Peter Herbison, Phil A Silva, Richie Poulton

Abstract

Background: The outcome of childhood asthma in adults has been described in high-risk cohorts, but few population-based studies have reported the risk factors for persistence and relapse.

Methods: We assessed children born from April 1972 through March 1973 in Dunedin, New Zealand, repeatedly from 9 to 26 years of age with questionnaires, pulmonary-function tests, bronchial-challenge testing, and allergy testing.

Results: By the age of 26 years, 51.4 percent of 613 study members with complete respiratory data had reported wheezing at more than one assessment. Eighty-nine study members (14.5 percent) had wheezing that persisted from childhood to 26 years of age, whereas 168 (27.4 percent) had remission, but 76 (12.4 percent) subsequently relapsed by the age of 26. Sensitization to house dust mites predicted the persistence of wheezing (odds ratio, 2.41; P = 0.00l) and relapse (odds ratio, 2.18; P = 0.0l), as did airway hyperresponsiveness (odds ratio for persistence, 3.00; P < 0.00l; odds ratio for relapse, 3.03; P < 0.00l). Female sex predicted the persistence of wheezing (odds ratio, 1.71; P = 0.03), as did smoking at the age of 21 years (odds ratio, 1.84; P = 0.0l). The earlier the age at onset, the greater the risk of relapse (odds ratio, 0.89 per year of increase in the age at onset; P < 0.00l). Pulmonary function was consistently lower in those with persistent wheezing than in those without persistent wheezing.

Conclusions: In an unselected birth cohort, more than one in four children had wheezing that persisted from childhood to adulthood or that relapsed after remission. The factors predicting persistence or relapse were sensitization to house dust mites, airway hyperresponsiveness, female sex, smoking, and early age at onset. These findings, together with persistently low lung function, suggest that outcomes in adult asthma may be determined primarily in early childhood.

Key words
Asthma, children, health surveillance, research

Sears MR, Greene JM, Willan AR, Wiecek EM, Taylor DR and 5 others. A longitudinal, population-based, cohort study of childhood asthma followed to adulthood. Reprinted with kind permission from *N Engl J Med*. 2003; 349: 1414-22.

Commentary by Paul Thomas

> *"Give me the boy until age seven, and I will show you the man."*

Melbourne researchers took children at age seven with asthma and have followed them up for nearly 40 years. This has spawned a number of papers relating to the prognosis for children with asthma and has provided much useful information, leading to predictions about the prognosis for childhood asthma, rather like the quotation above from the Jesuits who predicted that they could influence adult behaviour if given the child at an early stage.

The study shows that those with 'mild wheezy bronchitis' or 'wheezy bronchitis' would have few symptoms and normal lung function at age 42. Those who had severe asthma, which in this study would be persistent asthma (as opposed to severe episodic asthma) tended to have a reduction in lung function (mean FEV_1 85% of predicted), and were more likely to have asthma persisting into their current life.

What does this mean for the diving community? It suggests that if asthma is mild in childhood it will most likely resolve in adult life and there will be no residual decrement in resting lung function. It does not exclude the fact that these individuals may have a hyper-reactive response to inhaled bronchial challenge testing. Those who had severe disease as a child are likely to have persisting symptoms and clinical features of asthma.

While these results may not be entirely surprising it does suggest that mild asthma of childhood is less likely to be associated with symptoms or abnormal spirometry. They may have airway hyper-reactivity (untested in this study), but does such hyper-reactivity matter or mean anything? We would not treat airway hyper-reactivity without symptoms.

The study by Sears et al used a large group of children recruited in New Zealand, who have been followed up since initial assessment at age three years, but first reviewed for asthma at age nine years. They were reviewed every two years thereafter until age 15, then at 18, 21 and 26 years old. The drop-out rate was relatively low considering the time and number of interventions that were performed (40%). The reported rates of ever having had wheezing were high at 72.6%, suggesting that a single episode of wheezing should not be classified as asthma. Nonetheless, 26.9% were classified as having continuing symptoms of asthma, which is a high prevalence rate, while two thirds were thought to have had remission from their asthma, although this includes all those who ever wheezed.

The risk of relapse was associated with an early age of onset, atopy (especially sensitivity to house dust mite) and airway hyper-reactivity, while smoking may or may not be a risk factor. Again, while increased airway reactivity is associated with an increased risk of having asthma later in life, it would be interesting to see how many with airway reactivity were essentially asymptomatic and had normal spirometry. This information would be within this data set, but cannot be derived from the tables provided.

In summary, the studies are interesting, showing that two thirds of those with childhood asthma have remission, thus providing a guide to the prognosis of childhood asthma. The studies do not help us make any assessment for diving in relation to asthma. It will be interesting to see the data that emerge using self-reporting surveys from asthmatic divers. There are obviously many people who dive, who have airway hyper-reactivity, and who have not had any problems.

Dr Paul Thomas is Associate Professor in Respiratory Medicine, Faculty of Medicine, University of New South Wales, at the Prince of Wales Hospital, Randwick, New South Wales 2031, Australia.
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Health outcome following multi-day occupational air diving

Doolette D J

Anaesthesia and Intensive Care, The University of Adelaide, Australia 5005

Acclimatization to decompression stress has been reported in caisson workers and helium-oxygen divers; however the alternative notion that the risk of decompression sickness increases with successive days of diving is widespread. We examined 201 multi-day series of 2 to 29 diving days identified retrospectively in a database of occupational air dives for evidence of acclimatization or sensitization. Decompression related health status was measured using a self-administered diver health survey; resulting scores were analyzed by linear modelling. Daily diving consisted of 1-3 dives each to mean maximum depth of 17.2 (SD 3.9) meters seawater for a mean duration of 23 (SD 17) min. Daily diver health scores increased with calculated daily risk of decompression sickness but were not influenced by the order of dives in multi-day series. Poor health outcome indicated by treated decompression sickness and diver health scores > 8 occurred early in multi-day series. There was no evidence of sensitization to decompression stress whereas the timing of poor health outcomes suggests an element of acclimatization.

Key words
Decompression sickness, risk factors, health surveys, health status, diving, occupational health

Doolette DJ. Health outcome following multi-day occupational air diving. Reprinted with kind permission from *Undersea Hyperb Med*. 2003; 30: 127-34.

Editor's comment:

This is one of several papers from Dr Doolette examining the use of a health survey questionnaire (DHS) in field studies of divers. High DHS scores appear to correlate with the occurrence of decompression sickness and may be a useful way to assess decompression stress. Whilst these studies look promising, they have not been corroborated yet by other groups.

Book reviews

Proceedings of the Fourteenth International Congress on Hyperbaric Medicine

Frederick S Cramer, Paul J Sheffield (editors)

368 pages, hardback
ISBN 0-930536-13-5
Flagstaff, Arizona: Best Publishing Company; 2003
Available from Best Publishing Company, P O Box 30100, Flagstaff, Arizona 86003-0100, USA.
Phone: (+1) 928 527 1055; **Fax:** (+1) 928 526 0370
E-mail: <divebooks@bestpub.com>
Copies can be ordered online at <www.bestpub.com>
Price US$48.50, postage and packing extra

The appeal of the International Congress on Hyperbaric Medicine (ICHM) meetings is that they are held in a different country every three years and have a very inclusive philosophy that allows a wide range of opinion to be presented. It is the responsibility of the host president to organise the meeting in his/her own country. There is generally a study tour of the local hyperbaric facilities following the academic meeting. This can offer a fascinating insight into local practices and techniques. I well remember attending the Japan meeting where I found that stroke and a range of acute neurological indications were routinely treated with hyperbaric oxygen (HBOT). Asking the Japanese doctors about their supporting evidence was a little like asking a family practitioner why he uses antibiotics for otitis media. The irony is that neither have the evidence. So in reading these proceedings you are afforded a glimpse of what other doctors are doing with HBOT.

Paul Sheffield coordinated the scientific programme of 35 presentations and 35 posters. It started with historical perspectives on the Congress and on the development of HBOT in Holland, Japan, California and Texas. Oral presentations were divided into the physiological and biochemical effects of oxygen, bubble-related disorders, the clinical application of HBOT and patient safety. The Pacific Chapter of the Undersea and Hyperbaric Medicine Society (UHMS) co-convened their annual scientific meeting. The final session, moderated by Jim Joiner, concentrated on the use of HBOT in cerebral palsy and brain injury.

Fife presented a series of severe lower extremity wounds where the addition of the VAC™ negative pressure dressing to HBOT salvaged limbs expected to be amputated. Lampl reviewed the use of HBOT for intracranial abscess management and concluded that mortality was reduced. Feldmeier contrasted the processes of angiogenesis in wound healing and cancer growth. Collagen production or release has not been shown to be part of the events needed to successfully generate tumour angiogenesis. Yagi presented a case report of life and limb salvage with HBOT for *Vibrio vulnificus* septicaemia and cellulitis.

Morales reported a trial from six centres in Mexico involving 101 patients with “certain neurological disorders”. They were aged up to 20 years and had had no response to a course of HBOT. Apparently 65–70% of such patients do not benefit from HBOT in their experience. Hair analysis was used to make the diagnosis of heavy metal toxicity, with 17 excluded as this result was negative. The remainder (79) had detoxification for three months using chelating agents. The second phase was 40 HBOT sessions at 1.7 ATA for one hour. I will quote the entire results *“… marked decrease in heavy metal toxicity and demonstrated significant increases and prolonged changes which have persisted in the overall assessment of gross motor function, speech, memory, attention and functional skills.”* There are no tables or details of the assessments performed.

Neubauer presented two cases from his experience of treating 400 cerebral palsy and brain-injured patients. The first case is particularly dramatic with a five-year-old boy learning to sit up, crawl, walk with assistance and stop his anticonvulsant medication. SPECT scan showed substantial improvements in both cerebral hemispheres. The second case of a four-year-old girl also showed SPECT improvements with 149 treatments. She was more alert, attempting to speak, had less spasticity, but was still unable to crawl or roll over. She needed to return for more treatment and the possible use of growth hormone.

Two studies by Barboza report the use of sheep-produced embryonic cells and HBOT. Twenty-nine children with cerebral palsy or brain injury showed ‘remarkable changes.’ Thirteen patients with cervical or thoracic spinal cord injuries had embryonic cells implanted at the lesion, HGH injections, antioxidants and HBOT. Five apparently did well, but no consideration was given to incomplete lesions making a natural recovery. There were no institutional ethical review or consent process details.

These proceedings are the latest in the ICHM series, and as usual, represent a ‘curate’s egg’. Some of the scientific work is excellent and some dreadful. Every dedicated hyperbaric doctor should have one on the library shelf for the vast array of experiential information. They can be helpful for answering difficult questions on topics lacking scientific data. And the articles are sometimes the basis for an Internet misrepresentation. Please approach this publication with an open mind and the evidence-based filter switched off.

Martin Hodgson
Hyperbaric Unit, Vaucluse Hospital, Melbourne
Dr Hodgson is a life member of ICHM but did not attend the San Francisco meeting.

Key words
Book reviews, meetings, hyperbaric oxygen

Report on decompression illness, diving fatalities and project dive exploration

The DAN annual review of recreational scuba diving injuries and fatalities, based on 2001 data

132 pages, soft cover
2003 edition
ISBN 0-9673066-3-9
Published by Divers Alert Network,
Center for Hyperbaric and Environmental Physiology,
Box 3823, Duke University Medical Center,
Durham, NC 27710, USA

SPUMS readers may be familiar with the annual review of DAN data on recreational scuba injuries and fatalities. This edition is expanded by data from Project Dive Exploration (PDE), which is an ambitious attempt to collect prospective and accurate data on diving habits. This review summarises some of the interesting features of the annual review and makes some general comments on PDE. Some of the highlights of PDE are planned for the next edition of this journal.

Diving fatalities in US and Canadian residents peaked in 1977 at 147 and have reduced to 77 in 2001 (the year reported in 2003). Figures for diving injuries have not declined although it is hard to draw conclusions from this. As in other areas of medicine, mortality statistics may be a little more accurate than morbidity, and reporting to DAN has probably improved over the last 20 years.

The median age of 414 injured divers was 38.2 years, older than previously. DAN are very objective in reporting style. Taking age as an example, the publication would be more enjoyable for the reader by adding some expert commentary on why this has happened. Is it true or spurious? Are there more divers in the older age group or are older divers at greater risk? Do they have more medical conditions which might contribute, or are they less physically fit? Do we know and will PDE help inform us? I find the statistics fascinating but frustrating! Of injured divers, 6.4% reported existing asthma. This figure seems high but would be more informative with a description of medical certification policies for asthma in the US and the prevalence of asthma in the US population.

Eighty-five percent of divers were using air as breathing gas, showing a small increase in mixed-gas injuries. Another trend is the lower use of tables by injured divers and more divers using no decompression planning. Arterial gas embolism (AGE) usually occurred on the first day of diving, while decompression sickness (DCS) spreads over the whole dive series.

Rapid ascent was the most common problem to be reported during a dive leading to injury. Feeling cold and extra exertion were also common. Twenty-three percent of injured divers reported altitude exposure after diving. Of these, 60% developing DCS symptoms during or after diving had not waited 24 hours, and only one case had a surface interval of greater than 48 hours before flying. Is 24 hours long enough to wait before flying after diving?

A pleasing trend was an increase in the use of surface oxygen to 43% from 20% the year before. Delay to recompression is fairly evenly spread to 72 hours with AGE treated a little quicker. Only 80% had complete resolution of symptoms and outcome was stable by three months. Do divers realise that they have a 20% chance of permanent sequelae if they get bent?

Seventy-seven diving deaths were reported with 60% aged 40 to 59 years (average 43 years). Older divers were thus injured and died quite frequently. Of equal or greater concern, 5% of fatalities were aged 10 to 19. The advanced age of fatalities may be reflected in the years since certification, which shows two peaks at one year or less, and over six years. Very experienced divers may have health problems or be doing more hazardous diving.

Alcohol or drug use was found in 10% of fatalities and, although the leading contributing factor, 10% is much lower than the rate generally reported in statistics for drowning and vehicular accidents. The comparison to other databases is very informative for the reader and contributes greatly to the knowledge to be gained from statistics. Unfortunately, this was one of only a few such comparisons given.

Buoyancy problems were encountered by 60% of fatalities with the obvious equipment problems of BCD, regulator and weight belt in 31%. The causes of death were given as drowning in 62%, body not recovered in 10% and AGE in 9%.

The reviewer is enthusiastic about data on diving because diving physicians have had to advise divers on the basis of opinion not supported by data. Any criticism here is not lack of support for DAN and their work, but rather a desire to gain wisdom from the information presented. Some commentary and discussion of the data presented would add greatly to its value. Exactly these issues have led DAN to embark on PDE. PDE collects data on all dives by a cohort of divers over an extended period. It provides a denominator for incidents, injuries and deaths. Will it give us the answers?

Graham McGeoch
Hyperbaric Medicine Unit, Christchurch Hospital

Key words
Book reviews, scuba diving, accidents, deaths

Experimentations on laws of nature in swimming pools

Francis Collard and Frédéric Collard
80 pages, soft cover
Copyright registration number D/2000/8748/7
Brussels: Editions GUILIM; 1996

Scuba diving for children: swimming pool training

Frédéric Collard
154 pages, soft cover
Copyright registration number D/2000/8748/8
Brussels: Editions GUILIM; 1996

Scuba diving for children: physiology, structures and organisation

Francis Collard and Frédéric Collard
156 pages, soft cover
Copyright registration number 2001/8748/10
Brussels: Editions GUILIM; 1996

Available from Sprl GUILIM, Place Danco 1, 1180 Brussels, Belgium.
Fax: +32-(0)2-346-7602
E-mail: <libglobe@pophost.eunet.be>
Web site: <www.synec-doc.be/librairie/globe>
Price: 15.00 Euro

These three books are part of a series of five volumes of reference manuals for instructors involved in teaching children to scuba dive. They are recommended by the Confederation Mondiale des Activities Subaquatiques (CMAS) and are supported by the dive equipment manufacturer Mares. The authors, a father and son team, both have master's degrees in engineering and extensive scuba experience. Francis Collard is the President, and Frédéric the Vice President, of the Club des Marmottes et Castors Palmes, a Belgian scuba training school that specialises in scuba diving training for children.

The three books are very different in style and purpose, but the theme is focused around finding fun, imaginative and safe ways to teach children, 8-14 years old, basic diving knowledge. It is clear that the book was not written by someone whose first language is English, as there are numerous spelling errors, grammatically incorrect sentence structures and unusual phrases. Sometimes this is a struggle to interpret but, in general, the meaning is obvious and the quirky English brings a smile to the reader's face. However, for an international readership, the English edition needs much better translation from the French in the future.

Volume 1. ***Experimentations on laws of nature in swimming pools: an illustrative teaching of the laws of nature for the scuba diver***

This offers suggestions of how, with a little help from items such as plastic bottles, balloons, glass jars and plastic tubing, an instructor can demonstrate the various laws of physics in a practical and fun way. Each experiment is laid out in six steps: target (objective), pre-requisite (relate to previous experiments), explanation, experiment, materials and assembly. To assist with the interpretation of some of the English, I found it easier to read the materials and assembly before the instructions of the experiment. The clear photographs and diagrams helped enormously. The experiments first provide an understanding of the law and then apply this to diving. For example, utilising a plastic bottle to demonstrate the compressibility of air, in relation to depth, to illustrate Boyle's Law. Then using a glass jar and a balloon to demonstrate the effect of hydrostatic pressure on a membrane and how pressure affects the behaviour of the eardrum. This book was a very quick read, taking less than an hour, and provided some excellent suggestions for practical demonstrations.

Volume 2. ***Scuba diving for children: swimming pool training***

This book builds a structure for swimming pool lessons and gives the instructor options for practical exercises as the 'Marmotte' progresses through the levels of Bronze, Silver and Gold Dolphin Award Certifications. Games involving coloured pegs, hoops and plastic frames are suggested to make learning imaginative and fun. The exercises focus on the principles of fin swimming, weight adjustment, diving without a mask, mask clearing, snorkel clearing, buoyancy and communication. Initially the children become water confident in skills without a scuba cylinder, then use a cylinder lying on the floor of the pool, and eventually progress to wearing a full set of scuba. I note that the pool exercises include ascent training without a regulator, something which many would consider an unnecessary risk.

Volume 3. ***Scuba diving for children: physiology, structures and organisation***

The first chapter emphasises the requirements of a scuba instructor involved in teaching children. Not only is there an emphasis on a high level of skills, but also on the additional considerations of emotional, social and cultural aspects, as well as moral and legal responsibilities. The section on children's physiology covers broad topics from the respiratory, circulatory, ENT and nervous systems, and growth and development, through to drowning and resuscitation techniques. Whilst the information appears accurate, there are no references to the scientific literature or medical text books. Indeed, some of the extrapolations that are made regarding the significance of a physiological 'fact' to the diving environment seem to be the authors' opinions, and, in the absence of research data or a body of evidence, may or may not be correct. The book quotes the incidence of unexplained accidents when referring to decompression illness as "*an average of three occurrences per year over a sample of 10,000 scuba divers in Belgium*" but there is no reference allowing the reader to find out more information. The rest of the book covers instruction, equipment, pool lessons and open water dive travel.

Volumes 4 and 5 were not reviewed, but are entitled *Diving and didactical equipment* and *Open water diving travel and specializations* respectively.

Summary

The enthusiasm and passion of the authors in teaching children definitely show through in the books, as they try to provide a comprehensive guide which covers everything an instructor would want to know on the subject. Their engineering background and diving experience are undoubted strengths, but a medical co-author for the physiology chapters would have been an enhancement. On a practical note, the books would have benefited from an Index. They should have been proof read by a person fluent in English, who also had an understanding of the diving environment and some medical knowledge.

Lynn Taylor, PhD
National Dive Safety and Education Coordinator, New Zealand Underwater Association

Key words
Book reviews, scuba diving, children, training

Editor's note:

The authors of these manuals worked with Dr Guy Vandenhoven in the study on training children published in the SPUMS Journal in 2003.[1] This generated controversy, some of which appeared in the Journal. In the same issue Dr Taylor, a PADI IDC Staff Instructor, reviewed the PADI publication on teaching children to dive.[2] We were challenged by Dr Carl Edmonds to have failed to reveal a conflict of interest here. It seemed only reasonable, therefore, to ask Dr Taylor to review the 'rival' publication!

The medical implications of children diving remain unclear. Good, large longitudinal epidemiological studies are needed. The inherent difficulties and costs of such work make it unlikely we will see clear answers to these questions. If children are to dive, then their training must be done very well. Both the PADI and CMAS approaches, different though they are in some respects, achieve this.

References

1 Vandenhoven G, Collard F, Schamp E. Children and diving: medical aspects. *SPUMS J.* 2003; 33: 70-3.
2 Taylor L. Children and scuba diving: a resource guide for instructors and parents. *SPUMS J.* 2003; 33: 90.

The Poetry Doctor

John Parker

My bliss

The surface is a barrier
'Tween peaceful calm and stress,
Of which I am a carrier
That gives my life duress.
But when I dive and slowly sink
Beneath the watery waves,
I feel my mind begin to think
That, though I am enslaved,
Once in this weightless relaxed state
My spirit is set free
To escape the rut and navigate
Uncharted territory.

I feel as if I'm floating high,
As if I could be drugged.
Yet I'm alert, my mind can fly,
Restricting thoughts unplugged.
I feel my scalp is slowly smoothed
By all my exhaled bubbles,
That caress, stroke and gently soothe
And blow away my troubles.
I feel my muscles become less tight
With stretching and slow finning.
My mood lightens, I feel delight
And laughter bubbles, grinning.

I stare in awe at my surrounds,
An underwater shrine.
Wondrous beauty that abounds,
Whose hand is this design?
I rise with wonder and elation,
Sink into a meditation.
Absorbed within my inner being,
Flushed with feelings of wellbeing.
But soon enough I must return
To the pressures of one bar.
But to know each dive I learn
How special these times are.

Dilemmas

When I dive I marvel at nature.
The depths lift my spirit by such scenes heaven-sent,
But though I am gripped by its beauty and wonder,
I know I can't stay there or else I'm hellbent.

<www.thepoetrydoctor.com>

EUROPEAN UNDERWATER AND BAROMEDICAL SOCIETY
30TH ANNUAL SCIENTIFIC MEETING

Dates: September 15 to19, 2004
Venue: Ajaccio, Corsica
Convenor: Dr Bruno Grandjean
Congress organisation: Atout Corse
1, rue Saint Roch,
20000 Ajaccio, Corsica
Phone: +33-(0)495-225293
Fax: +33-(0)495-511040
E-mail: <eubs2004@wanadoo.fr>
Web site: <www.eubs.org>

HISTORICAL DIVING SOCIETY, UK

The Historical Diving Society, UK will be holding their Annual Conference in the Lecture Theatre of Hull Royal Infirmary on Saturday 23 October 2004. The speakers are:

George Wookey: *100 fathoms down – the story of a Royal Navy record dive and a life of adventurous diving*
David Challis: *Jeremiah Murphy. West Indies salvage diver, 1855 - 1895*
Michael Jung: *Sabotage! German military diving from the beginning of the eighteenth century to 1945*
Stéphanie Chanvallon: *The development of fins – a study of invention and evolution*

Enquiries: The Secretary, Historical Diving Society, 25 Gatton Road, Reigate, Surrey, RH2 0HB, UK

HISTORICAL DIVING SOCIETY
AUSTRALIA, SE ASIA

All enquiries to:
Historical Diving Society ASEA,
PO Box 2064,
Normansville, SA 5204, Australia
Phone: +61-(0)8-558-2970
Fax: +61-(0)8-558-3490
E-mail: <bramsay@iaccess.com.au>

ROYAL AUSTRALIAN NAVY MEDICAL OFFICERS' UNDERWATER MEDICINE COURSE 2004

Dates: 22 November to 3 December, 2004
Venue: HMAS Penguin
The Medical Officers' Underwater Medicine Course seeks to provide the medical practitioner with an understanding of the range of potential medical problems faced by divers. Considerable emphasis is placed on the contraindications to diving and the diving medical, together with the pathophysiology, diagnosis and management of the more common diving-related illnesses.
Cost: $Aus1833.00 (tbc)
For information and application forms contact:
The Officer in Charge, Submarine & Underwater Medicine Unit, HMAS PENGUIN,
Middle Head Rd, Mosman, 2088 NSW, Australia
Phone: +61-(0)2-9960-0572
Fax: +61-(0)2-9960-4435
E-mail: <Sarah.Sharkey@defence.gov.au>

Wanaka Conference 2005

Edgewater Resort, Wanaka, New Zealand
12-16 September 2005

The goals of the meeting are to combine continuing medical education, stimulating presentations, professional interaction and the exhilaration of skiing and snowboarding with family and friends. Presenters will be distinctly multi-disciplinary, allowing conference delegates to learn of clinical advances from leading clinicians in a variety of fields. Presentations will focus on delivering information in an entertaining, vibrant format. Physicians from Emergency Medicine, Radiology, Intensive Care, Obstetric Medicine, Orthopaedics, Otolaryngology, Sports Medicine, Vascular Surgery, Gynaecology and Diving Medicine are already represented.
For further information: contact Dr Greg Emerson
Phone: +61-(0)7-3636-7901
E-mail: <Greg_Emerson@health.qld.gov.au>
Web site: <www.wanakaconference.com>

MEDICAL AND LEGAL CONFERENCES 2004
Australian Medico-legal Conference

Dates: 8 to 15 August, 2004
Venue: Perisher Blue, NSW

Pacific Rim Medico-legal Conference

Dates: 25 September to 2 October 2004
Venue: Heron Island, Great Barrier Reef
Conference Director: Lorenzo Boccabella
E-mail: <conference@barweb.com.au>
Web site: <barweb.com.au>
We are now an endorsed provider of CME for the RACGP

JAMES COOK UNIVERSITY AND ANTON BREINL CENTRE FOR PUBLIC HEALTH AND TROPICAL MEDICINE

Tropical marine and diving medicine (TM5508:03)

Location: Townsville
Availability: Semester 2, external subject with compulsory limited attendance residential
Dates: 18 - 22 October 2004
Staff: Associate Professors G Gordon and P Leggat
Cost: $Aust 1,260.00
Overview: This subject, conducted in association with the Townsville Hospital, presents the basic principles of underwater and hyperbaric medicine over a five-day residential programme. A series of lectures, demonstrations and practical sessions highlight the taking of a diving history, performing a diving medical examination, decompression sickness, management of near drowning, hypothermia, sinus and ear barotrauma, diving equipment, gases, physiology, diving hazards and diving techniques. A hyperbaric unit is located at the Townsville Hospital. Optional dives may be conducted.

For further information or to enrol contact:
Marcia Croucher, Senior Student Officer,
Anton Breinl Centre for Public Health and Tropical Medicine,
James Cook University,
Townsville, Queensland 4811, Australia
Phone: +61-(0)7-4781-6107
E-mail: <sphtm-studentofficer@jcu.edu.au>

ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE COURSES 2004

Medical Officers Course

August 2004

Basic	2/8/04	to	6/8/04
Advanced	9/8/04	to	13/8/04

November 2004

Basic	8/11/04	to	12/11/04
Advanced	15/11/04	to	19/11/04

DMT Full Course

October/November 2004 3 weeks, 25/10/04 to 12/11/04

DMT Refresher Course

August 2004 2 weeks, 2/8/04 to 13/8/04 (2nd week optional)
November 2004 1 week (Wk 2), 1/11/04 to 5/11/04

For further information or to enrol contact:
The Director, Hyperbaric Medicine Unit,
Royal Adelaide Hospital, North Terrace,
South Australia 5000.
Phone: +61-(0)8-8222-5116
Fax: +61-(0)8-8232-4207

THE UNIVERSITY OF AUCKLAND
FACULTY OF MEDICAL AND HEALTH SCIENCES

Postgraduate Diploma Medical Science – Diving and Hyperbaric Medicine

Applications are now being accepted from registered medical practitioners for the Postgraduate Diploma Medical Science – Diving and Hyperbaric Medicine in the Faculty of Medical and Health Sciences, the University of Auckland. The Diploma can be completed in one year or spread over 2 years part time.
Availability: This new programme will be available in full from the first semester 2005.
Staff: Professor D Gorman, Associate Professor M Davis and other members of Faculty of the Occupational Medicine Unit, Department of Medicine.
Overview: The Diploma is designed as a distance learning programme, available internationally and without a resident component in Auckland. However, some courses require prior or concurrent attendance at a recognised residential course in diving and hyperbaric medicine available within Australasia, and one an attachment to a hyperbaric medicine unit. Graduates will be able to practise effective clinical diving medicine in a primary care setting or to embark on clinical practice within a hyperbaric medicine environment.

The paper titles are:

- Physiology and medicine of diving
- Health surveillance of divers and hyperbaric workers
- Hyperbaric medicine
- Clinical diving and hyperbaric practice
- Research essay in diving or hyperbaric medicine
- Research project in diving or hyperbaric medicine

For further information, including fees, please contact the Course Coordinator: Jessica Rorich
Phone: +64-(0)9-373-7599, extn 88489
Fax: +64-(0)9-308-2379
E-mail: <occmed@auckland.ac.nz>
Full information on courses and admission regulations is available in the University of Auckland Calendar or at <http://www.auckland.ac.nz>

UNDERSEA AND HYPERBARIC MEDICINE SOCIETY

38th Annual Scientific Meeting 2005
Preliminary Notice

Dates: June 16-18
Pre-courses: June 15
Venue: Flamingo Hotel, Las Vegas, Nevada
For more information contact: Lisa Wasdin, UHMS Offices
Phone: +1-301-942-2980, extn 104
E-mail: <lisa@uhms.org>

Instructions to authors

(Revised March 2004)

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

Contributions should be sent to:
The Editor, SPUMS Journal,
C/o Office 137, 2nd Floor, Christchurch Hospital,
Private Bag 4710, Christchurch, New Zealand.
E-mail: <spumsj@cdhb.govt.nz>

Requirements for manuscripts

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

Paper versions and electronic files should be double-spaced, using both upper and lower case, on one side only of A4 paper. Headings should conform to the current format in the *SPUMS Journal*. All pages should be numbered. Underlining should not be used. Measurements are to be in SI units (mm Hg are acceptable for blood pressure measurements) and normal ranges should be included.

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

Illustrations, figures and tables should not be embedded in the wordprocessor document, only their position indicated. All tables are to be in Word for Windows, tab-separated text rather than using the columns/tables option or other software and each saved as a separate file. They should be double-spaced on separate sheets of paper. No vertical or horizontal borders are to be used. Illustrations and figures should be separate documents in JPEG or GIFF format. Please note that our firewall has a maximum size of 5Mbytes for incoming files or messages with attachments.

Photographs should be glossy, black-and-white or colour. Slides should be converted to photographs before being sent. Colour reproduction is available only when it is essential for clinical purposes and may be at the authors' expense. Indicate magnification for photomicrographs.

Abbreviations should only be used in brackets after the complete expression, e.g., decompression illness (DCI) can thereafter be referred to as DCI.

References

The Journal reference style is the 'Vancouver' style *(Uniform requirements for manuscripts submitted to biomedical journals*, updated July 2003. Web site for details: <http://www.icmje.org/index.html>).

In this system references appear in the text as superscript numbers.[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 format for quoting journals and books are given below.

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

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

Consent

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

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DIVER EMERGENCY SERVICES PHONE NUMBERS

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

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

The DES numbers are generously supported by DAN-SEAP

PROJECT STICKYBEAK

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

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

DIVING INCIDENT MONITORING STUDY (DIMS)

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

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

PROJECT PROTEUS

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

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

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

CONTENTS

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