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SPUMS

The future of technical diving

Occupational diving health surveillance
Is it decompression illness?
Oxygen administration for divers
Human life in the ocean
Children and diving - a response from Carl Edmonds
Hannes Keller's 1000 ft dive
Surviving a crippled submarine

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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

In the last issue, Des Gorman used diving to illustrate the modern principles of occupational health surveillance.[1] He argued that the current practice of surveillance for employed divers generally falls well short of these standards. One of the fundamental failings is that present systems are based on a prescriptive process that is disease centred. The key risk taker, namely the diver, is excluded from any involvement in this process. Gorman noted that an audit by the New Zealand Diving Medical Directorate (NZDMD) of the initial medical assessments under AS/NZ 2299[2] had shown limited utility. This audit is reported in the first paper.

The data from NZDMD appear to confirm a limited utility for the existing approach. Whilst this is a preliminary report, it has important implications. Other countries, such as Australia, need to conduct similar analyses to compare with these findings. One of the anticipated difficulties may be that the databases themselves will be deficient, confounding attempts at analysis; NZDMD, for instance, took nearly a decade to develop a useable resource.

Since the initial medical assessment when AS/NZ2299 came into force, employed divers have completed a self-administered questionnaire in place of an annual medical for years two to five inclusive. Now the end of the first five-year cycle has been reached, the efficacy of this questionnaire as a triage tool will be testable in the near future. Perhaps the most challenging statement in the NZDMD paper is the final one.

> *"Although not tested here, our hypothesis is that assessment of diver fitness will be best served by way of functional capacity (competency) tests and physicians may have little role in this process."*

The next few years will prove whether they are correct.

Those who treat decompression illness (DCI) know how varied can be its presentation. To illustrate this, the cases are reported of four divers who presented to one recompression centre within the past two years with neurological symptoms and signs of varying severity. Even with hindsight, it is not possible to be confident about the final diagnosis in some patients, such as the second of these four, whilst the dive itself may possibly have triggered the final course of events in the two divers who, sadly, died from their underlying disease processes.

John Lippmann's book on oxygen resuscitation should be on the library shelf of every diving doctor.[3] The article in this issue, whilst summarising some of that publication, adds new information based on Diver Alert Network (DAN) accident reports and equipment performance assessments. It might best be read in conjunction with an earlier theoretical paper.[4] Now, at the beginning of the summer diving season, is the time to revise your knowledge of, and practise your skills in, the resuscitation of divers.

It is of concern to note in the DAN reports that many divers do not receive oxygen during evacuation for one reason or another. A few years ago, the Editor received for recompression treatment a paraparetic diver who had been air evacuated from some distance away. A physician, who had an aviation medicine qualification, assessed him before the flight and ordered the paramedic to take him off oxygen as he was "not cyanosed". We still have much to do.

Talks such as Lippmann's at the 2002 ASM are worthwhile educational tools. The pages of the Journal cannot match the ability of many guest speakers to bring their topics vividly to life. Des Gorman used underwater movie clips nearly a century old to illustrate part of his personal view, published here, of man's history of exploring the sea. This and the evocation by James Francis of the cold, clammy, dark, claustrophobic interior of a sunken submarine are just two examples of the many reasons for members to attend Society meetings, invariably supported by less than 10% of our membership. Now is the time to register for Noumea. I would also urge you to consider attending the Undersea and Hyperbaric Medicine Society meeting in Sydney the week before. This is a unique opportunity, especially for Australians to meet American colleagues.

Drew Richardson will probably be in the firing line again with his impassioned vision of today's technical diver as tomorrow's recreational diver, just as he is from Carl Edmonds in the section on children in diving. I was privileged to hear Hannes Keller, whose epic, tragic dive to 1000 feet is featured here, speak of his vision of diving in 2001 at the *Oceans 2000* Congress in London thirty years ago. His was a far more fanciful conception than Richardson's, most of which has not come to fruition.[5] I have just spent a week diving on vertical drop-offs in Fiordland with a British diver who used a closed-circuit breathing system whilst I donned my open-circuit air scuba. I think Richardson is probably right, and this will be exciting. However, I quail at the thought of the sleepless nights at the recompression chamber that it will bring.

Best wishes for Christmas and the New Year.

Michael Davis

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4 Davis FM. Oxygen therapy equipment: A theoretical review. *SPUMS J* 1998; 28: 165-172

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Front cover photo of Dr Simon Mitchell wearing a Mark 16 closed circuit breathing apparatus, courtesy of Carl Watson of MV Esperance Star

Original articles

The predictive power of initial fitness-to-dive certification procedures for occupational divers in New Zealand

Paul Greig, Des Gorman, Alison Drewry and Greg Gamble

Key Words
Health surveillance, occupational diving, medicals diving, research

Abstract
(Greig P, Gorman D, Drewry A, Gamble G. The predictive power of initial fitness-to-dive certification procedures for occupational divers in New Zealand. *SPUMS J* 2003; 33:182-187)
Objective: To determine which aspects of the initial medical assessment of New Zealand occupational divers influence the 'diving fitness' certification outcome.
Methods: The assessment process and the final certification outcome were analysed by calculation of sensitivities and specificities, positive and negative predictive powers, and the areas under the respective receiver operator characteristic curves for a random selection of 300 occupational divers.
Results: Logistic regression revealed only three independent predictors of outcome: a past history of asthma ($p < 0.0001$), abnormal cardiac auscultation ($p < 0.0005$) and abnormal respiratory function tests ($p < 0.0001$).
Conclusion: The certification outcome of medical assessments of occupational diver fitness in New Zealand, which is based on Australian and New Zealand Standard AS/NZ 2299, is largely determined by free text written on the questionnaire by the medical assessor and by respiratory system assessment. The predictive power of the survey elements would be more useful in diagnosis than a health survey, which is consistent with the origin of AS/NZ 2299. This is a strong argument for both reform of the process and for the ongoing restriction of such assessments to specifically trained medical practitioners.

Introduction

Occupational diving can be physically and psychologically demanding and occurs in an unpredictable, mobile, dense, irrespirable environment.[1] Although human error is primarily responsible for most diving incidents and accidents, it is essential that a person be 'fit to dive' if risks are to be managed adequately.[2-4] The issue then is how to assess this 'fitness' and to what extent this can be done by a physician.

In New Zealand, subcontractors to the Department of Labour (DoL) oversee occupational diving health assessments.[5,6] The process is based on an Australian and New Zealand Standard (AS/NZ 2299),[7] which is a derivative of Royal Australian Navy regulations (ABR 155).[8] Accredited diving medical examiners assess candidates using the AS/NZ 2299 questionnaire, examine the candidate and complete a standard record, and similarly record the findings of both required (e.g., air audiogram, lung function tests) and discretionary investigations (e.g., chest X-ray in a candidate with a history of respiratory disease). This questionnaire and these records are then audited, further information is obtained as necessary and an appropriate certificate is issued. A trial of discretionary certification and of only periodic (five-yearly) clinical assessment is underway, but a test of the efficacy of these modalities will not occur until sufficient occupational divers have completed a five-year cycle.

This analysis is of the predictive power[9,10] of the specific items of the initial assessment of fitness for occupational diving with respect to certification outcome. The AS/NZ 2299 questionnaire has never been tested in this regard. Anecdotal experience in employed divers suggests that a clinical assessment in the absence of a positive questionnaire response is poorly predictive and that similarly poor predictive power exists for investigations generally. Specifically, there is no diving-relevant test of cardiovascular fitness, and lung function tests are poorly predictive of risk for lung injury due to decompression barotrauma.[11]

A longitudinal study involving very large numbers of divers is needed to assess the quality of certification decisions in the context of long-term diver health and performance. Here, we will accept the certification response outcome as such and will determine what features of the assessment process are influential as a preface to reform if necessary.

Methods

POPULATION

The medical and dive records of all New Zealand occupational divers are kept in a confidential database at the Naval Hospital in Auckland. The subject population was the 1,790 occupational divers who had undergone an initial assessment of their fitness to dive up to and during the calendar year 2002 and remained registered as an occupational diver with the DoL.

SAMPLE SIZE

The study design was piloted using a random sample of 30 divers. Questionnaire responses, examination and investigation findings were independently grouped into organ systems by two observers. Kappa coefficient values were calculated to test internal agreement. Subsequently, each diver's medical record was categorised as follows:
1 positive questionnaire responses only;
2 positive clinical and or investigation findings only;
3 positive questionnaire responses and positive clinical and or investigation findings;
4 positive questionnaire responses or positive clinical and or investigation findings.

The proportion in each category enabled calculation of sensitivity, specificity, the positive predictive value (PPV), the negative predictive value (NPV), and receiver operator characteristic (ROC) values.[9,10]

Outcomes for the pilot and main study were categorised as follows:
1 accepted for certification without further action (category one pass);
2 accepted for certification after further action (category two pass);
3 not accepted for certification (fail).

A ROC plot was then determined for each organ system and for a positive screen being determined for a category two pass and or a fail by successively setting the positive screen threshold at one, two, three, four or more positive responses or findings.

From the pilot study, data estimates of the precision (width of the 95% confidence intervals) of sensitivity and specificity measures with various sample sizes could be calculated. The final study sample size of 300 was selected to give the optimal balance of tight confidence intervals and practicability.

For the main study, the methods described above for the pilot study were employed for a randomly selected sample of 300 divers, analysing the following organ systems. The organ systems not listed are those for which there were no positive responses:
1 respiratory system: positive questionnaire responses, positive examination findings, abnormal lung function spirometry (RFTs) results, abnormal chest X-ray findings;
2 cardiovascular system: positive questionnaire responses, positive examination findings, abnormal chest X-ray findings, abnormal resting and exercise ECGs (ETT);
3 neurological system: positive questionnaire responses, positive examination findings, abnormal audiometry results;
4 otorhinolaryngological system: positive questionnaire responses, positive examination findings, abnormal audiometry results, abnormal tympanometry results.

In addition to the statistical analysis described above, the frequencies of positive questionnaire responses and examination and investigation results were considered independently of outcome.

Results

The demographical data for the main study sample are listed in Table 1. There were 32 divers who had a category two pass. One diver with severe obstructive airways disease was determined unfit for occupational diving. Five of the 32 category two passes occurred only after a case conference involving the medical assessor, the diver, their employer, the dive school manager if appropriate, and DOL representatives. Such a discretionary outcome is not a subject for discussion in this report.

The AS/NZ 2299 questionnaire has 89 items requiring a yes/no answer, with free space for the medical assessor's

TABLE 1
DEMOGRAPHIC DATA FOR THE MAIN STUDY SUBJECTS

Sex	254 males 46 females
Age (years)	Median = 35 Range = 17 - 66
Previous diving experience	
Number of dives	Median = 200 Range = 0 - 10,000 Interquartile range = 100 - 500
Level of training	SCUBA (air) only = 235 SCUBA (mixed gases) = 56 SSBA = 10 Saturation diving = 9
Year of first dive	Mode = 2000 Range = 1960 - 2002

TABLE 2
CLASSIFICATION OF QUESTIONS AND POSITIVE RESPONSE RATES BY ORGAN SYSTEM

System	Number of Questions	PRR (per 1,000 questions)	Most frequently positive question	
Otolarnygological	14	57	"Do you suffer severe motion sickness"	(n=33)
Respiratory (RS)	13	40	"Do any of your relatives suffer from asthma"	(n=53)
(Co-categorised with CVS)	*3*			
Cardiovascular (CVS)	10	13	"Have you ever had an abnormal ECG test?"	(n=9)
(Co-categorised with RS)	*3*			
Neurological (CNS)	13	52	"Do you require prescription spectacles?"	(n=73)
(Co-categorised with MS)	*1*			
Musculoskeletal (MS)	5	193	"Have you ever sustained a fracture?"	(n=122)
(Co-categorised with CNS)	*1*			
Haematological	3	3	"Have you ever had an abnormal blood test?"	(n=2)
Gastrointestinal	3	38	"Have you ever suffered a hernia/rupture?"	(n=18)
Genitourinary	1	3	"Do you suffer from kidney or bladder disease?"	(n=1)
Endocrine	1	0	N/A	
Others	30	60	"Have you ever been admitted to hospital for any reason?"	(n=173)

PRR: Positive Response Rate

TABLE 3
SENSITIVITY, SPECIFICITY, POSITIVE (PPV) AND NEGATIVE (NPV) PREDICTIVE VALUES FOR POSITIVE QUESTIONNAIRE RESPONSES BY ORGAN SYSTEM AND FOR EXAMINATION FINDINGS VERSUS OUTCOME OF CERTIFICATION

	Sensitivity (95% CI)	**Specificity** (95% CI)	**PPV** (95% CI)	**NPV** (95% CI)
Questionnaire only	0.97 (0.9, 1)	0.21 (0.16, 0.25)	0.13 (0.09, 0.17)	0.98 (0.95, 1)
Respiratory and CVS exam	0	1	undefined	0.89 (0.85, 0.93)
Neurological exam	0.06 (0, 0.14)	0.92 (0.89, 0.95)	0.09 (0, 0.2)	0.89 (0.85, 0.93)
ENT exam	0.21 (0.07, 0.35)	0.88 (0.84, 0.92)	0.18 (0.06, 0.3)	0.9 (0.86, 0.94)
RFT	0.67 (0.51, 0.83)	0.66 (0.6, 0.72)	0.19 (0.12, 0.27)	0.94 (0.91, 0.97)
Tympanometry	0.52 (0.34, 0.69)	0.55 (0.49, 0.61)	0.12 (0.07, 0.18)	0.9 (0.86, 0.95)
Audiometry	0	1	undefined	0.89 (0.95, 1)
Questionnaire or				
RFT	1	0.21 (0.16, 0.25)	0.13 (0.09, 0.18)	1
Audiology	0.97 (0.91, 1)	0.19 (0.14, 0.24)	0.13 (0.09, 0.17)	0.98 (0.94, 1)
Tympanometry	0.97 (0.91, 1)	0.21 (0.16, 0.25)	0.13 (0.09, 0.17)	10.98 (0.95, 1)

RFT: respiratory function tests

comments. The organ system categorisation of the 89 questionnaire items was internally valid, with a 93% concordance (kappa coefficient 0.92, 95% CI = 0.87 to 0.97). The positive response rate per 1000 questions for each organ system is shown in Table 2. Only 56 (19%) questionnaires contained no positive responses (median number of positive responses = 2; range 0 to 14). Of the 300 divers, 102 responded positively to questions about previous diving-related problems, most commonly nitrogen narcosis, ear and sinus barotrauma and decompression illness.

TABLE 4
THE NUMBER OF POSITIVE FINDINGS FROM EACH QUESTIONNAIRE OR EXAMINATION VERSUS RELEVANT TEST OUTCOME

	No. +ve	Sensitivity (95%CI)	Specificity (95%CI)	PPV (95%CI)	NPV (95%CI)
ETT	1	Undefined	0.53 (0.48-0.49)	0 (0-0)	1 (1-1)
	2	Undefined	0.88 (0.84-0.92)	0 (0-0)	1 (1-1)
	3	Undefined	0.96 (0.94-0.98)	0 (0-0)	1 (1-1)
	4+	Undefined	0.98 (0.97-1)	0 (0-0)	1 (1-1)
Audio	1	0.78 (0.65-0.9)	0.29 (0.23-0.34)	0.14 (0.1-0.19)	0.89 (0.83-0.96)
	2	0.4 (0.25-0.55)	0.63 (0.57-0.69)	0.14 (0.08-0.21)	0.87 (0.82-0.92)
	3	0.15 (0.04-0.26)	0.83 (0.78-0.87)	0.12 (0.03-0.21)	0.86 (0.82-0.91)
	4+	0.05 (0-0.12)	0.93 (0.9-0.96)	0.1 (0.03-0.22)	0.86 (0.82-0.9)
Tymp	1	1 (1-1)	0.49 (0.43-0.54)	0.01(0.00-0.02)	1 (1-1)
	2	1 (1-1)	0.76 (0.71-0.81)	0.01 (0.00-0.04)	1 (1-1)
	3	1 (1-1)	0.89 (0.85-0.92)	0.03 (0.00-0.08)	1 (1-1)
	4+	0 (0-0)	0.95 (0.93-0.97)	0 (0-0)	1 (0.99-1)
RFT	1	0.6 (0.3-0.9)	0.63 (0.58-0.69)	0.05 (0.01-0.09)	0.98 (0.96-1)
	2	0.4 (0.1-0.7)	0.9 (0.87-0.94)	0.13 (0.01-0.24)	0.98 (0.96-1)
	3	0.2 (0-0.45)	0.97 (0.95-0.99)	0.2 (-0.05-0.45)	0.97 (0.95-0.99)
	4+	0 (0-0)	0.99 (0.97-1)	0 (0-0)	0.97 (0.95-0.99)
CXR	1	1 (1-1)	0.54 (0.48-0.59)	0.01 (0-0.03)	1 (1-1)
	2	0 (0-0)	0.88 (0.84-0.92)	0 (0-0)	0.99 (0.98-1)
	3	0 (0-0)	0.96 (0.94-0.98)	0 (0-0)	0.99 (0.98-1)
	4+	0 (0-0)	0.98 (0.97-1)	0 (0-0)	0.99 (0.98-1)

ETT: Exercise Tolerance Test; **Audio**: Audiometry; **Tymp**: Tympanometry; **RFT**: Respiratory Function Test
CXR: Chest X-ray

The AS/NZ 2299 examination form has 48 items, some for observed values (e.g. height, weight) and others for normal/abnormal notation.

All divers had audiometry (40 abnormal, 13%), RFTs (10 abnormal, 3%) and tympanometry (one abnormal) performed. An exercise tolerance test was performed on three of the divers; none were abnormal. Two out of 295 chest X-rays performed were abnormal.

Specificity, sensitivity, PPV and NPV data with respect to certification outcome (category one passes versus category two passes and failures) are shown in Tables 3 and 4.

The area under the curve (AUC) of the ROC curves for all single and aggregated common organ system indices are shown in Table 5. Any AUC determination for which a 95% confidence interval approximates 0.5 has little predictive value.

Predictors of certification outcome were sought from all recorded items, with the exception of free-text comments, which could not be standardised. Stepwise logistic regression determined the following three independent predictors of outcome, which were then confirmed by forward logistic regression analysis:

1 past history of asthma ($p < 0.0001$);
2 abnormal cardiac auscultation findings ($p < 0.0005$);
3 abnormal RFTs ($p < 0.0001$).

TABLE 5
AUC DATA FOR ROC PLOTS FOR AGGREGATED ORGAN SYSTEM INDICES

Organ system	AUC value	(95% CI)
Respiratory	0.67	(0.54, 0.8)
Gastrointestinal	0.65	(0.52, 0.79)
ENT	0.63	(0.50, 0.76)
Neurological	0.6	(0.47, 0.73)
Other	0.6	(0.47, 0.73)
Cardiovascular	0.6	(0.47, 0.73)
Musculoskeletal	0.56	(0.43, 0.69)
Genitourinary	Insufficient positive findings	
Haematological	Insufficient positive findings	
OVERALL	0.6	(0.47, 0.73)

Discussion

The AS/NZ 2299 questionnaire used to screen occupational divers in New Zealand, in isolation and in the context of certification outcome, has high sensitivity and NPV's, but low specificity and PPV's. Of the organ system examinations and required investigations, only RFTs possessed both high PPV and NPV. The AUC data similarly produced significant results only for the respiratory system items. Combinations of questions and findings in other organ systems did not cause an improvement in the NPV/PPV profiles. Three independent predictors of outcome, a past history of asthma, abnormal cardiac auscultation and abnormal RFTs, were identified in multivariate analysis. All three are clinically plausible.[1]

Many questions failed to generate any positive answers. However, not all of these questions warrant exclusion. This highlights the difference between clinical and statistical significance. Some conditions may be unusual in such a (potential) worker cohort, but of great significance to diving, e.g., epilepsy, such that concerns regarding statistical validity are superseded by the necessity of detection. The same comments apply to some items of the examination and investigations. Some others need to be included for purposes of baseline data collection. An example of the latter is audiology, where many (13%) of those undergoing this initial fitness assessment for diving were noted to have pre-existing hearing loss.

The optimal balance of sensitivity and specificity depends on the significance of false positive and negative results.[9] In this analysis, none of the questionnaire, examination and investigation items, alone or in combination, offer an acceptable balance. In general, the profile here of low PPV and high NPV would be more useful in diagnosis than in health surveillance. This conclusion is supported by the ROC-AUC analyses, in which, as cited above, the closer an AUC value lies to 0.5, the less statistically significant is the factor. This result is predictable given the genesis of AS/NZ 2299; a list of diseases that were considered relative and absolute contra-indications to diving was used as the basis for the standard. Consequently, the survey has some diagnostic utility. However, this should be an exercise in determining the level of health-related risk for someone who wishes to become an occupational diver. A high-utility occupational health survey would then be based on a list of determined functional competencies and not on a list of diseases.

These data suggest that decisions regarding 'fitness to dive' are not based so much on the questionnaire response, but more so on the free-text component. It follows that, if the AS/NZ 2299 questionnaire is to be used, review of the yes/no responses and free-text clarification by the medical assessor and a subsequent clinical audit are critical components. It is also apparent that such an assessor must not be naive in the context of diving medicine. The real conclusion here, however, is that the AS/NZ 2299 questionnaire is of low utility and needs to be replaced.

It is not clear from this analysis as to the merit of clinical examination and investigation in the absence of positive questionnaire responses, in part due to the poor predictive power of the questionnaire. Nevertheless, it is noteworthy that both abnormal cardiac auscultation and RFTs were predictive of certification outcome, independent of cardiovascular and respiratory system questionnaire responses. It is highly likely that this observation would apply only to initial assessments, but this will be tested subsequently. Again, the conclusion here is that reform of the health surveillance of occupational divers is justifiable.

The relatively small number of fails within each organ system limits this study. However, by focussing on the data that can be objectively collected rather than the process of finally passing or failing a diver, the possibility was raised for an objective audit of the utility of the questionnaire component.

Although not tested here, our hypothesis is that assessment of diver 'fitness' will be best served by way of functional capacity (competency) tests and physicians may have little role in this process.

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An element of doubt: four divers with acute neurological problems

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Key words
Decompression illness, case report, medical conditions and problems, death

Abstract
(Davis FM. An element of doubt: four divers with acute neurological problems. *SPUMS J* 2003; 33: 187-191)
Decompression illness (DCI) presents in a multitude of guises, and divers may present with concomitant disease processes that can confuse diagnosis and management. The cases described are of four divers who were referred for hyperbaric oxygen therapy with an initial working diagnosis of neurological DCI, These illustrate the diagnostic and management dilemmas that may arise. One diver was diagnosed with migraine, whilst in one no final diagnosis was made but DCI was considered to be unlikely. Two patients died, one from a brainstem infarct due to severe cerebrovascular disease and the other from an acute cardiac event secondary to viral myocarditis.

Introduction

Decompression illness (DCI) presents in a multitude of guises. Often neurological lesions are multiple, making diagnosis difficult. Concomitant disease processes may be present in the individual diver to compound this. Recently, the case was reported of a patient with eosinophilic meningitis who was referred for hyperbaric treatment.[1] Here four divers are described who presented to the same regional hyperbaric unit with an initial working diagnosis of neurological DCI in order to illustrate the diagnostic and management dilemmas that may arise.

Case One

A 39-year-old, fit, professional underwater cine photographer diving in a remote area developed two episodes of transient visual disturbance each lasting five minutes about half an hour after a single nitrox (40/60 mix) dive to 22 m for 25 minutes. These were described as a hazy zigzag arc at 11 to 3 o'clock just above visual focus, progressing into a more widespread blurred patch in the temporal visual field, stronger in the right than the left eye but present bilaterally. As these episodes were brief he took no action. This phenomenon recurred the next day whilst crossing a mountain pass at above 800 m altitude. After two further episodes, each worse than the last and accompanied by headache, he presented in his home town two days post-dive, and was air evacuated to the regional hyperbaric unit.

On admission, his only symptom was a "pounding" right frontal headache unrelieved by anti-inflammatory analgesics. Previous medical history was unremarkable except for one year earlier when, after a period of intensive diving lasting several weeks, he developed intermittent neck pain and tingling in the arms which had persisted. At the time of presentation, he was awaiting MRI investigation for this.

On examination, he was fully conscious and orientated and in no distress. No visual field abnormalities were detectable, and the fundi were normal, with no evidence of focal emboli or oedema. The cranial nerves and power, tone, reflexes and sensation in the limbs were all normal. Sharpened Romberg's test was stopped at 60 sec on the first attempt.

In discussing the situation with the patient it was considered that his symptoms were unlikely to be due to DCI. However, given his high public profile, he underwent a US Navy Table 6 hyperbaric oxygen treatment, which relieved his headache. This was followed the next day by a further short oxygen treatment at 283 kPa. During this period he remained entirely asymptomatic and at no stage were there any identifiable objective neurological signs.

Two days after discharge he reported a further similar episode of transient visual changes. MRI of the neck showed no abnormality. Since then he has had further episodes associated with a “cracking” headache. He was prescribed sumatriptan succinate (Imigran), which provided rapid relief if taken at the start of an attack. During a recent intensive diving programme over several weeks in the Southern Ocean for a new film he had no further attacks. He now reports a family history of migraine, in his mother, of which he was not previously aware.

Case Two

A 29-year-old recreational diving instructor with 12 years’ diving experience did two dives on the first day to maximum depths of 37 m and 30 m, and a single 25 m dive lasting 50 minutes and including a long safety stop in shallow water on the second day. Diving conditions were described as “lovely”, all three dives being very relaxed and well within safety limits.

Nine hours post-dive, whilst on night shift as a baggage handler, he suffered an “explosive” onset of severe “stabbing” left retro-orbital and frontal headache, photophobia, blurred vision, slurred speech and left-calf pain. According to eyewitnesses, he “collapsed” with severe shaking and hyperventilation.

On admission at about 0200hr, his headache had eased to a score of 3 out of 10 compared with the initial severity. He denied any previous medical history. He was a smoker and indulged in binge drinking at weekends. There was a family history of polycystic kidney disease. On examination, he was fully conscious and orientated, with a mini-mental score of 30 out of 30. Neurological examination was normal apart from a subjective, patchy and inconsistent diminution of light touch and pinprick sensation in the left arm and leg. There was no neck stiffness.

It was considered unlikely his symptoms were due to DCI, and he was admitted to hospital for observation and urgent investigation, but not for hyperbaric oxygen treatment (HBO_2). In the morning, the headache had improved considerably. Physical examination was essentially unchanged with possibly diminished pinprick sensation on the left as above, and minimally reduced power in the left arm below the elbow.

Brain CT scan and lumbar puncture were normal. The case was discussed again with the Hyperbaric Unit. It was felt that a diving-related illness was extremely unlikely, but it was agreed that he be given a short HBO_2 treatment at 242 kPa. This resulted in improvement of his symptoms. A further treatment was given the following day, by which time he still had a mild headache but was otherwise well.

At this stage his previous medical records came to hand. At age 15 he had been admitted to hospital following collapsing on the beach secondary to a possible seizure. Investigations at that time, including a CT scan and EEG were normal. After this episode he continued to have headaches and episodes of clumsiness and “loss” daily for some weeks, but was not placed on any medication. At the ages of 23 and 26 he was admitted with unexplained neurological symptoms including severe headache that were attributed to (unconfirmed) viral meningitis. No final diagnosis was made.

Case Three

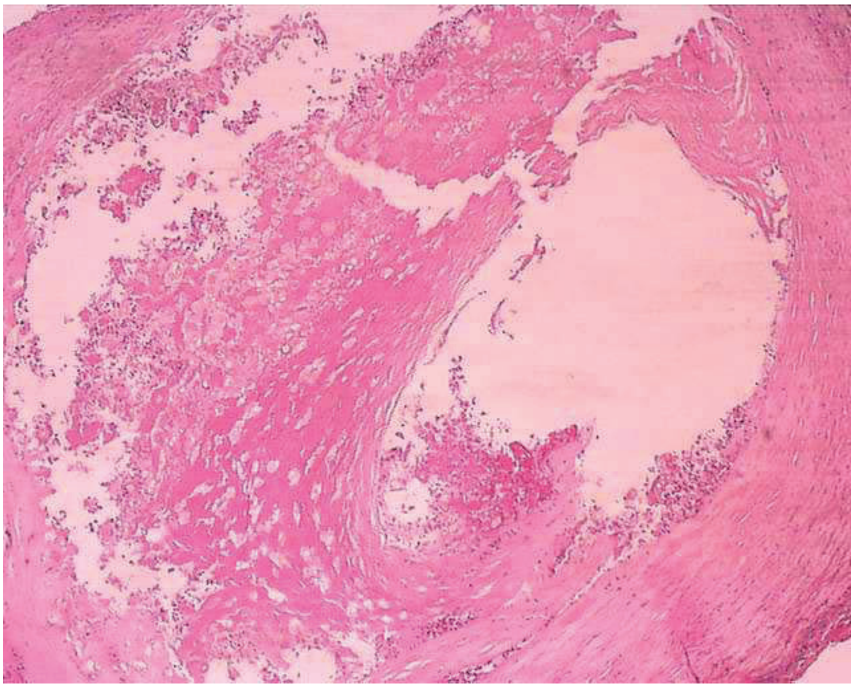
A 47-year-old experienced diver undertook an apparently uneventful solo dive for crayfish to 26 m for approximately 17 to 20 minutes. On boarding the boat a friend noted his mouth to be asymmetrical and he appeared drowsy. A quarter of an hour later he developed left-sided weakness and consciousness became impaired. When retrieved by paramedics about an hour later on shore, his Glasgow Coma Scale (GCS) score was 8 out of15.

On admission about an hour later, he was fully conscious and cooperative, but then rapidly deteriorated again in the Emergency Department with aphasia and a fluctuating level of consciousness. Examination was curtailed to commence recompression on the assumption that he had severe early-onset neurological DCI. The only known medical history at the time of admission was that he was a heavy smoker and had hypertension for which he was on some type of medication.

He underwent a US Navy Table 6 HBO_2 treatment during which his neurology continued to fluctuate markedly and bizarrely, but with a steadily worsening picture. At times he was talking and appeared rational, at others barely rousable, whilst both left and right transient hemiparesis were observed. The treatment was not extended or deepened, as there was a growing conviction that he was not suffering from DCI. After his treatment he was transferred to the ward where he rapidly became deeply unconscious with a GCS of 3 out of 15. He was intubated and transferred to the intensive care unit for life support.

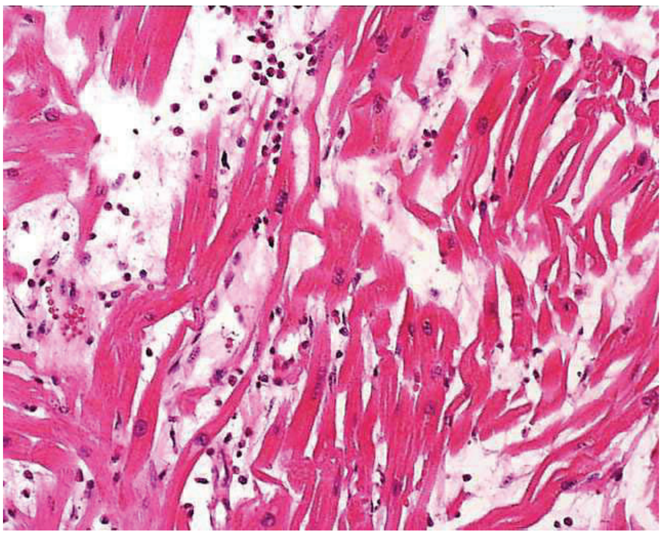
Further history became available from the family. He had been due for neurological assessment and brain CT scan that week for recurrent transient ischaemic attacks, including episodes of aphasia. A CT scan showed large areas of infarction of his brain, particularly the cerebellum and brainstem, but no gas. He was subsequently pronounced

FIGURE 1
CROSS-SECTION OF A CEREBRAL ARTERY FROM CASE THREE, SHOWING EXTENSIVE ATHEROMATOUS DEGENERATION OF THE WALL WITH RECENT THROMBUS FORMATION WITHIN THE NARROWED VESSEL LUMEN
(original magnification x 40)

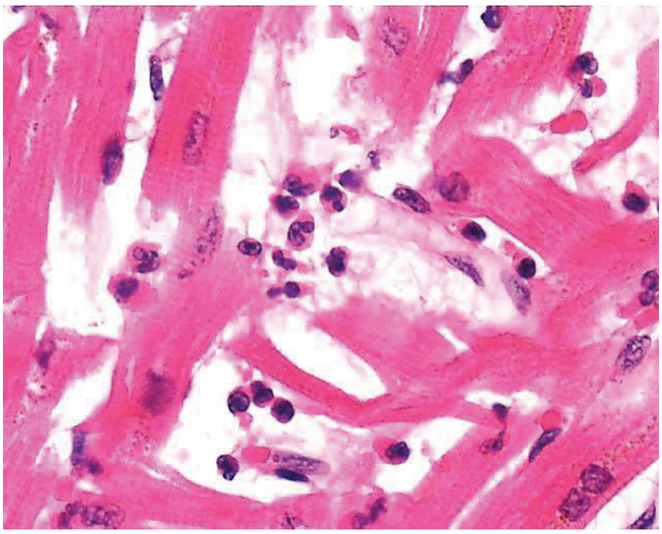


FIGURES 2a and 2b
THE ABNORMAL FOCUS OF MYOCARDIUM FROM CASE FOUR, SHOWING LOSS OF NORMAL PATTERN WITH POLYMORPH, MACROPHAGE AND LYMPHOCYTE INFILTRATION
(original magnifications: 2a x 200; 2b x 400)

2a



2b



brain dead and, following discussion with the family, life support was withdrawn. During organ donation, he was found to have widespread atheroma throughout his aorta and coronary vessels. A coroner's autopsy also showed widespread atheroma of his cerebral vasculature with recent in-situ thrombus consistent with the massive brainstem infarct. There was no evidence of vascular air embolism.

A typical atheromatous plaque with recent thrombus in one of his cerebral arteries is shown in Figure 1.

Case Four

This previously healthy, 41-year-old, experienced female diver was diving with her diving-instructor father. They swam from the shore and then descended to the bottom in about 3 m depth. She indicated that she felt unwell and immediately surfaced. Whilst swimming to shore she collapsed and lost her mouthpiece and her father towed her to shore. On reaching shore, he confirmed that she was pulseless, and commenced basic life support. This was continued by he and bystanders for about half an hour until an advanced ambulance and medical team arrived by helicopter. She was intubated and a high-dose adrenaline infusion was commenced. Sinus rhythm was re-established with a reasonable cardiac output. An arterial gas embolism was suspected, and the regional base hospital requested an air evacuation for hyperbaric oxygen therapy. Whilst awaiting air transport, a brain CT scan revealed gross cerebral oedema, but no gas.

On arrival she was deeply unconscious; GCS score of 3 out of15. Spontaneous respiratory activity was present but no cough or gag reflex. Her pupils were fixed and dilated. Her cardiovascular status was stable on a high-dose adrenaline infusion. Core temperature was 32.5^{O}C. She had a distended abdomen with profuse, watery, blood-stained diarrhoea and haematuria. Investigations revealed severe metabolic acidosis with a base deficit of -21, and a coagulopathy.

With the possibility of a cerebral arterial gas embolism (CAGE) considered unlikely and with evidence of a gross global hypoxic brain injury, a short HBO_2 treatment was reluctantly undertaken. She underwent a US Navy Table 5, during which she also received four units of fresh frozen plasma and was continued on high-dose adrenaline. A lignocaine infusion was commenced. Towards the end of this treatment there was deterioration in her cardiac output and she became profoundly shocked. On transfer to the ICU, and following discussion with the family, active treatment was withdrawn and she died soon after.

Subsequent history from the family revealed she had recently had a flu-like illness and was not feeling well prior to the dive. Postmortem histology indicated a small focus of active myocarditis (Figures 2a and b) and no evidence of arterial gas embolism. It was thought likely that she had suffered an acute myocardial event leading to arrhythmia and cardiac arrest, and that cerebral gas embolism was not a factor in her death.

Discussion

In the first case, migraine rather than DCI was suspected as the most likely diagnosis from the outset. The patient's single dive was well within safety limits, and there was a nearly 24-hour delay between this and his drive to altitude. However, having been air evacuated from a city 400 km away, it was felt appropriate that he be managed as though he had acute neurological DCI. His subsequent course and the successful use of sumatriptan really confirmed the original suspicions. HBO_2 has been reported as an effective treatment for migraine and Wilmshurst has reported a link between migraine and DCI, so the approach to management was not unreasonable.[2,3] Investigation for patent foramen ovale (PFO) might have been useful in this man, as presence of a PFO would have implications for his professional diving activities for the future.

In the second case, the explosive onset and nature of his symptoms made acute sub-arachnoid haemorrhage by far the most likely working diagnosis initially, the diving being coincidental. Therefore, he was not considered for HBO_2 until such other diagnoses were excluded. No explanation for the improvement of his symptoms with HBO_2 is offered, unless this was indeed a very atypical presentation of DCI. No final diagnosis was made, although neurological consultation labelled him as a possible case of 'pseudo-epilepsy'. Given the subsequent information on his past medical history, he was advised to cease scuba diving, advice he declined to accept. Headache is a common presenting symptom in DCI and its differential diagnosis, as in other circumstances, may be difficult.

In the third case, the experienced forensic pathologist conducting the autopsy considered it highly unlikely that the dive contributed to his death, given the widespread, severe atherosclerotic disease with occlusion of the circle of Willis. However, it remains possible that a small intra-vascular gas phase was the final precipitator of his acute demise. HBO_2 was considered appropriate, but his presentation and subsequent course were so unusual that a diagnosis of DCI was doubted. For this reason we did not extend the USN Table 6 or switch to a deep heliox therapy (RNZN 1A), either of which is a common approach to management for severe neurological or life-threatening DCI not responding to oxygen at 283 kPa. Other vascular pathologies that have been reported in divers presenting with neurological signs include inflammatory vasculitis and carotid artery dissection.[4,5]

Acute viral infections have been reported previously in association with decompression sickness.[6] We have had one diver present with non-specific systemic symptoms and pyrexia following diving, who convulsed on oxygen at 283 kPa early during recompression therapy, which was then abandoned. A subsequent diagnosis of influenza was made. We are unaware of any reports of viral myocarditis presenting as suspected CAGE. The referral of this unfortunate woman (Case Four) for HBO_2 was appropriate given the history, although by the time of her arrival her condition was clearly terminal.

Other non-diving pathologies masquerading as DCI that have been reported include acute appendicitis and acute psychosis.[7-9] Personality and affective changes are common in divers with DCI and after successful recompression therapy it is not unusual to feel that one is dealing with a different person to the one who first presented. However, it is unlikely that psychosis in a diver is attributable to DCI in the absence of other neurological symptoms of injury.

Munchausen's syndrome has been reported presenting as DCI,[10] and we believe that we have seen one such case.

These cases and other case reports illustrate the importance of a careful history, physical examination and investigation of divers referred with DCI. Whilst more often than not a diver in whom the diagnosis of DCI is doubtful has been given hyperbaric treatment, this has usually been on a precautionary basis. Physicians are reluctant not to treat divers once they have been evacuated, often at considerable expense, to a regional hyperbaric centre. DCI may present in a myriad of ways, leading to it being called the "syphilis of diving" by one expert. That other pathologies may mimic its presentation is consequently not surprising.

Acknowledgements

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First aid oxygen administration for divers

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Abstract
(Lippmann J. First aid oxygen administration for diver. *SPUMS J* 2003; 33: 192-198)
Hypoxia in divers can result from a variety of causes, including decompression illness (DCI). The benefits of oxygen first aid in DCI are increased denitrogenation and improved oxygenation, and the sooner oxygen is provided the better the outcome. When oxygen is provided prior to recompression, symptoms may be relieved earlier, and there is a slightly lower chance of post-treatment residua. Despite this, DAN America data indicate that only 30 to 40% of injured divers receive oxygen. This provides an ongoing challenge for the diving community. There is a plethora of oxygen equipment available and careful consideration needs to be given when selecting appropriate equipment to manage a dive accident. Such equipment needs to easily provide high oxygen concentrations to responsive or unresponsive, breathing or non-breathing victims. The wide range of available devices all have advantages and disadvantages that need to be weighed against the required outcome. Important considerations include the oxygen concentrations that can be provided; the ease of use; the amount of training and practice required and the number of operators needed to use the device effectively.

Introduction

Hypoxia causes cells to change to anaerobic metabolism, which may create a shortage of energy for normal cellular function and leads to a metabolic acidosis. The acidosis further impairs cellular function, particularly in the vital organs such as the brain and heart. Body cells cannot survive for long without oxygen. Brain cells are particularly sensitive to oxygen starvation and will die within minutes because of their limited capacity for anaerobic metabolism.

There are many ways that tissue hypoxia may occur. The normal ambient oxygen tension in air is approximately 21 kPa (101 kPa equals 1 bar). Too little oxygen in the gas we breathe will affect the whole body. This will begin to occur when the partial pressure of oxygen (PO_2) falls below about 16 kPa. Many disorders of the cardiorespiratory systems or oxygen extraction by the cells will reduce oxygen availability, resulting in tissue hypoxia. Unconsciousness will occur in most people when the PO_2 falls below about 8–10 kPa, and coma and ultimate death will normally occur if the PO_2 falls below about 8 kPa.

There are several ways that tissue hypoxia can occur in divers. These include water inhalation; pulmonary barotrauma; hypoxic gas mixtures (e.g., incorrect mixing of enriched air nitrox or in rebreathers); and contamination with carbon monoxide. Decompression illness (DCI), where gas bubbles may damage or obstruct blood vessels, may reduce perfusion and local tissue oxygenation. Tissue hypoxia may also occur from disorders not specifically related to diving, such as heart attack or stroke.

In the event of hypoxia, increasing the inspired oxygen may help to increase haemoglobin saturation. Increasing the oxygen concentration will also cause more of it to dissolve in the plasma. When breathing air at 101 kPa there is 3 ml of oxygen dissolved in each 1000 ml of blood plasma. Breathing 100% oxygen at 101 kPa enables 23 ml of oxygen to be dissolved in each 1000 ml of blood. This in itself is insufficient to supply the body's needs. The higher oxygen concentration, by increasing the tension gradient for diffusion will cause the oxygen molecules to diffuse further into the tissues, possibly reaching areas that have a reduced oxygen supply due to impaired circulation. This increases the chances of survival of tissues with a poor blood supply, as well as other impaired tissues.

Rationale for oxygen use in diving accidents

For injured divers, it is important to provide an increased oxygen concentration, probably close to 100%, especially where DCI is suspected. Breathing 100% oxygen provides very important benefits for a diver suffering from DCI:

- By eliminating nitrogen from the inspired gas, 100% oxygen breathing accelerates nitrogen elimination from the body, thus reducing bubble size more quickly.
- Any reduction in blood flow due to bubble formation may cause hypoxia in affected tissues. The higher oxygen partial pressures will help to oxygenate any hypoxic tissues by increasing diffusion of oxygen to those areas. It may also assist in reducing the swelling in hypoxic tissues by drawing fluid away from injured tissue.
- Elevated oxygen concentrations can help compensate for reduced blood oxygen content resulting from

impaired gas transfer from the lungs to the blood, and reduce any breathing distress caused by hypoxia.
- Higher oxygen concentrations may help reduce circulatory shock and cerebral oedema, uncommon but serious complications of DCI.

Although pure oxygen is recommended for the first-aid management of DCI, it is possible that certain helium-oxygen mixtures could sometimes prove advantageous for nitrogen elimination.[1] However, the use of such mixtures would introduce many practical disadvantages, and 100% oxygen currently remains the gas of choice for the first-aid management of DCI.

Prompt provision of high concentrations of inspired oxygen can minimise the damage that may occur while the diver is being transported to a recompression facility, possibly in certain circumstances alleviating the need for further treatment. There have been numerous anecdotal reports of even severe symptoms of DCI disappearing while an injured diver was breathing oxygen.

In DAN America data for 2000, 57% of divers administered oxygen at some stage prior to recompression showed improvement, and 14% had complete relief of their symptoms (Figure 1).[2]

DAN Europe data on dive accidents reported for 1989–2000 indicate that 23% (302/1314) of the divers received oxygen first aid. Forty-eight per cent of the divers who received oxygen showed improvement in symptoms, compared with only 4.3 % of the divers who received no oxygen ($p < 0.001$) (Table 1). In addition, 18.8% of the divers who received oxygen first aid were asymptomatic prior to recompression, compared with 1.5% of those who received no oxygen prior to recompression ($p < 0.01$) (Table 2).[3]

FIGURE 1
RESULT OF ADMINISTRATION OF SURFACE OXYGEN FOR DECOMPRESSION ILLNESS[2]

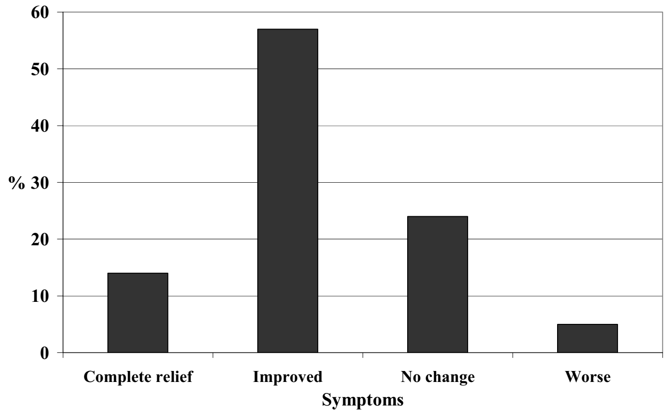


TABLE 1
RELIEF OF SYMPTOMS PRIOR TO RECOMPRESSION ACCORDING TO USE OF OXYGEN FIRST AID[3]

Evolution	O_2 first aid % divers	No O_2 % divers	Significance
Worse	15.6	22.6	n.s.
Static	20.0	69.4	$p < 0.02$
Improved	48.0	4.3	$p < 0.001$

FIGURE 2
PERCENTAGE OF DCI CASES GIVEN OXYGEN FIRST AID[2]

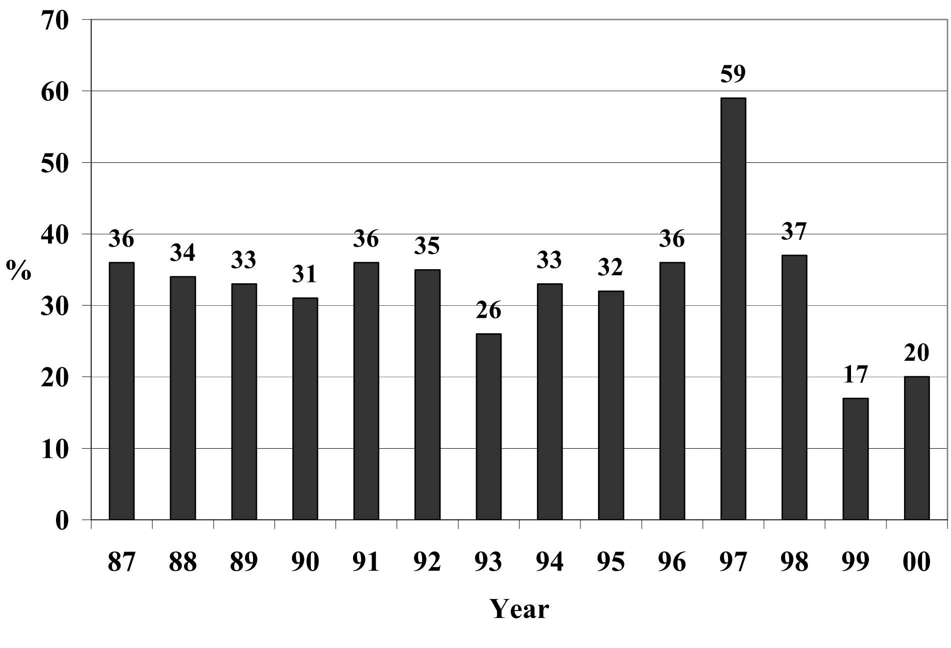


TABLE 2
OXYGEN FIRST AID AND HYPERBARIC TREATMENT RESULTS (percentage)[4]

Surface Oxygen	Complete recovery	Partial/ temporary	None	Residual symptoms
No	2	38	60	47
Yes	13	54	32	42

Oxygen breathing prior to recompression also appeared to enhance the outcome of the treatment, giving the diver the greatest possible chance of a full recovery (see Table 2).[4-6] For example, a DAN America analysis of 2192 dive accidents from 1989–93 indicates that there were significantly fewer residual symptoms in divers who had received oxygen prior to recompression, compared with those who had not received oxygen first aid ($p = 0.05$) (Table 2).[4] Although the difference in residual symptoms was only relatively small, one must remember that oxygen provision is often delayed, not continuous, and frequently is at a far lower concentration than desirable.

The requirement to have appropriate oxygen equipment and a trained oxygen provider available is now viewed as a ‘standard of care’ in the dive industry. Despite this, those of us who deal with diving emergencies are constantly reminded that many boat and diving operators still do not have appropriate oxygen equipment or adequate knowledge and training. Too often injured divers are provided with a lower than desirable level of emergency care by the ‘dive professionals’ who are responsible for them.

DAN America data of the DCI cases from 1987–2000 illustrate this. Only about one third of divers received oxygen first aid prior to recompression (Figure 2).[6] This will be due in part to the late recognition and reporting of symptoms of DCI. However, it is a depressing statistic and one that we constantly strive to improve through education and training.

Choosing oxygen equipment

There are now many different types of oxygen equipment in the marketplace and it is important to choose the most suitable gear. When looking for oxygen equipment some of the points that should be considered are:

- potential oxygen concentrations available;
- duration of oxygen supply at the desired concentrations;
- ability to provide high concentrations of oxygen to both responsive and unresponsive victims;
- ease of use by relatively inexperienced, lay oxygen providers, especially for ventilating a non-breathing victim;
- the number of inexperienced oxygen providers required to adequately ventilate a non-breathing victim (e.g., it is generally agreed that a bag-valve-mask requires two operators to safely and effectively ventilate a person in the field);[7]
- how many victims can be given oxygen simultaneously;
- the training and re-training requirements;
- durability and suitability for the marine environment;
- cost and ease of servicing.

Appropriate equipment should be capable of easily and effectively providing high inspired-oxygen concentrations to the responsive victim, the unresponsive breathing victim, and the non-breathing victim. Many people mistakenly believe that because an oxygen cylinder contains pure oxygen, and this gas flows out from the regulator and down the tubing, a person breathing from an oxygen set will be breathing 100% oxygen, no matter what mask or other delivery device is used. This is generally not true because, when the person inhales, a substantial amount of air is normally entrained, diluting the concentration of oxygen.

To supply 100% oxygen, an oxygen-delivery system must be able to provide for all of the person’s respiratory requirements. In addition, air entrainment must be prevented and expired breath must be vented effectively to prevent hypercapnia and further oxygen dilution.

Consider a person with a tidal volume of 0.5 l with a breathing cycle of four seconds, one second being for inhalation and three seconds for exhalation. With such a cycle, a person’s respiratory requirement is $0.5\ l.sec^{-1}$ or $30\ l.min^{-1}$. In other words, unless there is a reservoir in which oxygen can collect during the exhalation phase, an oxygen-delivery system needs to provide an oxygen flow rate of $30\ l.min^{-1}$ or more in order to provide 100% oxygen. If a lower flow rate is supplied, as it is with most oxygen regulators, air will be entrained and the oxygen concentration will be reduced accordingly.

The addition of an oxygen reservoir enables a reduction in flow rate. However, such a reservoir should generally have a minimum volume of the wearer’s tidal volume.

Oxygen delivery systems

DEMAND VALVES

The easiest and usually the most effective way to provide an oxygen concentration approaching 100% to a breathing injured diver is via an oxygen demand valve (Figure 3). Most current medical oxygen demand valves are capable of providing oxygen flow rates in excess of $100\ l.min^{-1}$ and so are capable of supplying all of a person’s respiratory requirements.

Demand valves are often designed to entrain some air so that the user doesn’t asphyxiate if the oxygen supply runs out. If the breathing resistance is too high, air will be entrained when the user inhales and the inspired oxygen concentration will fall. This problem may be increased if the victim is sitting with their head down or lying on their

FIGURE 3
OXYGEN DEMAND VALVE AND MASK

FIGURE 4
NON-REBREATHER MASK AND RESERVOIR

side, as gravity will make it harder for the valve to open.[8,9] Injured divers who are breathing only weakly or hyperventilating may be unable to trigger the demand valve and should not be administered oxygen by this method.

Apart from the above-mentioned limitations, well-designed and maintained demand valves provide a very simple and effective method of administering near 100% oxygen. They are the delivery system of choice in the first-aid management of scuba diving injuries for which near 100% oxygen is required, as well as for other conditions for which the inspired oxygen concentration needs to be maximised. They can be relatively economical with oxygen usage as long as the user's breathing rate and volume are not too high.

CONSTANT-FLOW DEVICES

The most commonly available oxygen-delivery systems are those that deliver a constant flow of oxygen at either a fixed or variable flow rate.

Many constant-flow delivery devices are not as economical on oxygen usage as demand valves. In addition, most such devices cannot provide such high oxygen concentrations. Despite these potential limitations, certain constant-flow devices are very useful in the management of a non-breathing victim, or one who cannot use a demand valve effectively.

The oxygen concentration delivered by a constant-flow system depends on a variety of factors and, in almost all cases, will be well below 100%.[10] It varies from about 25–35% with a loose-fitting (Hudson) mask or nasal cannula, to up to 98% with a tight-sealing bag-valve-mask system with an additional oxygen-reservoir bag attached, and a flow rate of about 15 $l.min^{-1}$ or higher.

There are a number of different constant-flow delivery masks available and the concentration of oxygen delivered by these masks depends on how well the mask seals, the flow rate, the breathing rate and depth, and size of the wearer, and whether or not a reservoir bag is used in conjunction with the mask. A tight-sealing mask will minimise air dilution. If the flow rate is too low, hypercapnia can occur. High flow rates will minimise hypercapnia but will deplete the oxygen supply more rapidly.

There is a plethora of constant-flow delivery devices and only a few will be briefly discussed here.

Non-rebreather mask

The non-rebreather mask is now probably the most commonly used oxygen-delivery device for injured divers (Figure 4). This mask is fitted with both a reservoir bag and a set of three one-way valves. It is designed to reduce the amount of air and carbon dioxide inhaled, thereby increasing the concentration of oxygen.

For proper use, the reservoir bag must be primed and should always contain enough oxygen so that it does not deflate fully when the wearer takes the deepest inhalation. In addition, a good seal needs to be achieved and all three one-way valves should be fitted and seated properly. Under these ideal circumstances, a non-rebreather mask is capable of supplying an oxygen concentration of up to 95% with flow rates of 10 to 15 $l.min^{-1}$. However, in practice such a high concentration is difficult to achieve and the mask will

FIGURE 5
RESUSCITIATION MASK WITH OXYGEN ATTACHMENT

usually deliver a substantially lower oxygen concentration, probably closer to 70–80%. (Chan C, Williamson J, Duff M, unpublished data). A flow rate of about 25 l.min^{-1} may be required to achieve an oxygen concentration near 90%.

Resuscitation mask

In general, the simplest way to provide supplemental oxygen to a non-breathing victim is via a resuscitation mask with oxygen inlet (Figure 5). Such masks are capable of providing a good seal on the victim's face and enable a rescuer to perform mouth-to-mask ventilations, supplementing their expired breaths with additional oxygen.

Using this technique and at a flow rate of 15 l.min^{-1}, it is possible to provide an oxygen concentration of up to 50–55% to the non-breathing victim.[11] Although this potential oxygen concentration falls considerably short of the desired 100%, because this technique is so simple to perform it is recommended by many resuscitation and oxygen-provider training bodies worldwide, including DAN.

A rescuer can use both hands to open the victim's airway and seal the mask. There is plenty of air available in their lungs to ventilate the victim adequately and compensate for any leaks. The skills required to perform mouth-to-mask ventilations are easily acquired and retained far longer than more complicated ventilation techniques.

Bag-valve-mask (BVM)

BVM devices fitted with a reservoir are capable of providing near 100% oxygen (Figure 6). However, as with most oxygen-delivery systems, the oxygen concentration delivered to the lungs depends on several factors, including the fresh-gas flow rate, the mask-to-face seal and the depth and rate of ventilation.

A major problem with bag-valve devices lies in the level of skill required to ventilate a non-breathing victim. Several studies[12,13] have shown clearly that the single-operator technique generally produces very poor ventilations, even when performed by well-trained and regular users.[10,11] Experience has shown that such devices generally require two trained operators to use effectively with the non-breathing victim. Hence, although a bag-valve-mask is capable of providing higher concentrations of oxygen to the non-breathing victim than a resuscitation mask with oxygen, it will provide little benefit if the ventilations are inadequate.

FIGURE 6. A BAG-VALVE-MASK OXYGEN SYSTEM

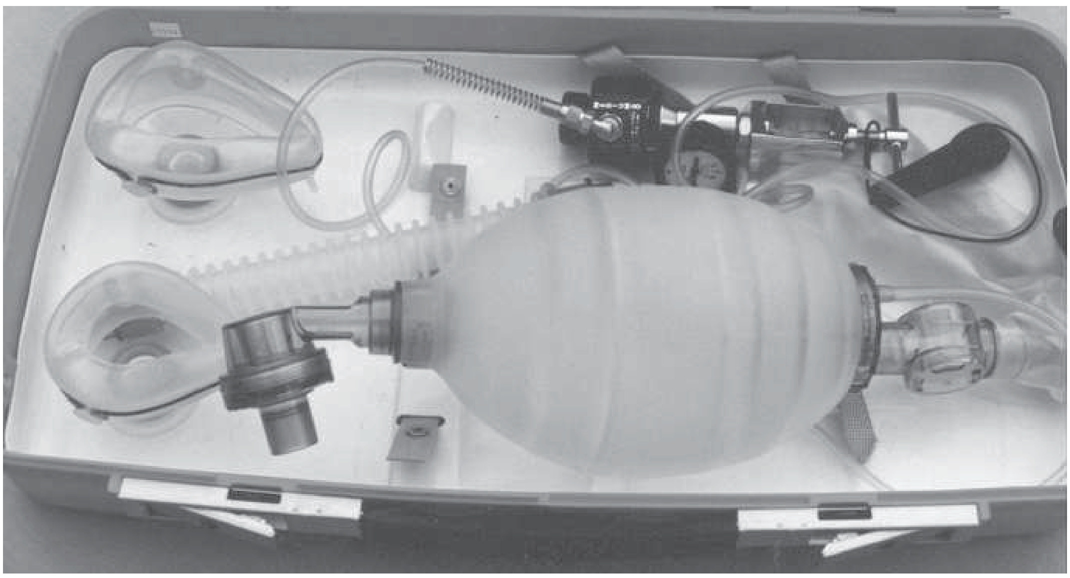
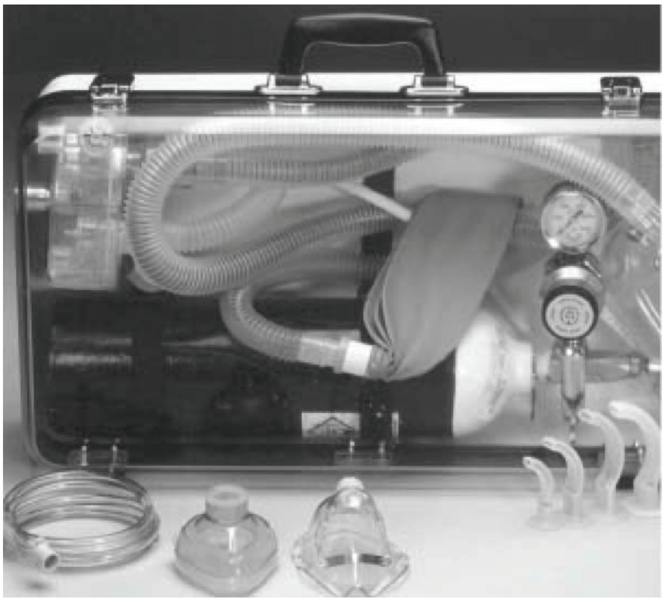


FIGURE 7
CLOSED-CIRCUIT PORTABLE OXYGEN RESUSCITATION SYSTEM



CLOSED-CIRCUIT PORTABLE OXYGEN RESUSCITATION SYSTEMS

Closed-circuit oxygen-delivery systems are based on systems commonly used in anaesthesia (Figure 7). The main benefit of such a system is the potential to increase the duration of the oxygen supply. Such units provide advantages to divers in remote areas who cannot carry a large oxygen supply. A 450 l oxygen cylinder, which would last around 30 minutes with a constant-flow device set at 15 $l.min^{-1}$, could potentially provide oxygen for up to four hours using a closed-circuit device, depending largely on the size of the carbon dioxide absorbent canister and the flow rate utilised.

Other than the considerable additional maintenance requirements, the major drawback with closed-circuit devices is again the extra training and skill required to use them effectively, especially with ventilation of the non-breathing victim in the closed-circuit mode. As with BVM devices, it usually requires two people to adequately ventilate a non-breathing victim.

Another area of some contention has been the potential for nitrogen to be trapped in the closed system, and the consequent reduction of the oxygen concentration. Due to retained nitrogen and entrained nitrogen, normobaric oxygen rebreathers typically maintain a mean oxygen concentration in the order of 80–95%.[14,15] When using such devices to provide first aid for DCI (and toxic gas inhalation) it is important to flush the circuit periodically and to use an adequate oxygen flow rate.

CHEMICAL REACTION SYSTEMS

These systems utilise a chemical reaction to produce oxygen. One such system that has been marketed to divers is known as the emOx™ (Figure 8). It consists of a plastic flask in which the chemical reaction takes place, with delivery tubing connecting the closure cap to a mask. Pre-packed quantities of the powders are placed in the flask and a measured amount of water added. The chemical reaction commences immediately and the flask is then closed to direct the oxygen produced via the delivery hose to the face mask.

Although the system has some advantages in certain, very limited situations, it is most definitely not suitable for divers with decompression illness. The most important reason for this is the inability of this system to provide anything near to 100% oxygen to the injured diver. The advertised mean flow rate of 6.4 $l.min^{-1}$ is often incapable of producing inspired oxygen concentrations higher than about 30–40% using the supplied delivery system.[16]

FIGURE 8
THE emOx™, A CHEMICAL REACTION OXYGEN SYSTEM

DAN oxygen units

The Divers Alert Network has configured and assembled a series of oxygen units, designed specifically to cater to divers' requirements. DAN oxygen units are not only effective, but also easy to use and so require minimal training.

Training

It should be obvious from the discussion above, that some types of equipment are easier to use than others. As mentioned, a demand valve is usually the simplest system to use with a breathing, injured diver. A resuscitation mask with oxygen inlet is the easiest method for ventilating a non-breathing victim. These techniques require far less initial training and continued practice than other methods, and can be performed effectively by one trained person.

All divers are strongly advised to undergo training in oxygen provision, and should be thoroughly familiar with any oxygen equipment that they might use. DAN has created relatively simple but very effective oxygen-provider programmes to train divers, and others, in the use of various oxygen-delivery devices.[17] To date, DAN has trained more than 150,000 oxygen providers worldwide, with in excess of 12,000 in the Asia-Pacific region. Some organisations other than DAN also provide oxygen training, but this is not aimed specifically at the diving environment. Skills must be regularly updated as they deteriorate relatively quickly. In Australia, the Australian Resuscitation Council recommends that oxygen-provider (and CPR) certifications are renewed annually. Re-certification should involve a demonstration of the main skill competencies as well as a knowledge review.

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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 Annual Scientific Meeting 2003

An essay on the hazards of human life in the ocean

Des Gorman

Key words
Underwater diving, underwater hazards, decompression illness

Abstract
(Gorman D. An essay on the hazards of human life in the ocean. *SPUMS J* 2003; 33: 199-202)
This essay is a personal view of the attraction that many humans have to being in the ocean, both with respect to the drivers of that attraction and to its related hazards, which persist despite years of attention. There is no doubt that the pursuit of food, riches and military conquest can explain much of human behaviour both in and out of the ocean but, as is true for any complex human behaviour, a singular gain explanation is limited in applicability. The converse argument that much human activity in the ocean occurs independently of gain is also true. It is a physiological fluke (the low perfusion pressure of the pulmonary arteries and the consequent trapping of venous bubbles) that enables any form of prolonged human hyperbaric exposure without significant neurological injury, and decompression illness remains an enigma. The human attraction to being in the ocean is ancient and is almost certain to continue, providing countless hours of pleasure, reward and disease.

Introduction

This essay addresses the attraction that many humans have to being in the ocean, both with respect to the drivers of that attraction and to its related hazards, which persist despite years of attention. The sub-theme of the essay could be the Latin phrase, 'e mare, a mare', which translates literally to 'from the sea, to the sea'. The associated hypothesis here would be that humans are engaged in a costly reverse evolution for reasons that remain elusive.

What are the drivers for the human attraction to being in the ocean?

The human attraction to being in the ocean is ancient. This essay is not a historical treatise, but Alexander the Great's employment of divers in various military roles could be used to both illustrate the antiquity of diving and to argue that the main driver in this context is primary and secondary gain (gain). There is no doubt that the pursuit of food, riches and military conquest can explain much of human behaviour both in and out of the ocean but, as is true for any complex human behaviour, a singular gain explanation is limited in applicability.

The converse argument that much human activity in the ocean occurs independently of gain is true for some archeological and scientific diving and for almost all recreational diving. Indeed, given the reality of the hazards that humans experience in the ocean, and even allowing for the perceptual inflation of the risks associated with some of these hazards and the deflation of others, this pre-occupation occurs despite many negative influences and often at considerable financial cost.

Jacques Cousteau proposed through the medium of his anthropocentric documentary movies and television programmes that humans are attracted to the ocean in a form of reverse evolution. His romantic theory was based on an analogy of the ocean to the womb and the return of adult humans to the uterine environment. It is easy to parody this by absurdly extrapolating the tides to the ebb and flow of uterine blood flow.

There are several more poignant reasons why Cousteau's hypothesis is flawed. The most important of these are that humans are a 'long evolutionary distance' from the primeval swamp and ocean, are essentially terrestrial, and have little or no residual and/or new adaptation to life underwater. Indeed, with the exception of some concurrent adaptations, such as neuronal and cerebrovascular responses to hypoxia, humans have little or nothing in common with marine mammals in the context of the so-called diving reflexes. This is even true for accomplished diving societies such as the Japanese and Korean Ama, who are well acclimatised but poorly adapted to being in the ocean.

In the context of this argument about any human predisposition to being in the ocean, it is worth noting that it is a physiological fluke (the low perfusion pressure of the pulmonary arteries and the consequent trapping of venous bubbles) that enables any form of prolonged human hyperbaric exposure without significant neurological injury.

For my generation, much of the appeal can be attributed to our heroes and anti-heroes, and to the media that maintained their imagery; Lloyd Bridges as Mike Nelson in *Sea Hunt*, and Hans Hass as himself are obvious examples. It is amusing in this context to recognise that Hass's favourite closed-circuit diving equipment and the oxygen that he used to dive with would be lethal for many mere-mortals.

During World War II, Ken Donald, later Emeritus Professor of Medicine at Edinburgh University, visited this variability in oxygen tolerance; lessons seemingly unknown to many contemporary and consequently temporary technical divers. Donald's navy frogmen are part of the legend of diving that inspired so many of us, as were the mysteries such as Buster Crabb's disappearance without trace during an underwater reconnoitre on a Russian warship in Portsmouth Harbour. Hass himself was considered to be so important that he had considerable freedom of movement during World War II despite being an Austrian behind enemy lines (he was in the Caribbean when war broke out).

The media have been a mixed blessing for the recreational diving industry. Movie characters such as James Bond in *Thunderball* inspired would-be aquanautic 007's, whereas, the anxious were greatly troubled by the mechanical shark that starred in the *Jaws* series. The recreational diving industry has probably been a victim of its own success. The popularity of such diving increased rapidly during the last decade, in large part due to the careful media portrayal of diving as being avant-garde, somewhat dangerous and 'sexy'.

This, of course, was in conflict with the claimed safety record for sports diving, but the spin doctors managed this very well. By the end of the decade, divers had become so commonplace that the social image consequently suffered; other 'out-there' sports were readily available and recruitment and retention suffered. The response has been to develop new forms of recreational diving and to debate the lower age at which it is appropriate to teach children to dive. Although the suggestion is cynical, both of the latter can be interpreted as a direct commercial response to declining markets.

Commercial and military diving has also suffered a recent fall off in interest due to robotics, although not to the extent predicted by the United States Navy in 1983, the collapse of the Soviet Union and the general fall in real terms of the price of oil. Stricken submarines, mine countermeasures and Special Forces operations remain the stimulus to military attention to diving.

This current decline in popularity is probably best seen as cyclic and as a correction to the extraordinary growth of recreational diving in the previous decade, a growth that involved many individuals poorly suited to working and playing in a dense, mobile, non-respirable and unpredictable marine environment. The human attraction to being in the ocean has survived for millennia and is almost certain to continue, albeit with socially influenced troughs and peaks of interest.

The hazards of human life underwater

In general terms, there has been a progression from breath-holding techniques for being in the ocean, to diving using surface supplied breathing apparatus (SSBA), to diving using self-contained breathing apparatus (scuba), and a concurrent attempt to avoid hyperbaric exposure by the use of armour.

Breath-hold diving is accessible and rich in hazard. As cited above, even societies of breath-hold divers may be well acclimatised but are poorly adapted. Immersion causes a centralisation of blood volume and a consequent contraction of blood volume, which can have deleterious effects during and after any subsequent rescue, and loss of lung compliance. Hypothermia is common. Ambient pressure is transmitted through body fluids such that gas volumes change and cause a plethora of barotraumata. Dangerous marine animals are encountered, divers become entangled and for these, and many other reasons, they drown. One of the most important of these reasons is hypoxia of ascent, an event that is made more likely by pre-dive hyperventilation and by hard work while underwater. The onset of hypoxia is unlikely until the diver returns to the surface, as the relevant gas tension is a product of ambient pressure and alveolar oxygen fraction.

Breath-hold diving was also used to salvage sunken sailing ships, a process facilitated by firing of the ships. The advent of bells to assist the diver resulted in breath-hold diving from a compressed gas source; this resulted in even more barotrauma and the increased duration of hyperbaric exposure caused tissue and venous bubble-induced decompression illness (DCI).

Early attempts to armour the diver were naive to the transmission of pressure through fluids and also frequently flooded. Later attempts have become very sophisticated and have enabled very deep exposures. However, to date the robotics industry has not found an effective substitute for the human hand, which has the highly desirable and functional properties of proprioception and torque. Although remote-operated vehicles have replaced divers for many occupational and military tasks, there remain many that are still the province of the diver.

Armoured suits have intrinsic problems in maintaining oxygen and carbon dioxide levels, and in the waste products of additional equipment for propulsion, etc. This is best exemplified by submarines, which are (hopefully) normobaric, sunken, steel cylinders replete with every known industrial environmental hazard.

The recent sinking of the *Kursk* has also highlighted the associated problem of escape and rescue from a stricken submarine. There has been much debate about the likely morbidity and mortality of such events. While the traditional approach to support of a sunken boat has been based on the infrequent occurrence of lung injury and arterial gas embolism in training (about 0.05% of training ascents), it is probable that, in most situations, almost all submariners escaping and/or being rescued from a stricken submarine will be sick or injured.

The ongoing reliance on commercial and military divers and the growing number of recreational divers has been responsible for the development of both SSBA and scuba diving. The invention of effective SSBA quickly increased the depth and duration of underwater exposure. The former resulted in increasing problems with nitrogen narcosis and gas density, and the work of breathing. The latter was manifest mainly as DCI.

Helium and then hydrogen were seen as alternatives to nitrogen; the United States Navy developed oxygen-helium diving schedules more than 60 years ago and hydrogen was used by the Swedish to dive to 500 fsw during World War II. Both gases have advantages and disadvantages (e.g., thermal stress) compared with nitrogen as a diluent gas in diving. Although the various inert and metabolic gases have a differing propensity to bubble formation, relatively if $N_2 = 1$, then $He = 0.7$ and $O_2 = 0.3$, neither helium nor hydrogen has resolved the problem of DCI. Liquid breathing could, but remains very experimental.

Buhlmann and Keller developed oxygen decompression schedules for a 1,000 fsw dive, which Hannes Keller carried out 40 years ago with lethal outcome for his co-diver and for one of the standby divers. Media pressure and the threat to his funding may have been the major reasons why he embarked on the dive despite a cracked bell and leaking helium supplies. However, this is mere anecdote and rumour. What is clear is that Keller encountered the High Pressure Neurological Syndrome. This syndrome appears to be hydrostatic in nature, such that it could not be prevented by liquid breathing, and may well be the hazard that limits human underwater exploration in the absence of submarines.

The time taken to compress divers to a work site and the very long times needed to decompress to avoid DCI, e.g., 10 days from 300 msw, resulted in an economic incentive to develop saturation diving. Despite the bizarre physiology and predictable psychology of such diving, this development has had health benefits for working divers as the long-term health problems of diving (e.g., deafness, bone infarction, brain injury) appear closely linked to the number of decompressions that a diver performs in their career. The techniques of saturation diving and the current standard operating procedures represent a record of trial and, usually, error. It is not surprising that an escalation of diving in society would involve the antithesis of such equipment-dependent diving, that is, scuba diving; although technical divers seem ‘hell bent’, literally, on reversing that trend.

Although scuba well pre-dates Cousteau and Gagnon, their invention of a breathing regulator was the stimulus for the still current scuba domination of diving. Three phases of the modern scuba epidemic can be identified. The first was that of untrained, male hunter-gatherers. Mortality and morbidity were relatively high. Equipment was blamed, but then, as now, most underwater accidents were the result of human error. The second was characterised by the expansion of diving training agencies, the adoption of conservative diving practice and by increasing numbers of women and ‘environmentalists’. Mortality and morbidity fell dramatically.

The third phase is current and is technologically and not intellectually driven. There are signs that morbidity and mortality are increasing again, but, despite the financial growth of the recreational diving industry in the broadest sense, the denominator of exposure is still unknown such that incidence data are not available. Wreck diving appears more dangerous than cave diving, largely due to the conscientious behaviour of cave-diving organisations in response to earlier alarming death rates.

The use of closed and semi-closed diving apparatus by recreational divers will acquaint this community with the problems of hypoxia, oxygen toxicity and carbon dioxide toxicity so well known to the commercial and military divers who have been using such equipment for more than a century. Few lessons learnt by the latter appear to have been understood by the former.

The mystery of decompression illness

Decompression illness remains an enigma. Although the physical explanations for bubble formation are at variance with observation, it is probable that bubbles form in tissues and venous blood after nearly all dives below 4 msw. Unless there is intra-pulmonary or intra-cardiac shunting and/or pulmonary barotrauma, the arteries remain relatively free of bubbles. The role of the pulmonary arteries in filtering venous bubbles has already been cited.

The result of bubble formation is mechanical, biochemical and vascular disease, which varies from no discernable change in health status for the individual, to death, and everything in between. Research on the subject and especially on the prevention of DCI has been bedevilled by an arbitrary threshold category outcome imposed on this spectrum of disease, which results in a binomial outcome, DCI versus no DCI, where one outcome, DCI, is relatively rare.

Factors such as anxiety, hypochondriasis, insurance, litigation, and proximity to a treatment facility will shift the threshold of reporting to the healthy end of the spectrum, for which the natural outcome remains uncertain. Conversely, the nonsensical concept of safety, which literally means freedom from risk, in diving, the paranoia that accompanies this and consequent denial behaviour will shift the threshold in the other direction. The number needed to treat (NNT) and harm (NNH) for all the conventional modalities used to treat DCI are unknown; dogma and anecdote rule. A shift in emphasis to altering the vascular effects of bubbles has some support. Using cardiac surgical patients as a facsimile for divers, the NNT for lignocaine to prevent brain injury from arterial gas embolism in comparison to placebo one month after the event is about five.

The hazards of human life in the ocean

I am unable to answer simply the question of what are the drivers for the human attraction to being in the ocean. Nevertheless, I am sure that singular theories of gain do not provide an adequate explanation any more than does reliance on theories of media-influenced societal fashions. Certainly, these drivers operate in the context of a rich environment of hazards and despite the limited adaptations that humans have for being in the ocean. What I am sure of is that human activity in the ocean will persist and provide countless hours of pleasure, reward and disease.

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This essay is the text of an illustrated presentation given by Dr Gorman at the 2003 SPUMS Annual Scientific Meeting in Kuror, Palau, where he was the principal Guest Speaker.

Taking ‘tec’ to ‘rec’: the future of technical diving

Drew Richardson

Key words
Technical diving, recreational diving, general interest

Abstract
(Richardson D. Taking ‘tec’ to ‘rec’: the future of technical diving. *SPUMS J* 2003; 33: 202-205)
Today technical, ‘tec’, divers push the frontiers of manned exploration of inner space. When technical diving is being performed properly, tec divers are not thrill seekers or fools who simply disregard limits; on the contrary, they recognise that limits exist for legitimate, risk-management reasons. They seek to render the limits obsolete by applying new equipment and methodologies. In this sense, tec divers are diving’s future. They are diving’s innovators and problem solvers. They see change, challenge and choices, not ‘one size fits all’ diving.

Introduction

In 1962, US President John F Kennedy put forth a dream and a challenge to land a man on the moon by the end of the decade. Moreover, to make it really tough, that man had to come back safely. The technology did not yet exist. At that point in history, humans had made only a handful of short, orbital flights. As a result, the risks were unknown at the time. It was not known if humans could even live in space more than a few hours. In addition to this, the costs were unknown and there was not even a reliable estimate. From any reasonable point of view, it was impossible. Despite these odds, an entire generation in the US and much of the free world made it happen. It happened because they shared a dream and a vision to go beyond existing limits.
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The relationship between space exploration and technical diving

Today technical, ‘tec’, divers push the frontiers of manned exploration of inner space. They challenge themselves to new accomplishments just as President Kennedy challenged the free world. However, in doing so three relevant and important questions are raised:

1. What is tec diving, and who are tec divers?
2. How do you make the transition from recreational diving to tec diving, and should you?
3. If tec diving is pushing the envelope today, what will tec diving be doing tomorrow?

I hope that by sharing my views, I can shed some light on the answers to these questions.

Defining tec diving

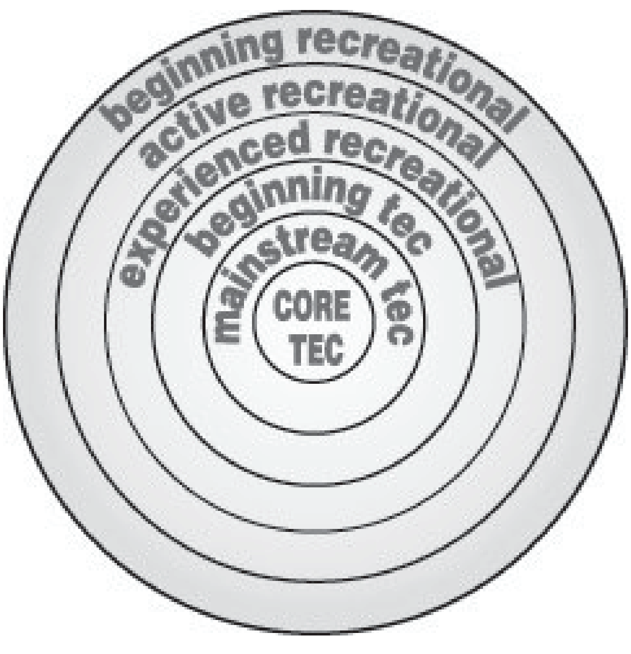
Let us start with both a formal definition and philosophical definition. A textbook, formal definition for technical scuba diving is as follows: diving, other than conventional commercial or research diving, that takes divers beyond recreational limits. It is further defined as and includes one or more of the following: diving beyond 40 metres, required stage decompression, diving in an overhead environment beyond 40 linear metres from the surface, accelerated decompression, and or the use of variable gas mixtures during the dive.

That is a technically accurate, but somewhat boring, description. I would prefer to rework it into more of a philosophical definition. In doing so, I propose that tec divers are better defined as both dreamers and visionaries:

- They see the possible when others see limits;
- They see opportunity when others see risk;
- They say, "There is a way, even if no one has invented it yet."

When technical diving is performed properly, technical divers are not thrill seekers or fools who simply disregard limits; on the contrary, they recognise that limits exist for legitimate, risk-management reasons. They seek to render the limits obsolete by applying new equipment and methodologies. They endorse recreational diving limits by acknowledging what is required to exceed those limits. So, in this sense, tec divers are diving's future. They are diving's innovators and problem solvers. They see change, challenge and choices, not 'one size fits all' diving. They act as the dreamers and visionaries for the future of scuba diving. They are the niche; the small segment of divers who not only see what is on the road ahead for diving, but also steer the course that gets us there.

FIGURE 1
A MODEL TO DISTINGUISH THE RELATIONSHIPS AND PHASES OF RECREATIONAL FROM TECHNICAL SCUBA DIVING



Who are 'tec' and 'rec' divers?

Figure 1 attempts to model the distinctions and transitions between recreational scuba diving and degrees of technical scuba diving. The outer rings depict recreational scuba diving, which has been well defined over the years, and consists of beginning, active and experienced recreational divers ('rec' divers). The experience and training needed to cross these various thresholds is arguable; however, there is generally accepted thinking as to what is required. The transition to technical diving and the progression based on experience are less well understood or defined.

'Mainstream tec' defined

Defining 'mainstream tec' is worth a short discussion for the purposes of argument. Divers who are categorised as mainstream tec generally can be defined as those who follow established tec protocols and are ready for challenge. Although they are following a beaten path, it is a far less travelled path as compared with recreational diving. That said, it is important to identify that the risks in doing so have increased. Just because a path is travelled does not make it safe. Consider this analogous example: many people have climbed K2 and Everest. Taking the same route with the same guides as others may reduce risk, but does not make it safe. The same is true for mainstream tec diving. mainstream tec divers are crucial to tec diving because they verify, refine and improve tec diving's innovations by repeating and reapplying them. They also serve a crucial purpose in doing so, as they uncover new problems. It is important to establish that interested divers must first participate in this group to reach the leading edge of tec diving, just as you have to start as a recreational diver and gain experience to begin tec diving.

Who are the leading edge 'core tec' divers?

For the purposes of clarification, I have categorised 'core tec' divers into three distinct groups:

- Pioneers – exploring new environments, depth and distances;
- Innovators – creating new technologies to make it possible;
- Test pilots – experimenting with their new technologies in new environments.

An example of 'core tec' diving was found in the Wakulla Project in 1987. Dr Bill Stone, Sheck Exley, Paul Heinerth and other cave-diving pioneers innovated open-circuit mixed-gas diving procedures for making long-range explorations on modified diver-propulsion vehicles. It was all new territory. Expeditions that are more recent have eclipsed the Wakulla Project's depths and distances, but these efforts stand on the foundation laid by the early leading-edge core tec divers.

Core tec divers are the group that faces the greatest risk, but also enjoys the greatest reward. Diving has always had 'test pilots' over its history; examples are found, for instance, in the first utilisation of helmet diving, scuba diving, oxygen rebreather applications or cave diving. This group drives advancement of diving techniques, methods and knowledge over the long run and is crucial to the entire model. The future of recreational diving is linked to technical exploration in many important ways.

How recreational diving benefits from tec diving

Recreational scuba diving has long been a benefactor of the innovation found in technical diving. Consider if you will the influence of innovation. It is conceivable, based on history, that today's mainstream tec diving may well be commonplace recreational diving tomorrow. Unconvinced? There are many examples of this, which are considered mainstays of recreational diving. These include the utilisation of alternative air sources, buoyancy compensators and the recreational usage of enriched air nitrox. These were all made possible through a process of innovation by leading-edge tec groups followed by refinement and verification by mainstream tec divers. This verification process establishes the infrastructure necessary to move new procedures, applications and equipment into the realm of recreational diving.

A second major benefit to recreational diving is in the form of exposure; tec diving raises scuba diving's visibility. Tec diving is exciting to the media because it is risky; it gets attention. This, of course, is a double-edged sword. Negative visibility can actually damage the image of scuba diving at large. Positive stories on the other hand, can depict tec diving as glamorous to many rec divers because of the gear and training required. There is a responsibility to communicate the training and equipment needed to safely make the transition from one to the other in the process. A third benefit is found in an excitement factor. For some divers, tec diving offers new excitement in diving. It should be noted that a subset of divers thrives on risk-related challenges; tec diving appeals to them. Other divers are passionate about specific dive environments, and tec diving is simply a means to reach some of them, deep wrecks for example. Tec diving enriches rec diving for casual divers who enjoy the excitement vicariously, much as casual surfers like rubbing shoulders with the champions they see on magazine covers and documentaries.

Bridging the gap

So, how does one progress from rec diving to tec diving? Let me first say that promoting or pushing tec diving as something for all divers is not desirable, because it is not for all divers. The reasons for this are obvious:

- It is risky;
- It is physically and mentally demanding;
- It loses its extreme status, which is its unique appeal;
- Most importantly, it is not what every diver, or even most divers, want out of diving.

For the minority who want to go into mainstream tec and qualify to do so, there needs to be a path. There is no reason to relearn lessons that cost someone his life. There are many tragic stories of divers dying due to ignorance, complacency or choosing to ignore known safety requirements on 'psuedo-tec' dives. In all cases, requirements for training, equipment and methods were not respected. To minimise this type of problem, an educational pathway is appropriate and must accomplish three main objectives:

1 Train to meet the demands of the activity;
2 Build upon minimum experience requirements;
3 Use sound learning psychology and instructional system design applied to tec community practices.

While this may be reasonably clear, for those divers who wish to go from mainstream tec to core tec diving, the test pilots pushing the envelope, the pathway is much less clear. There is no path through formal training, and there cannot be a legitimate one. By definition, the core goes beyond the known to the unknown. You cannot educate before you innovate. So how would one make that transition? The best path is to gain lots of mainstream tec experience and team up with others breaking new ground. It is imperative to first know what one is doing and then to accumulate a large amount of practical experience. By definition, core tec, or expeditionary technical, divers are people who are making it up as they go. They work in the environment where we often count lessons learned by counting bodies. The important point is that one must have a broad experience base with what has worked and what has failed to work in the past in order to become an expeditionary or core tec diver.

The future of tec diving

What we call tec diving today will not be technical in the future. Today's tec diving may be tomorrow's recreational diving. In 20 years, a trimix dive to 80 metres may be a typical Advanced Open Water dive. Equipment technology could make tomorrow's gear so reliable, redundant and navigationally proficient that it would be reasonable for brand new open water divers to explore caves and wrecks. But if these dreams come true, tec divers may be making 300 metre dives routinely using hydrheliox (hydrogen/helium/oxygen) gas mixtures, exploring the *Titanic* in the fourth generation of Phil Nuyten's one-atmosphere suit, and building and living in underwater habitats for long-duration adventures. Dreamers and visionaries can make this possible.

As long as humans have the desire, drive and passion to explore, there will always be tec diving. The 1960s dreams of humanity expanding into seas to live and explore faded with government funding cuts in the 1970s. However, they did not die. Today they lie before us, rekindled by the hearts and minds of diving visionaries worldwide, Sheck Exley, Bill Stone, Jacque Cousteau, Parker Turner and others.

As a community, our future lives or dies with a few concepts. Firstly, there is enough experience within mainstream tec diving for a consensus of broad guidelines and community practice. We need to unify with respect to these to minimise accidents. There is no future in disunity or an ‘anything goes’ attitude. Whilst we need such a consensus, we also need reasonable flexibility to tackle problems in different ways. We need to treasure our differences. Innovation arises from diversity, not uniformity. When we disagree, we need to disagree respectfully, or we lose credibility. If without mutual respect, the world sees us as squabbling amateurs, fresh ideas do not flow and progress stagnates. There is no future in infighting and backstabbing. Finally, we need to accept the consequences of taking risks. Those of us who choose to undertake tec diving must accept that we may die or end up with permanent disability.

Complacency must never be allowed to creep into our procedures and approach. We must never drop our guard because tragedy often strikes when risk seems the most remote. We need only remind ourselves that in the quest to reach the moon, three astronauts died, not in space, but in a fire on the ground during training. This means that should we experience injury or death, we accept the blame and responsibility ourselves, no matter who or what failed, or what did or did not happen. There is no future in finger pointing and scapegoating. Humankind’s future underwater, and the future of the underwater world itself, lies in our hands; in your hands. Dreams are fragile. Handle them carefully.

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10 commandments of closed-circuit rebreather diving

1 You might be the most experienced open-circuit, mixed-gas diver, but always remember that you are a novice on a rebreather.
2 The most important check you can make is to breathe from your unit for five minutes before you dive. It’s better to pass out on the boat deck, where you can be resuscitated, than in the water where you’ll more likely than not to drown.
3 Complacency kills. If there’s any doubt about your absorbent, change it.
4 If you think you’ve got ‘just enough’ oxygen or diluent, you haven’t.
5 Know what mix you’re breathing. This is more important that anything else. If you have a problem check what you’re breathing.
6 If your mind wanders and you find yourself not doing anything during a dive, immediately check your consoles. Otherwise you must check them every two minutes.
7 Think about preventative safety, rather than remedial safety.
8 Remember, when rebreathers bite they bite hard. You may not be alive long enough to even realise what’s going on.
9 Learn to listen to your rebreather in the same way you listen to a car. You’ll know when something is wrong, even if you can’t locate it.
10 Turn it on!

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SPUMS web site development

SPUMS urgently needs a volunteer from the membership to take an interest in redeveloping the SPUMS website with the aid of a web site professional.

This is your chance to have input to the direction your Society takes in regard to its appearance and presentation in the growing world of electronic media. The Committee believes this is a very important aspect of the ‘face’ of the Society that needs more attention.

Computer literacy is essential. Some web site development experience would be desirable.

Once the site has been revamped, it would be expected that you would have a continued contribution to its running.

Any expressions of interest should be directed to the SPUMS President, Secretary or the Journal Office.

Children and diving

Children and diving: a review of SPUMS articles

Carl Edmonds

Key words
Children, recreational diving, scuba

Abstract
(Edmonds C. Children and diving: a review of SPUMS articles. *SPUMS J* 2003; 33: 206-211)
This review of recent articles relating to scuba training of children published in the SPUMS Journal counterbalances some of the perceived bias of the diving industry organisations and affiliates. Additional case reports are supplied and factual information regarding diving deaths is related to the specific limitations imposed by childhood. The legal and moral implications are discussed and proposals are made to ensure that safe scuba diving experience is made available to children who are medically fit to undertake this.

Introduction

I was saddened to read the latest SPUMS Journal articles on children scuba diving.[1–8] Because of the apparent absence of critical editorial or peer review, I felt obliged to respond to the Editor's request for debate and share some facts and opinions contrary to the tenor of the publication.

I have tried, as far as possible, to restrict my comments to information now available in the Australian literature. As the original much-debated decision of SPUMS was to treat all divers below the age of 16 as children, requiring independent guardianship, and as it has some basis in law, I have persisted with this definition.

Case histories

Three previously published cases are selected to illustrate several important issues.[9–12]

CASE ONE

In 1971 I assisted at an autopsy on a previously healthy 14-year-old boy who drowned while under scuba instruction and performing shallow-water training exercises. On the surface, he cried out for help and appeared to be panicking just prior to disappearing. His body was recovered in 9 m of water. There were signs of facial and upper respiratory tract barotrauma, indicating that he was alive but possibly unconscious as he sank.[13] He died of drowning, aggravated by over-weighting and panic.

CASE TWO

Another 14-year-old diver was trained in that same year, but presented a year later after acquiring reasonable experience. He was on an organised club boat training/excursion and became seasick and vomited before diving. During a dive to 13 m, he lost contact with his more experienced adult buddy on the ascent and died from drowning, probably secondary to pulmonary barotrauma.

CASE THREE

The third case was certified as an open water diver at 12 years of age, and was very conscientious in her post-qualification training. Eight hours after a routine three-monthly dive at Manly, to 6 m for 37 minutes, her father drove her home over the Blue Mountains. Aware of the precipitation of decompression sickness (DCS) with altitude, symptoms started to develop. They got worse as the father and the daughter sought reassurance from each other. They managed to contact the Diver Emergency Service in Adelaide, and were diverted to Westmead Hospital for intravenous infusion and finally ended up in a hyperbaric chamber, where she really was in a very disturbed state. The anxiety, dyspnoea, hyperventilation, numbness, paraesthesias and confusional state, aggravated by the protracted assessments and treatments, were all totally identifiable as an acute psychological reaction. The whole family ended up with post-traumatic anxiety problems.

Clinical commentary

Why mention these three cases? Because they complement Walker's cases[5] and illustrate some situations in which children are more vulnerable than adults to diving problems. They also illustrate the inadequacy of the 'diving limitations' for children divers to be discussed later.

In Case One, the effect on the parents, the instructor and the other students was catastrophic. It also had a profound effect on this observer and instigated a career-long drive to reduce diver deaths, especially in the young. The instructor was equally devastated.

Case Three was a normal 13-year-old female with a psychological profile of obsessionality and an anxiety-induced hyperventilation syndrome. The emotional basis for this syndrome is part of early adolescent development. This is a normal development, unrecognised and probably unrecognisable by most dive instructors or non-psychiatrically-aware doctors.

During my years as a specialist diving physician, I would have treated only a few dozen children scuba divers, and the majority presented for either upper respiratory tract barotraumas (sinus and ear) or psychological-based problems presenting during diving. The latter would be classified as normal developmental problems of immaturity by most psychiatrists. There were a few asthmatics.

The youngest scuba diving death I am aware of was aged seven years,[14] although the University of Rhode Island did state that the 10- to 15-year age group represented 7.8% of the diving deaths in 1970.[15] Child diving had a burst of popularity around those years, which may have explained this high incidence, not evident in the intervening years.

Review of SPUMS papers

There are some comments that are general and were not refuted in the papers published recently:

- There are no adequate evidence-based medical data available.[7]

Corollary: One can still rely on experience and case reports to illustrate the type of problems that exist and the means of prevention.

- Scuba kids are here to stay.[1]

Corollary: So is dental caries. This does not mean that one should not try to prevent pathology.

- A strong emphasis on snorkelling skills is needed.[1]

Corollary: We should encourage safety-orientated swimming and snorkelling training by qualified instructors. Medical fitness for snorkelling is described elsewhere.[16]

- Industry-based figures for accidents suffer from under-reporting.[3,6]

Corollary: All statistics should be critically evaluated before publication, especially those that look too good to be true.

- Children are less physically powerful (most authors).

Corollary: Aquatic/physical fitness standards should be applied, as tidal currents are not influenced by the age of the diver. A 200 m unassisted swim in less than five minutes is a reasonable prerequisite.

- Children are emotionally immature (most authors).

Corollary: Age is the best correlate with maturity. Vigilant supervision of children and competent 'duty of care' is obligatory. They need to be genuinely supervised while diving, not just have a companion.

- Children are not little adults.[5,7]

Corollary: Then let us not treat them like little adults.

Taking the specific presentations in order:

THE EDITOR'S OFFERING[1]

The editor made his views clear. If SPUMS and specifically its president, Dr Walker, refuse to change their recommendations to comply with the diving industry's wishes, they will be seen as dinosaurs. His praise of the diving instructor organisations' (DIOs) "well-designed training programmes", "clear limitations" and "tightly controlled parameters set by the training agencies" both in his editorial and case report leave no doubt where his inclinations lie. His endorsements will be greatly appreciated by the marketing branches of the DIOs. But is the SPUMS Journal the place for them?

The Editor gave unqualified praise to the Belgium paper, which finds no problems with children scuba diving, and expresses regret that this decade-old study has not been previously published in the medical literature. One possible explanation could be the quality of the data and therefore its conclusions. He also delegated the responsibility of scuba training decisions to the parents/guardian who, unless they have comprehensive knowledge of medical and diving problems, will make uninformed judgments.

As the Editor, it is his privilege to agree or disagree with specific contributions. Nevertheless his endorsements are unsupported by argument, and conflict with the case reports supplied later in the Journal, the thoughtful guest editorial and previous contributions to the SPUMS Journal.[12]

CHILDREN AND DIVING: MEDICAL ASPECTS (BELGIUM STUDY)[2]

Its methodology and design need to be elaborated and defined before credence is given to this study, performed by a sports physician, an engineer and a nurse.

A prospective eight-year follow up of 234 children trained with scuba sounds impressive. However, questions relate to this population sample. The six- to 13-year-olds seem to not reflect the Belgian community, with an asthma prevalence of less than one fifth the normal.[17,18] No other cardiac or respiratory problems, no grommets, no epilepsy and no emotional limitations were apparent in these children, influencing their fitness to dive. This is either a highly selected group, or it suffers from inadequate assessment or poor documentation. Such options can also be considered in appraising the rest of the clinical data and 'statistics'.

The series of 205 children extended over an average of five years, but with different children. It was not 205 children for five years. The drop-out rate, for a variety of reasons, was 25% per year! 'Drop-offs' were replaced. This is not a population survey; it is a survivor survey. Thus, it will predictably under-report morbidity and virtually exclude mortality. The study is not dissimilar to the misrepresentation of asthma and diabetes surveys also used to market the concept of scuba safety.[19]

Exercise ECGs and EEGs were performed on all candidates. The latter were performed to assess psychological maturity. This is not a well-established method in the English-speaking world. Will the proponents of child diver training in Australia and USA now recommend exercise ECGs and EEGs for children under 16? I was not, then, surprised to find that "hyperventilation is prohibited before the age of 10 years and strictly limited before the age of 14 years". Water temperature greater than 12°C is classified as warm.

There seems to be a discrepancy between Belgium, in its diving medical knowledge and culture, and Australia. This requires clarification and extends to the fields of psychology, electroencephalography and population statistics. I am not sure about New Zealand.

No incidents or accidents occurred during the children's 2216 open water dives. Not even ear equalisation problems (which they do define as incidents). The reporting procedure, if one existed, was not specified. To my knowledge, no other group has ever achieved such a spectacular safety record, except for the 800 pregnant women exposed to hyperbaric oxygenation in the USSR. They also had no complaints recorded.

CHILDREN AND DIVING EDITORIAL[3]

Cvitanovich and Langton gave a measured and informative resume of the problems of exposing children to hazardous situations, and especially a child's different emotional capability in handling stress, problem-solving and responsibility. They warned of the unpredictability of behaviour in 10- to 15-year-olds. They re-asserted that supervision by an adult needs to be close supervision, not merely accompaniment by an adult 'buddy'. Also, they stressed that informed consent of a child, even as they approach 15 years of age, can be a difficult issue. They gave references to the "well-documented risk of death and permanent disability" that can occur during dive training and that a small, prospective theoretical risk will almost certainly be viewed differently with the benefit of hindsight.

DCS IN 14-YEAR-OLD DIVER[4]

Davis presented an informative DCS case report illustrating "what can go wrong if the tightly controlled parameters set by the training agencies are ignored". What this article did not address is what can happen even if the parameters are followed. Fortunately, Walker's case reports[5] and my own cases add this dimension.

I agree with his comment that "post-traumatic stress problems are not uncommon" after these injuries. If this paediatric patient had had a less satisfactory response, with permanent neurological or psychological damage, there would be an excellent case in law questioning the fullness of the disclosure and understanding of the dangers of scuba by the client against his guardian, the instructor and his original medical examiner (not Dr Davis). Because of the statute of limitations as applied to children, this remains a possibility at least for a decade after the accident, until he reaches the age of 24 years, in most Australian states. I would also question the duty of care supplied by each of these potential defendants.

HOW OLD IS OLD ENOUGH?[5]

Dr Robyn Walker, president of SPUMS, documented the current (1992) policy, which is far more lenient than the previous one requiring a minimum age of 16 years before certification and the presence of a parent/guardian at the medical examination until the age of 18 years. SPUMS requirements were not relaxed on the basis of any data, but to comply with the Australian Standards. It may not be wise to allow commerce to dictate to medicine, but it did.

Walker, in her usual sensible manner, described nine paediatric deaths related to scuba diving. Of relevance in these cases was that:

- at least four were diving with their father;
- two were under training at the time (both died from pulmonary barotrauma with CAGE, probably initiated by panic);
- six died at depths less than 10 m;
- most drowned.

One of my three cases was under training at the time of death, at least two had panicked, and one was with her father. The two deaths occurred at a depth of less than 13 m, one from pulmonary barotrauma, and one from drowning. None of the combined 11 deaths died from DCS. These factual data should be kept in mind when assessing the DIOs' safety recommendations ('limitations').

Prudent general advice was given about the problems relating to equipment, environment and rescue requirements and how these related to the physical and emotional limitations of childhood. Walker was also the only contributor to the debate who actually extracted case records of scuba child deaths and reviewed them.

HOW YOUNG IS TOO YOUNG?[6]

A dive instructor, technical and deep diver and diving physician, Mitchell's presentation was originally written for PADI diving instructors, so perhaps the absence of case material was to be expected. He states that the figures supplied from CMAS and PADI indicate that the risk of serious injury is low, but these are likely to suffer from under-reporting.[3,20]

RECREATIONAL DIVING TRAINING PERSPECTIVE[7]

Richardson uses diving-industry-generated data to promote the commercially valuable concept of children becoming scuba qualified. DIO figures have always been treated with suspicion and were refuted by Monaghan, a population statistician and one of PADI's own instructors, in the past.[21,22] Richardson in a previous article in this journal used highly selective figures indicating scuba diving to be safer than swimming (hard to understand as one does both during diving) and bowls![23]

He now quotes figures of 3.5 million open water exposures with SNUBA, to depths up to 6 m, without incident! Those perennial problems that beset young adults learning to dive, such as claustrophobia and panic, aspiration of water, ear and sinus barotraumas, etc., were allegedly absent from his 3.5 million SNUBA experiences. This is surprising when all the other authors seemed to infer that children were more vulnerable to upper respiratory problems and emotional lability than adults.

Search of the internet site that he quoted in support of these figures, revealed not only no statistics on SNUBA, but no reference to SNUBA at all. I know only one child who used SNUBA, and he burst his tympanic membrane.

If one assumes that the reference quoted is an unfortunate typographical error and one searches the internet for information on SNUBA and SNUBA accidents, it becomes apparent that some commercial groups claim more than three million SNUBA exposures without a (legal) insurance claim against the company (internet search, followed by personal communication, Sub Sea Systems Inc, dated 19 August 2003). This is not the same as three million clinically injury-free dives!

Even if we restrict the 3.5 million dives as being free of 'legal or insurance-claim injuries', there are two provisos of note. Firstly, the legal waiver of responsibility for accidents, which according to the commercial web sites must be signed before exposure and indemnifies the operator, mitigates against any legal claims. Why would they need this if the activity is so safe? Also, perusal of some web sites demonstrates that litigation for such accidents has occurred.[24]

I deduce that it all depends on where you get your figures from, on how you re-define and collect incidents, or how truthful you wish to be in their presentation.

Richardson uses the same distraction techniques in this article that are often employed by DIOs. Despite knowledge of the child deaths described in his references, he spends most of his extensive report arguing 11 Dorothy Dix questions. He refers to these as "the main issues...in considering children and scuba diving". DCS, not a major cause of recreational diving deaths, dominates his discussion (five questions). He also deals with other less relevant or easily coped with conditions, such as oxygen toxicity, thermal protection and developmental factors such as patent foramen ovale and respiratory physiology.

Using this approach, the most common cause of death in children divers, drowning, is ignored, whilst the major contributors to death, such as panic (mentioned only in association with asthma, which excludes diving) and pulmonary barotrauma (reduced by not accepting anyone below the age of 10) are dismissed. This is a disingenuous approach that avoids tackling the real problems. He quotes two irrelevant projects that do not in any way bear on the genuine psychological immaturity problems described by Walker, Cvitanovich and Langton.[3,5]

Richardson does, however, succinctly and openly describe the PADI programme and the safety limitations it employs.

- PADI junior open water scuba divers aged 10-11 are limited to 12 m depth and may dive only with a PADI professional or a parent/guardian who is a certified diver;
- PADI junior divers, aged 12–15, may dive to 18 m or 21 m if doing a PADI course, and must dive with a certified adult scuba diver.

These 'limitations' on junior divers, even if applied, would not prevent most child deaths. They are minimalist standards that equally apply to adults and do not address most of the genuine 'immaturity' concerns defined elsewhere.

Legal implications

In an increasingly litigious society, one can anticipate that morbidity and mortality are now likely to be followed by demands for compensation for an unfortunate outcome. This is especially so with injury to children. The medical examiner, for pecuniary reasons, is a more vulnerable target for litigation than the less affluent dive instructor.

The most obvious cause for action will be the death of a child. More frequent, but still very serious, are the problems of hypoxic encephalopathy of near drowning, hearing loss from barotrauma, chronic sinusitis and a prolific myriad of psychological reactions.[25] In the case of children there is an automatic extension of damages resulting from interruption to education, limitation of occupational potential and interference with social functioning.

One of these problems has been addressed by Davis.[4] After the age of 24 years, it becomes more difficult for the diver described to take action for injuries caused whilst a child, but often the statute of limitations can be circumvented. For the medical examiner to demonstrate that the child was fully cognisant of the dangers is unlikely to be given credence once damage is experienced. The claimant will have logic as well as sympathy on his or her side. There is considerable doubt that a child can be held to understand the full implications of hazardous exposures, or be expected to behave in a mature manner during this stress, to avoid being injured.

Above the age of 16 to 18 years, most teenagers are considered to develop this responsibility. Thus they can then drive cars, fly planes, become surf life-savers, make financial commitments, etc. Scuba diving is not the exception that makes children act like adults. Most dive instructors and doctors cannot accurately predict a child's maturity, and especially how they will react to life-threatening stress in the absence of expert supervision.

Diving limitations for children

In assessing these proposals, one must appreciate the motivation of the proponents. If it is a genuine health issue, then health professionals experienced in diving medicine should be involved. If a commercial DIO is involved, then allowance must be made for their pecuniary interests. A survey of 35 diving physicians conducted by Professor Taylor at the World Congress on Drowning, incorporated eight paediatric specialists and a wide spectrum of other medical specialists.[26] It disclosed the following. The minimum age recommended for diving by this group was 14.9 years (mean) or 16 years (median). For those whose children were already diving, the age of commencement was 15.7 years mean and 16 years median, suggesting that their own practice was even more conservative than their recommendations.

Some advisers, be they medically qualified or diving enthusiasts or both, are risk takers. Of these, some will restrict their risk-taking behaviour to themselves, in which case they are not much of a danger to others. Some risk takers will promote their behaviour to others, and this is a particular concern if the others are children, whose capability to comprehend and counter the danger they may face, or its sequelae, is limited. The other wild-card proponent is the 'wanna-be' expert who, in the absence of experience or genuine contributions, relies on being avant-garde and fashionable.

Despite the rhetoric of both the physicians and the DIO affiliates, PADI requires only that their 12- to 15-year-old diver needs to dive in the ocean with 'a certified diver'. The latter may have achieved this certification with less than a handful of open water dives. That is not an adequate supervisor, whether a parent or not. That is someone who themselves needs supervision. It certainly does not fulfil the requirements for supervision and guardianship of a child.

The most common contributors to scuba diving deaths are panic (39%), aspiration of water (37%) and fatigue (28%).[27] The most common ultimate pathological causes of death in younger divers are drowning and pulmonary barotrauma. The acclaimed 'limitations' on children divers will have little influence on these causes, and indeed they are virtually ignored in the propaganda campaign run by the DIOs.

It is my opinion that a child under the age of 16 should only have 'dive experiences' under the following, moderately safe, conditions:

- They want to, without parental, peer or promotional pressure;
- They are medically fit to do so;
- They dive to a maximum depth of 9 m.

The nine-metre depth will certainly not prevent a child from developing pulmonary barotrauma, cerebral arterial gas embolism, any of the other respiratory tract barotraumas or anxiety reactions. It will, however, usually prevent decompression sickness.

- They are trained by and dive with a qualified instructor, and under the personal and total control of that instructor (i.e., not three or four trainees together).

The instructor has total responsibility for the child's safety. A buddy line between the child and the instructor is prudent to prevent uncontrolled ascents.

- After adequate training, all other dives are to be carried out only in calm and good environmental conditions.

This should be with the same controls as referred to above and with an experienced diver of instructor standard taking absolute control and responsibility.

- For open water diving the child should be aquatically and physically fit (200 m unaided swim in less than five minutes).

The child should not have the responsibility of rescuing others (such as a diver-parent). Unfortunately some have already experienced their parent's demise while diving. Irrespective of the child's total innocence, subsequent guilt can be catastrophic in these cases.

Giving a dive certificate to children under the age of 16, other than one that stipulates diving under the above very special conditions is, in my opinion, both courageous and irresponsible. I would be interested in all the contributors' responses, but especially those of the Editor, and Drs Walker, Cvitanovich and Langton on these safety recommendations.

This may make me a dinosaur, but I believe that a more accurate analogy for Dr Walker is a tall poppy being hacked at by commerce and fashion.

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Dr Vandenhoven replies:

Dear Editor,

Thank you for the opportunity to respond to Dr Edmonds' criticisms of our study.[1] Evaluation of prospective paediatric divers in this study was based largely on medical opinion, as there was only limited information in the literature and no adequate evidence-based medical data available in the mid-1980s.

To establish and assess a system of scuba diving initiation for children with a focus on safety and prevention of diving or other injuries, we undertook a prospective study in the first children's diving club in Belgium.

Two hundred and thirty four children between the ages of six and 13 years entered the study over an eight-year period. The average follow up was five years, with a range between one and eight years. The drop-out rate in this study reflects a real-life situation in different diving organisations throughout the world (CMAS, PADI, etc., since many divers, adults and or children, discontinue their diving activities after one or more years for different reasons. If one of the 205 children approved for scuba training discontinued diving activities, the reason(s) for this discontinuation was/were recorded as described in our paper. If the child was still diving, a phone survey of each child was performed by a registered recreational dive instructor using a structured questionnaire in order to avoid loss to follow up and eventual under-reporting of diving accidents and fatalities. No diving accidents were recorded in the above-mentioned group during the eight-year period of the study.

The study population sample is a highly selected group of Belgian and other European children living in Brussels. Potential paediatric scuba divers and their parents were first informed by the registered recreational instructors of the Brussels children's diving club of major contra-indications, such as asthma, epilepsy, etc. At that time, all divers in the Belgian diving federation (FEBRAS/BEFOS, a member of CMAS) had to undergo a mandatory, annual medical fitness-to-dive evaluation including resting and exercise ECGs and an EEG during the initial medical check. The children of this scuba diving club underwent the same medical evaluations. Therefore, the children in this study had a much lower incidence of asthma, epilepsy and other medical problems due to pre-selection as is commonplace before sports and diving medicine evaluation in Belgium. In other words, a high standard of medical evaluation of sports divers was and is required in our country.

EEGs were performed to exclude previously undiagnosed epilepsy in these paediatric divers, and not to assess psychological maturity as suggested by Edmonds. EEGs were mandatory for initial fitness-to-dive evaluation in Belgium until the mid-1990s. Presently a yearly sports medical evaluation is still mandatory, but an EEG is at the discretion of the evaluating physician.

The psychological maturity of children in terms of fitness to dive was very difficult to evaluate, a problem we all recognise. Optimal communication between parents, instructors and the diving physician during swimming-pool scuba training sessions allowed the evaluation of some aspects of psychological maturity before open water dives. The objectives of the indoor pool sessions were not only the introduction of the child to scuba diving and the equipment to be used, but also the progressive acquisition of diving skills and confidence before open water experiences.

Open water dives were allowed only once children had acquired sufficient basic diving skills. This included unaided swimming and snorkelling skills, as mentioned by Edmonds, and knowledge of the underwater environment in order to minimise the risk of panic reactions. These dives, under vigilant supervision and competent 'duty of care', were strictly limited to a maximum depth of 5 m for children certified divers aged eight to 11 years old and 10 m for the children certified divers aged 12 to 14 years. In practice, none of the children in this study undertook open water diving until the age of 10 years. Incidents and accidents were recorded by registered recreational dive instructors and a sports diving physician. Medical supervision by one or more sports diving physicians was provided during all 12 open water diving trips in this eight-year study. No incidence of aural barotrauma occurred during openwater diving activities because the children were well trained and practised in the skills of ear clearing by that time.

Basic requirements and rules for teaching children to scuba dive are a specific educated and trained team, detailed sports medical evaluation, a minimum age of eight years, modified equipment, education and training programmes focused on the individual child, selected environments within a suitable range of water temperature and limited depth and diving times. Communication between parents, instructors and the sports diving physician must be optimised. This system resulted in safe diving for these children.

At a recent conference in Switzerland, experience was reported from French (FFESSM) and Belgian (FEBRAS/BEFOS) children's diving programmes over the previous three years.[2,3] No fatalities, pulmonary barotrauma or decompression illness were reported since the introduction of these programmes, which were developed from our experience. These programmes differ from those of PADI.

Education, training and diving must be focused on and adapted to the individual child; if you can't change the child, adapt the environment.

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Dr Richardson replies:

Dear Editor,

Thank you for the opportunity to respond to the comments of Dr Carl Edmonds. Despite his personal and historical bias against 'DIOs' such as PADI, I believe Dr Edmonds reinforces a vital message for diving safety and for the importance of addressing complacency in avoiding morbidity and mortality in divers. Even though the tragic case studies he uses are thirty years old, from an era when diving standards and practice were not as well developed as today, they serve to reinforce the importance of vigilance when it comes to diving safety and supervision, especially for young divers. As programme and standards developers, my colleagues and I share a personal commitment to this end in our professional practice.

Dr Edmonds may be surprised to learn that we have more in common than he thinks. However, his allegation that we have taken a minimalist approach to the topic of diving programmes for children is simply ludicrous. Had he taken the time to read our publication *Children and scuba diving: a resource guide for instructors and parents*,[1] and the extensive body of PADI standards and educational material addressing this topic, he would find that many of his criticisms and concerns are actively addressed in detail. Given his lack of background and experience in instructional design, training and education, I find it disappointing that he persists in ignoring or dismissing out of hand sophisticated programmes, methods and techniques of the modern educational approach to diver education. Rather, he seems stuck with his pre-existing, and very dated, negative perceptions. His comments, that PADI programme and safety limitations on junior divers "even if applied would not prevent child deaths", are not supported by empirical data and therefore purely speculative and reflective of his negative bias. Further to this, it would appear that Dr Edmonds might believe that introducing young people to scuba diving is a new development lacking an empirical experience base, which it is not.

Does scuba diving have risks for children? In the event that he misunderstood my arguments, or felt I was overwhelmed with pecuniary interest, let me be clear – yes, it does. Considering that it has risks for adults, obviously scuba diving has many potential risks, which include drowning, lung over-expansion injuries, decompression sickness and middle ear injuries. There are also some theoretical concerns presented specific to children scuba diving because they are still growing.

The article I submitted to the SPUMS Journal attempted to provide a rationale for the programmes that PADI has recently introduced to mitigate these risks, not eliminate or understate them. Safety is the very basis for diver training and, to be fair, the outcomes of poorly organised diver training in the 1960s and 1970s were much worse than those from today's training paradigms. Even by the crudest indicator, diver mortality data are supportive of this fact. Each year, millions of scuba exposures occur, far more than did in the 'old days'. There are far more participants, far more exposures, and fatalities are not increasing. In short, modern diver training, education, supervision and practice are a vast improvement over the past.[2]

Anyone involved in scuba diving, adult or child, faces some risk of death or permanent, debilitating injury. Nothing aside from abstinence from diving can eliminate these risks, yet we believe that scuba diving is a reasonably safe activity. Assuming that abstinence is an unrealistic option, we have attempted to put together a comprehensive and incremental age-based programme of guided experiences for younger people. It is common sense that, while scuba has a lower accident rate compared to certain other sport and adventure activities, the potential severity were an accident to occur is much greater.

Children interested in diving, and their parents, need to accept these risks before they participate. PADI and other organisations such as SSI have created educational materials and videos such as the '*Youth Diving: Responsibility and Risk*' programme to explain these risks so both parents and children can decide for themselves whether to accept them.

When faced with potential risks and hazards, the easiest answer may appear to be 'no', but that may not always be the best answer. The truth is, there is no way to protect children from all risks they face in life. Children will grow up to be adults who face risks. Establishing responsible boundaries and monitoring a child's behaviour are important in order to avoid disaster. PADI programmes involving children handle the potential risks the same way. Limiting depths, requiring specific adult supervision and setting minimum ages for differing activities effectively manages and mitigates the potential risks of diving, including those unique to children. Parental involvement helps ensure that children respect and stay within these limits. Establishing a link between scuba instruction and a child's broader world requires communication between the instructor and parent. Parents participate in the instruction process, either as students in the same class, or by interacting with the child and study materials. Is this disingenuous? I think not.

The fact is, thousands of youngsters enjoy diving every year and have done so for decades. Dr Edmonds chooses to ignore the long-standing empirical database of the CMAS, and other similar programmes cited in my article, and focuses extensively on my reference to SNUBA, demonstrating a selective bias in his arguments. It is interesting that he spends four of his eight paragraphs of critique of my article of over 60 paragraphs refuting a point made regarding SNUBA, which was all of three sentences long. If one discounts the brief discussion of SNUBA from my article and the safety record that company claims, my arguments and rationale stand.

That said, even with proper supervision and within limits, accidents happen, but they are rare. In perspective, one need only look at other activities children enjoy that carry the potential for severe injury, permanent disability and death. These do not dissuade children from these activities, nor their parents from allowing them to participate. Their lack of adult learning skills and behaviours doesn't exclude children from learning to dive, any more than it excluded children from learning to ski, target shoot or play football. To the contrary, various diving experiences and programmes foster overall learning and growth and ask for reasonably mature behaviour, rudimentary mastery of physical and scientific principles, attention to following rules and guidelines, self-control and motor-skill mastery.

As for my utilising "distraction techniques" to argue 11 "Dorothy Dix questions", these questions were framed by the diving medical personnel at DAN when consulted on the matter and do not reflect a selection bias on the part of this author. Finally, I must correct Dr Edmonds and state that PADI requires all children to dive under the supervision of a dive professional, adult or parent, period.

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2 *Bennett and Elliott's Physiology and Medicine of Diving*, 5th edition. Brubbak AO, Neuman TS, editors. 2003: 51-54

The Editor replies:

Most importantly, Dr Edmonds criticises what he sees as a failure of peer review for the "*Children and scuba diving*" issue. The editorial intention was to provide a wide range of perspectives to stimulate critical debate on this important issue. The opinions of the authors were their own. As long as they were argued reasonably then these were not subject to 'peer review' in its full definition. One omission was not to identify Dr Taylor as a PADI instructor rather than simply a diving instructor in her book review. Both she and I considered this irrelevant, but the potential conflict of interest should have been acknowledged.

As a general principle, publication of material in this journal is NOT an endorsement by SPUMS (see "Disclaimer" on inside back cover). Any attempt by commercial enterprises to claim such would be regarded in the worst possible light by the Executive Committee.

The only new data provided by any of the writers, including Dr Edmonds, were those of Vandenhoven et al.[1] Dr Edmonds is correct that this paper was subject only to the Editor's review (which was extensive) and was not sent out for additional commentary prior to publication. The reason for this is worth noting. Vandenhoven et al's paper was received only shortly before that issue's publication deadline. The original intention had been to reproduce the abstract of their paper from the proceedings of the 2002 European Undersea Baromedical Society meeting. As a moderate-sized single cohort prospective study it is the only research I have seen that actually looks at what really happens from a medical standpoint with teaching young children to dive. As such, I took the decision to publish based on my peer review alone, and I make no apology for having done so.

"Unqualified praise" of the Belgians' paper was not given. Indeed, my comment regarding their failure to publish their work earlier should be taken as a strong criticism, one that Vandenhoven accepts. It is of little use if studies are undertaken then not submitted promptly for peer review and publication. Having said that, these data had been presented verbally at various medical forums in Europe over several years.

Dr Edmonds has chosen to misinterpret my editorial in a number of ways. I did not make my views clear, as he supposes. In fact, they fall very much in line with the policy of the Society as presented by Robyn Walker. Like Bill Douglas's, my children did not learn to scuba dive till over the age of 16, though they were all proficient swimmers and snorkellers long before then, hence my comment regarding the need for a stronger emphasis on these skills by the training agencies. This is a criticism of the DIOs, not an endorsement. Also, I would point out that the case report was carefully chosen to add caution to the arguments, and that I contributed New Zealand data to Robyn Walker's paper. These are not the actions of a biased editor.

It is regrettable that the "dinosaur" comment has been so misinterpreted, especially that the President regarded it as a personal attack. This was not meant to be so. The point is that the commercial training agencies have moved on to new markets without a body of medical knowledge to underpin the safety of that decision. Few doctors, apart from Vandenhoven's group, have made any real attempt to conduct prospective research in this area, but rather have chosen to pontificate based on theory. In this respect, we have indeed been left behind and it is now, in my opinion, too late to close the door.

In Europe, physicians have been more closely involved with the development of children's diving programmes than in the United States or Australasia. The model we take is from PADI and SSI, the USA-based companies that dominate the Australasian market. If Dr Edmonds read carefully the criteria proposed by Vandenhoven, he would find that these are remarkably similar to his own.

Interestingly, the British Sub-Aqua Club at their 2002 annual general meeting defeated a motion to reduce the age limit for its young branch divers from 14 to 12, but only on a technicality. Those who campaigned for the age reduction feared that failure to change would encourage continuation of an existing trend for parents to switch to other agencies so that their children can learn to dive, even if it means paying for the service. One of the campaigners for the change was quoted as saying "what parents want is to be made aware of the risks and then allowed to make their own decision with their child".[2] There is indeed a market out there and the training agencies have gone for it. As a profession, we have not provided sufficient evidence on which to say whether they are right or wrong. Thus far, what evidence there is suggests scuba diving is no more dangerous for young teenagers than for adults.

It was this evidence, collated by Diver Alert Network (DAN) medical advisers, as well as knowing about Vandenhoven's study, that the PADI decisions were based upon, utilising the best available evidence at the time. PADI should not be criticised for this. However, Edmonds rightly argues that no evidence does not mean the same as negative evidence. SPUMS, and its Editor, would continue to urge caution.

Nearly 50 years ago Jacques Cousteau published a now famous photo of himself scuba diving with his wife and young teenage children. The debate remains open within the covers of this Journal for the time being. It would be helpful if this were supported by scientific research from all parties to the debate rather than mere opinion.

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Articles reprinted from other journals

The Atlantis affair

Bernard Eaton

Forty years ago this month [Ed. note: December 1962], two divers made history by reaching 1000 ft in open ocean in a diving chamber called *Atlantis*. If only they hadn't opened the hatch. Bernard Eaton, a close friend of one of the divers, Peter Small, recalls what happened.

Last November [2001], John Bennett dived to 1000 ft – the deepest open-circuit scuba dive ever undertaken. This remarkable achievement, though appropriately heralded in diving circles, attracted comparatively little media attention.

But it was a different story 40 years ago. Then, on 3 December 1962, another Englishman became one of the first two divers to reach a depth of 1000 ft in the open ocean. This scientific triumph, which was to end in tragedy, was attended by the world's Press, the navies of Britain and the USA, and numerous top-ranking scientific establishments.

One of the men was Selby-born Peter Small, 35, a freelance science journalist of national repute, with whom I shared an office. Small was co-founder of the British Sub-Aqua Club, founder-chairman of the Underwater Equipment Research Society and principal organiser of the 2nd World Congress of Underwater Activities. He was a visionary who had uncompromisingly campaigned for more 'inner space' research.

The other was a previously little-known 28-year-old Swiss mathematician, Hannes Keller. The historic but fateful mission was his brainchild.

For though Keller survived the dive, Peter Small did not. Nor did a 19-year-old Lancastrian called Christopher Whittaker, who was one of two safety divers during the attempt.

The events of that tragic day off Catalina Island in the Pacific had their roots in 1958, when the young Hannes Keller became interested in diving. He quickly learned about all the physiological limitations and their effects – including nitrogen narcosis and decompression sickness.

Using his mathematical know-how, he came up with the theory that a diver should breathe a combination of gases different from those which make up ordinary air. Keller took his theory to Dr Albert Buehlmann, a specialist in lung function and blood circulation at the University of Zurich, who suggested which gases he should use.

Breathing Buehlmann's mixture, which was kept secret, Keller was lowered 400 ft to the bottom of Lake Zurich in a 40 gallon oil-drum and suffered no ill effects. Keller thereafter systematically fed 250,000 statistics into a computer and worked out the safety factors for dives down to 1000 ft. In 1960 he successfully dived to 500 ft in Lake Maggiore, and in 1961 he reached the record depth of 728 ft and returned safely after 45 minutes.

By then the US Navy was extremely interested in Keller's work and gave him a contract to continue his research. As a result, and in preparation for a 1000 ft dive, he designed and built a diving chamber called the *Atlantis*, 7 ft high and 4.5 ft in diameter, with a bottom hatch through which divers could leave and re-enter.

Early in 1962, Keller met Peter Small. He knew of Keller's project and asked to join it. Keller tested him by taking him on a simulated dive to 1000 ft in a decompression chamber, which he successfully completed. Peter was to write about the dive for a British national newspaper.

That November, Keller and his team arrived in Los Angeles to carry out preliminary tests. Peter Small arrived with his 23-year-old wife Mary, daughter of aircraft designer F G Miles, whom he had married three months previously.

Two local divers joined the party, American Richard Anderson and Christopher Whittaker, who was studying in UCLA. They were signed on as safety divers, their role to check the *Atlantis* in shallower depths if anything went wrong.

In one test, two days before the 1000 ft dive, Small and Keller descended to 300 ft in the *Atlantis*, remained for an hour and swam outside the chamber checking the equipment. This was probably the first time that any diver had stayed at that depth for so long. Small later complained of muscle pain but seemed all right after spending 4.5 hours in a decompression chamber.

On the morning of 3 December, the expedition's two ships set out from Avalon, which is on Catalina Island. Observers included experts from the US Navy's experimental diving programme and people from the Shell Oil Company, which supplied the support ship *Eureka* and the decompression chamber. Keller's surface crew, which included Dr Buehlmann, controlled the operation.

The historic dive began with a six-minute stop at 16 ft to check equipment. Then the descent began, with *Eureka* quickly paying out the cable. The two divers had water up to their knees and kept the hatch partly closed to prevent them falling out.

At 250 ft, Keller and Small stopped for two minutes to switch to the gas mixtures and the final descent began. The cable touched bottom at 1020 ft and Keller was later to say that when they opened the hatch there was about 5 ft of water between the hatch and the seabed.

Keller dropped out feet first, his aim being to place a Swiss and US flag on the bottom and return immediately. But as he left the chamber, the flag became entangled in the breathing tubes of his face mask and he couldn't see.

It took him two minutes to untangle himself from the flags and get back in the chamber. The two men then tried to close the hatch.

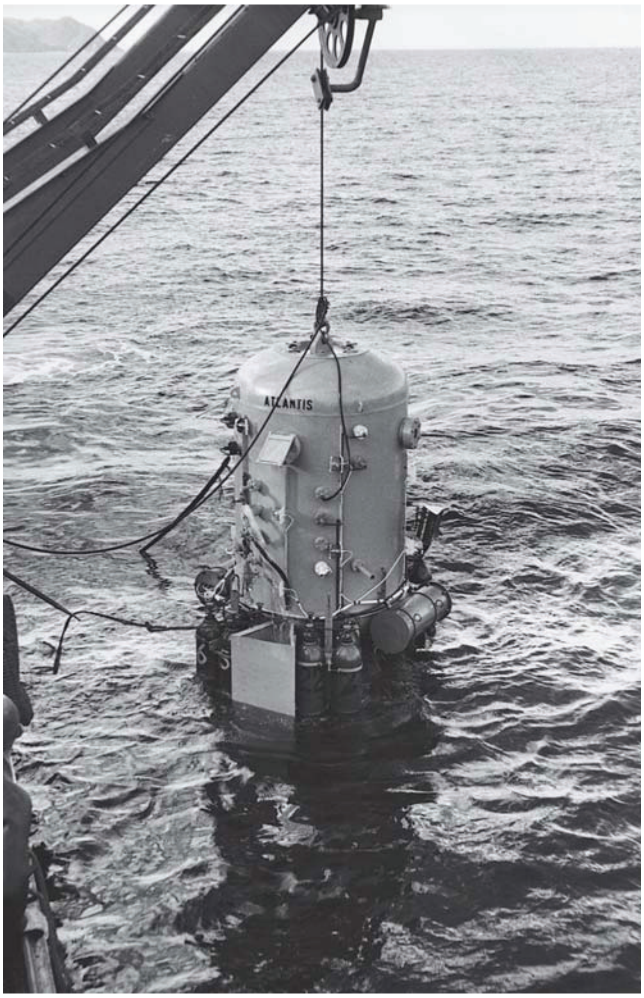
What happened then was related by Hannes Keller a few weeks later at the offices of *Diver* (then *Triton*) at a meeting that included BSAC Chairman Colin McLeod and Vice-President Oscar Gugen; Sgn-Capt Stanley Miles, Director of the Royal Naval Medical School; Sgn-Lt Tony Jarrett, RAF Institute of Aviation Medicine; Cdr R Harland, ex-Supt of Diving RN; Mary Small and myself.

Keller explained that four tanks supplied mixtures to the *Atlantis*. Tank 1 had been intended to take the two from 250–1000 ft, then back to 500 ft; Tank 2 from 500–300 ft, and Tank 3 from 300–130 ft. Tank 4 was a reserve.

During the early stages of the dive, Keller noticed that Tank 1 was showing only 80 bar instead of 150. The two were using semi-closed-circuit breathing sets with 3 litre tanks, and their reserve at 1000 ft would therefore be reduced to four minutes instead of 10 or 12.

Their dilemma, therefore, was whether to continue the dive and keep refilling their tanks, or to abort. They decided to keep on refilling, but instead of staying at 1000 ft for five minutes, as originally planned, to cut their bottom time to three.

Small (left) and Keller are suited up ready for the dive



The *Atlantis* chamber is lowered into the water

In Keller's opinion, this decision was one of two which probably caused Peter Small's death. The second mistake was to exit to drop the flags on the ocean floor at 1020 ft. In the circumstances, this should never have been attempted.

Keller said he was exhausted and dizzy when he climbed back into the chamber, and also felt some fear. In retrospect, he wondered if he should have promptly refilled the apparatus, but decided to close the hatch first instead. He tried to do this but a fin got caught in the hatch, so it wouldn't close properly.

All he could then do was to open the air-pressure valves to blow the water out of the chamber to prevent them drowning while unconscious. He then opened his face-mask and took his mouthpiece away to breathe ordinary air so that he wouldn't die from lack of oxygen. Peter Small tried to help him and also removed his mouthpiece, but failed to refill his own apparatus and, apparently, remove his face mask.

Within 30 seconds of re-entering the chamber, Keller lost consciousness and remained that way for half an hour, suffering from oxygen hallucinations. Small's pulse rate was low and his breathing shallow. He lost consciousness for 90 minutes, after which he began to speak and appeared reasonably normal.

However, he was exhausted and couldn't stand. He was given a drink and was suffering from heat, so Keller cut away his suit and underwear. He was in touch with Dr Buehlmann and finally reported that everything seemed OK.

Decompression continued for six hours and Small began to sleep. He kept changing positions and was very uncomfortable and nervous. When the bell was lifted onto the pier and laid down, Keller changed Small's position and noticed that he was not breathing. He failed to respond to mouth-to-mouth respiration. The chamber was opened and Small was rushed to the Navy's hospital ship, where he was pronounced dead on arrival.

A post mortem was to follow, with a high-level inquiry in the USA. This concluded that, with the exception of a serious gas embolism, Peter Small's condition was physically sound, with no evidence of cardiac diseases.

The committee agreed with Dr Buehlmann's conclusion that Small's circulation was seriously impaired through possible prolonged anoxia with loss of consciousness. He was therefore not able adequately to eliminate the nitrogen from his body, and so developed the symptoms of decompression illness.

One conclusion was that the whole experiment was fraught with potential hazard, caused by the complexity of pressure groups: magazine commitments; public announcements; navy contracts; borrowed items, including ship and closed-circuit TV; timetables; weather factors; limited individual time and expectant creditors.

Nevertheless, the committee concluded that the dive had produced a significant scientific achievement, if one that had saddened the worldwide diving fraternity.

Peter Small's death was not, of course, the only tragedy. What must not be forgotten was the courage and heroism of his friend and fellow-diver Christopher Whittaker.

Whittaker was one of the two safety divers who went to the aid of Peter and Hannes Keller when they were lying unconscious in the diving chamber. It was impossible to raise them to safety until the leak in the chamber, caused by the trapped fin, had been sealed.

No one will know just how exhausted Chris Whittaker felt, or what his thoughts were, after the unsuccessful first dive to 200 ft to close the hatch. But one thing we know is that, against advice and with an unselfish disregard for his own safety, he turned his back on those aboard the *Eureka* and plunged 200 ft down again to the leaking bell. He was never seen again.

There was to be a deeply sad and distressing ending to this saga. The young and beautiful Mary Small had been married to Peter for only 12 weeks before his untimely death. She found life without him unbearable, and nine weeks later ended her life in a gas-filled room at home, surrounded by photographs of her husband strewn on the floor.

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Key words
History, reprinted from, bell diving

Editors note: At the 2001 ASM in Madang, PNG, the Principal Guest Speaker, Dr James Francis, gave a presentation on research related to physiological studies of crew survival in a crippled submarine. This has recently been published and the abstracts appear below. Dr Francis's presentation vividly brought out the human element of this experiment in a way that scientific papers are unable to do. It is for moments like these that Society members are encouraged to attend the ASMs; some aspects of these meetings cannot be represented on the printed page.

Physiological responses to cold exposure in men: a disabled submarine study

Castellani JW, O'Brien C, Stulz DA, Blanchard LA, Degroot DW, Bovill ME, Francis TJR, Young AJ.

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A disabled submarine (DISSUB) lacking power and/or environmental control will become cold, and the ambient air may become hypercapnic and hypoxic. This study examined if the combination of hypoxia, hypercapnia, and cold exposure would adversely affect thermoregulatory responses to acute cold exposure in survivors awaiting rescue. Seven male submariners (33 ± 6 yrs) completed a series of cold-air tests (CAT) that consisted of 20-min at T_{air} = 22°C, followed by a linear decline (1°C.min^{-1}) in T_{air} to 12°C, which was then held constant for an additional 150-min. CAT were performed under normoxic, normocapnic conditions (D0), acute hypoxia (D1, 16.75% O_2), after 4 days of chronic hypoxia, hypercapnia and cold (D5, 16.75% O_2, 2.5% CO_2, 4°C), and hypoxia-only again (D8, 16.75% O_2). The ΔT_{sk} during CAT was larger (p <0.05) on D0 (-5.2°C), vs. Dl (-4.8°C), D5 (-4.5°C), and D8 (-4.4°C). The change (relative to 0-min) in metabolic heat production (ΔM) at 20-min of CAT was lower (p <0.05) on D1, D5, and D8, vs. D0, with no differences between D1, D5 and D8. ΔM was not different among trials at any time point after 20-min. The mean body temperature threshold for the onset of shivering was lower on D1 (35.08°C), D5 (34.85°C), and D8 (34.69°C), compared to D0 (36.01°C). Changes in heat storage did not differ among trials and rectal temperature was not different in D0 vs. Dl, D5, and D8. Thus, mild hypoxia (16.75% FIO_2) impairs vasoconstrictor and initial shivering responses, but the addition of elevated $FICO_2$ and cold had no further effect. These thermoregulatory effector changes do not increase the risk for hypothermia in DISSUB survivors who are adequately clothed.

Key words
Hypercapnia, hypothermia, hypoxia, shivering, vasoconstriction

Castellani JW, O'Brien C, Stulz DA, Blanchard LA, DeGroot DW, Bovill ME, Francis TJ, Young AJ. Physiological responses to cold exposure in men: a disabled submarine study. Reprinted with kind permission, *Undersea Hyperb Med* 2002; 29: 189-203.

Subjective symptoms and postural control during a disabled submarine simulation

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To simulate conditions aboard a disabled submarine, 7 submariners were confined for 5 d to a normobaric environment of 16.75% O_2, 2.5% CO_2, 4°C, and 85% relative humidity (RH). After 2 control days and 1 d of hypoxia, the remaining environmental conditions were imposed for the next 5 d, followed by 1 additional day of just hypoxia. Daily morning symptoms were assessed using the Environmental Symptoms Questionnaire (ESQ). Postural stability was determined on 4 occasions using a computerized balance system: control period, after 2.7 and 4.7 d of steady-state test conditions, and after 5.7 d (with return to normal ambient temp, RH, and CO_2). Three balance tests were performed: eyes open, eyes closed, and a dynamic test. Postural stability deteriorated after 2.7 d (87% eyes open, p <0.001 and 26% eyes closed, p =

0.01). ESQ symptom subsets for acute mountain sickness, exertion, fatigue, alertness, and ear/nose/throat were not significantly different. Cold symptom subsets were increased after 3-7 d (p <0.001); distress and muscle discomfort subsets after 7 d (p = 0.02). Continued exposure to the combination of cold and hypoxia elicited subjective symptom changes and disturbances in postural stability that are statistically significant. These observations may be of practical importance when tasks aboard a disabled submarine involve balance and mobility.

Key words
Hypoxia, hypercapnia, postural control, Environmental Symptoms Questionnaire

Cymerman A, Young AJ, Francis, TJR, Wray DD, Ditzler DT, Stulz D, Bovill M, Muza SR. Subjective symptoms and postural control during a disabled submarine simulation. Reprinted with kind permission, *Undersea Hyperb Med* 2002; 29: 204-215.

Open water scuba diving accidents at Leicester: five years' experience

A J Hart, SA White, PJ Conboy, G Bodiwala, D Quinton

Abstract
Objectives: The aim of this study was to determine the incidence, type, outcome, and possible risk factors of diving accidents in each year of a five year period presenting from one dive centre to a large teaching hospital accident and emergency (A&E) department.
Methods: All patients included in this study presented to the A&E department at a local teaching hospital in close proximity to the largest inland diving centre in the UK. Our main outcome measures were: presenting symptoms, administration of recompression treatment, mortality, and postmortem examination report where applicable.
Results: Overall, 25 patients experienced a serious open water diving accident at the centre between 1992 and 1996 inclusive. The percentage of survivors (n = 18) with symptoms of decompression sickness receiving recompression treatment was 72%. All surviving patients received medical treatment for at least 24 hours before discharge. The median depth of diving accidents was 24 metres (m) (range 7–36 m). During the study period, 1992–96, the number of accidents increased from one to 10 and the incidence of diving accidents increased from four per 100,000 to 15.4 per 100,000. Over the same time period the number of deaths increased threefold.
Conclusions: The aetiology of the increase in the incidence of accidents is multifactorial. Important risk factors were thought to be: rapid ascent (in 48% of patients), cold water, poor visibility, the number of dives per diver, and the experience of the diver. It is concluded that there needs to be an increased awareness of the management of diving injuries in an A&E department in close proximity to an inland diving centre.

Keywords
Scuba diving, decompression sickness, barotrauma, nitrogen narcosis

A J Hart, S A White, P J Conboy, G Bodiwala, D Quinton. Open water scuba diving accidents at Leicester: five years' experience. Reprinted with kind permission, *J Accid Emerg Med* 1999; 16: 198-20.

Editors note: This is one of very few studies in the literature where there is a reasonably accurate idea of the denominator, that is, the size of the total population of diver. This allows a true incidence rate to be derived for fatalities and serious diving injuries.

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>

Critical appraisal

Improved healing of ulcers but no significant decrease in amputation rate in diabetic patients with lower-limb chronic wounds

Clinical bottom line

1 More ulcers healed at six weeks and one year with the addition of hyperbaric oxygen therapy.
2 No difference in major amputation rate.

Citation

1 Abidia A, Laden G, Kuhan G, Johnson BF, Wilkinson AR, et al. The role of hyperbaric oxygen therapy in ischaemic diabetic lower extremity ulcers: a double-blind randomised-controlled trial. *Eur J Vasc Endovasc Surg* 2003; 25: 513-518

Three-part clinical question

For diabetic patients with ischaemic lower-extremity ulcers, does the addition of hyperbaric oxygen, compared with other measures alone, result in improved healing or reduced amputation rates?

Search terms

Diabetic ulcers, amputation

The study

Double-blinded randomised controlled trial with intention-to-treat.

The study patients:

Diabetic patients with non-healing, lower-limb ulcers for at least six weeks of medical management and no vascular reconstruction possible.

Control group

(N = 9; 8 analysed) Sham hyperbaric treatment with air breathing at 2.4 Ata (242 kPa) for 90 minutes daily to a total of 30 treatments. Intensive multidisciplinary wound management.

Experimental group

(N = 9; 8 analysed) Regimen as above with 100% oxygen at 2.4 Ata (242 kPa). Same wound management.

The evidence

See Table 1.

Comments

1 Small study with low power to detect a significant reduction in major amputation rate. One major amputation in each group is a low rate in these patients.
2 There is likely to be a cost saving and reduced number of visits with HBO_2.
3 One would expect to treat two patients with HBO_2 to heal one extra ulcer.
4 No significant overall difference in SF36 between groups.
5 Two abstracts were clearly superseded by the full report.

Appraised by

Dr Michael H Bennett,
Department of Diving and Hyperbaric Medicine,
Prince of Wales Hospital,
Randwick, NSW 2031
AUSTRALIA
E-mail: *<m.bennett@unsw.edu.au>*

This appraisal has been adapted from the database of randomised controlled trials in hyperbaric medicine at <www.hboevidence.com>

TABLE 1
MAJOR OUTCOMES IN RANDOMISED STUDY OF HYPERBARIC OXYGEN FOR ISCHAEMIC DIABETIC LOWER-EXTREMITY ULCERS

Event outcome	Time to outcome	Sham group rate	HBO_2 group rate	Relative risk reduction	Absolute risk reduction	Number needed to treat
Failure to heal	6 weeks	0.78	0.33	57%	0.45	2
95% CI:				4% to 100%	0.03 to 0.86	1 to 29
Failure to heal	1 year	0.89	0.33	63%	0.56	2
95% CI:				21% to 100%	0.19 to 0.93	1 to 5

Non-event outcomes	Time to outcome	Sham group	HBO_2 group	Difference
Median wound area reduction (%)	1 year	52	100	p = 0.027
Number of visits (SD)	1 year	136.5 (126)	33.8 (62)	95%CI -3 to 209
Average cost (UKP)	1 year	7,946	4, 972	2,960

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 examined course(s) in Diving and Hyperbaric Medicine at an approved institution.
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 research proposal in a standard format for approval by the Education Officer before commencing their research project.
5 The candidate must produce, to the satisfaction of the Education Officer, 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. Preference will be given to reports of original basic or clinical research. 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). 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 Education Officer reserves the right to modify any of these requirements from time to time.

The Education Officer's address is:
Dr David Doolette, Department of Anaesthesia and Intensive Care, University of Adelaide,
Adelaide, South Australia 5005, Australia.
Phone: +61-(0)8-8303-6382.
Fax: +61-(0)8-8303-3909.
E-mail: <David.Doolette@adelaide.edu.au>

Key words
Qualifications, underwater medicine, hyperbaric oxygen, research

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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>

Minutes of the SPUMS Executive Committee Teleconference held on 5 August 2003

Opened: 1830hr

Present: Drs R Walker (President), G Williams (Immediate Past-President), C Meehan (Secretary), B Trytko (Treasurer), M Davis (Editor), D Doolette (Education Officer), M Bennett, S Mitchell (Committee Members)

Apologies: Dr D Walker, Dr S Mitchell (Committee Members), Dr D Smart (ANZHMG Representative)

1 Minutes of the previous meeting (22, 24 May 2003)

Moved that the minutes be accepted as a true record. Proposed Dr M Davis, seconded Dr G Williams, carried.

2 Matters arising from the minutes

2.1 Improving our Internet cost effectiveness.

Dr G Williams has suggested <www.surf.net.au>, which offers full service for $22.95 per month. Dr C Meehan will make enquiries with Ozemail regarding using the domain name for committee members' email addresses. Example of these addresses are as follows: <firstname.lastname@spums.org.au>, or just <administrator@spums.org.au> etc.

Options for improving the web site for functionality such as online membership and payments were discussed. There is a need to organise secure online credit card payments, and possibly pay for subscription fees. This would decrease the work of the administrator and treasurer. The investment account could be used to employ a qualified person to set up secure web site, and smarten up the SPUMS web site. Alternatively, there may be secure web sites already set up that SPUMS could utilise. There needs to be a review process regarding the costing of this. It is hoped that someone from SPUMS will be able to oversee the web site when it has been updated. As the committee members already have significant commitments, it was thought that someone from the SPUMS membership may have an interest and expertise in this area. It was suggested that an advertisement be placed in the Journal seeking interest from the SPUMS membership regarding this. Dr Trytko will formulate the advertisement and it is hoped that this service could be offered to SPUMS on a voluntary basis. Dr C Meehan to update Steve Goble regarding these suggestions.

2.2 Update from Editor, Dr M Davis, including discussion regarding EUBS newsletter, and proposed name change of the SPUMS Journal. Approval was given for the purchase of EndNote and Photoshop Pro, at an approximate costing of $1500.

There was discussion regarding the need for double signatures on the BNZ account for the Journal.

Dr Davis will look into the costing of binding one full set of journals.

The name change for the Journal is still under discussion. The name needs to be distinguishable from other such journals. This needs to be finalised at face to face in Sydney. If decided upon, a name change will need to be adopted by the Association at the next general meeting.

The Editorial Board was discussed and can continue as is.

A list of web resources in diving and hyperbaric medicine will be published in the Journal. Dr M Bennett has such a resource, which was formulated for the Hyperbaric Medicine Course.

The Committee would like to congratulate Dr M Davis, the new Editor for the quality of the SPUMS Journal.

2.3 Update on UHMS in Sydney given by Dr M Bennett.

All arrangements are on schedule. The transition from UHMS to SPUMS may be problematic for some as the UHMS dinner is on the night before the departure day for the SPUMS ASM. It has been suggested that seats on the evening flight as well as early flight should be held.

2.4 Update from Education officer, Dr D Doolette.

There are two more candidates who have almost completed the diploma, and two new ones starting.

2.5 Further discussion regarding letter Australian Standard Workshop.

Update given by Dr R Walker regarding producing a specialist diving medical position on chamber support at some occupational diving sites. The reality of getting a workshop running is difficult with the time constraints. Dr David Elliott is holding a conference on this topic later this year as well as next year. SPUMS would have difficulty funding such a workshop. It was decided to wait until further contact was made from Australian Standards, or the diving industry.

2.6 There was no further information with regard to the letter with reference to the occupational diving work proposal, DIR (Department of Industrial Relations).

2.7 SPUMS response to Scuba Doo letter. The consensus at the committee meeting was that Scuba Doo should follow the guidelines set out by Workplace Health and Safety.

3 Annual Scientific Meetings

3.1 2003 Palau update on final costings/FOC allocations show that despite the lower attendance, all costs to SPUMS were covered. Full details to be presented at the next committee meeting.

3.2 2004 Noumea: Guest speakers to be discussed. It was decided that the second guest speaker should come from SPUMS membership. Dr David Doolette was recommended, and he will speak on decompression modelling.
Conference booklet is being processed. Unfortunately, there is a reduction in the number of dive operators with the downturn in the tourist industry. In view of this a six package will be offered.

3.3 2005 update given by convener, Dr C Meehan. Full details of these proposals to be presented at the next committee meeting.

3.4 NZ has been mentioned for a future ASM.

4 Treasurer's report

Discussion regarding candidates for Treasurer. The accounting process is complex. There is no surplus money to pay for a wage slave for the Treasurer. Any candidate for the position will need to be willing to do the bulk of the work themselves.
Electronic equipment no longer used by the Committee should be sold. These items should be advertised in the Journal. There needs to be an open way of disposing of these items. All members to e-mail Dr Tryto details of any such.

5 Correspondence Nil

6 Other business

6.1 AGM minutes were discussed by the Committee. In accordance with rule 16 of the SPUMS constitution, a notice of all motions passed shall appear in the next issue of the Journal for approval by the membership. No motions were passed at the AGM.

6.2 Face-to-face meeting to be held in Sydney on 25 October 2003.

Closed: 2100hr

The SPUMS web site is at http://www.SPUMS.org.au

SPUMS Representative for SF-017 Occupational Diving Committee and SF-46 Non-Diving Work in Compressed Air and Hyperbaric Facilities Committee

After 13 years, John Knight has indicated his intention to retire from the position as the SPUMS representative on the Standards Australia Occupational Diving Committee (SF-017) and Non-Diving Work in Compressed Air and Hyperbaric Facilities Committee (SF-046).

A replacement is sought from suitably qualified SPUMS members resident in Australia.

The Occupational Diving Committee comprises representatives from some 27 organisations (e.g., Industry, Union, Medical, Government, Police) and has the prime function of achieving standardisation in the field of occupational diving with respect to the occupational health and safety of the diver. All aspects of occupational diving procedures and training are covered.

The Non-Diving Work in Compressed Air and Hyperbaric Facilities Committee has the prime function of standardisation in the field of safety for persons working in compressed air and for the design, manufacture and operation of hyperbaric treatment facilities other than those used in connection with diving operations.

The Society sees it as important that the medical profession is suitably represented on these committees.

These committees meet once or twice annually in Melbourne. SPUMS will reimburse all reasonable expenses associated with attendance at committee meetings.

Expressions of interest for this position are sought from SPUMS members with occupational diving medicine experience.

An application including details of experience, qualifications and personal details should be forwarded to the SPUMS President (<Robyn.Walker@defence.gov.au>) by 30 January 2004.

Robyn Walker, President

SPUMS Diploma award

Dr Juliette Leverment, Prince of Wales Hospital, Randwick, has been awarded the SPUMS Diploma in Diving and Hyperbaric Medicine.

Her thesis was entitled:
Lung function following exposure to Royal Navy treatment table 62

Minutes of the ANZHMG Annual General Meeting, Hotel Grand Chancellor, Hobart Thursday 28 August 2003

Meeting opened 0900 hours

1 Present

David Smart (Chairman), David Wilkinson (Secretary), David Griffiths, David Cooper, Margaret Walker, Mike Davis, Sarah Sharkey, Ian Millar, Martin Hodgson, Greg Emerson, Bob Long, Mike Bennett

2 Apologies

Jan Lehm, Harry Oxer, Bob Wong, Barb Trytko, Brian Spain

3 Minutes of previous meeting

Mike Davis pointed out that, under item 10, there was no previous standard applicable to hyperbaric facility practice in New Zealand. Also, under item 12, it is specifically the index of the SPUMS Journal that will be Endnote compatible.

Subject to these alterations, minutes to be accepted. Proposed by Mike Davis. Seconded by David Smart. Passed on show of hands.

4 Business arising

Discussion evolved on the issue of developing and revising the Standards documents. The ANZHMG sees value in pursuing the suggestions of last year's meeting: developing a standard for hyperbaric practice in New Zealand and supporting a workshop to establish uniform criteria for requiring a RCC during diving operation. However, the issue of funding such activities has not attracted sufficient support.

5 Chairman's address

David Smart welcomed all to the meeting with particular reference to Bob Long and David Cooper attending their first meeting. It has been a busy year and tribute was paid to Mike Davis as Editor of the SPUMS Journal, Ian Millar for coordinating the ANZHMG/SIG course, Mike Bennett in organising the Sydney UHMS meeting and Robyn Walker as continuing SPUMS President. The MSAC review continues with uncertainty as to the outcome; however, it has highlighted the need for our group to develop a system for better collection of evidence. The use of a minimum data set was promoted as a quality-related activity to relate the indications for HBO to measurable outcomes and complications at both a national and local level. In a broader sense, this idea reinforces the need for our group to undertake a strategic review to establish our priorities for the ensuing years. Congratulations were offered to the effort everyone has made and the importance of continuing communication was stressed.

6 MSAC

6.1 Report on progress – The report of the supporting committee has been passed up the line and is now somewhere between the MSAC Committee and the Minister, the nature of this negotiation is unknown.

6.2 Publication of submissions to MSAC – Some revision of the documents was felt to be necessary, particularly in light of some of the review articles recently published in UHM.

Action: Authors of these documents to work towards submission to SPUMS Journal.

7 ANZHMG/SIG list of approved indications for HBO_2

Bob Long suggested there was an increasing mass of literature dealing with HBO_2 in the treatment of avascular necrosis and this may warrant consideration. No other changes to the current list.

Action: Bob Long to collate the literature with a view to presentation at next year's meeting and consideration for addition to the list.

8 ANZCA/SIG

8.1 Introductory Course in Hyperbaric Medicine – Next course to be held at Prince of Wales Hospital in Sydney, 1–12 March 2004. Cost of $1,600 per registrant.

8.2 Certificate – ANZCA Council have approved the awarding of 17 certificates. A number of people who failed to met the criteria may be eligible to sit an exam and this is to be published in the ANZCA Bulletin.

8.3 Minimum qualification for AS/NZS 2299 medicals – The 2299 document refers people to SPUMS for "appropriate" courses. A plethora of courses exist, ranging from 3 days to 10 days with varying objectives. It was felt the decision of which courses might be appropriate should be made by SPUMS – perhaps some method of course accreditation might help although the mechanism was not described.

Action: Letter to be sent to Education Officer of SPUMS concerning courses training medical officers in "fitness to dive".

8.4 Minimum qualification for supervising the HBO_2 therapy for a diver – The context of the question related to recompression of divers in the chamber in Broome with advice provided by the Unit in Fremantle. It was felt that developing a local policy for Western Australian practice would adequately cover this concern.

9 SPUMS

9.1 Journal report – Mike Davis reported that he was now 12 months into his stewardship as Editor of the Journal and invited feedback. He made no apology about expecting submissions to be of a high standard, and reserved the right to be occasionally controversial. The issue of a name change for the Journal continues to spark debate within SPUMS.

9.2 SPUMS 2003 diving workshop – SPUMS AGM 2003 held in Palau included a workshop, which questioned the current recommendation of 'dive medicals' for all. There was broad interest by the medical officers for an initial screening questionnaire, with review only if indicated. The concept of a risk assessment with counselling as opposed to a simple yes-or-no response also found support. A summary of the workshop and its recommendations will be published in the SPUMS Journal in due course.
Action: Mike Bennett to summarise workshop recommendations.

10 Minimum data set
No new developments to report.

11 Wound outcome measurement
Mike Bennett circulated a data sheet for non-healing wounds, which has been trialled in Sydney. It collects demographic detail, assessment, progress and a scored outcome that could be collated in a national database. Although it obviously won't constitute a randomised controlled trial, such information could be vital during a review of activity such as the recent MSAC exercise. The Unit at Prince of Wales has offered to act as central coordinator. The data sheet will need to be approved for use by each institution's research ethics committee.
Action: All units encouraged – most vigorously – to adopt the data sheet, seek ethics committee approval and start collecting data from 1 October.

12 UHMS Sydney 2004
Mike Bennett reported that organisation for the meeting is proceeding. It will be held over 27–29 May at the Four Seasons Hotel. A two-day diving medicine workshop will precede the conference and the HTNA ASM will run concurrent with one day of the conference. The SPUMS ASM will follow the UHMS meeting and is being held in Noumea. This is a big event and deserves to be enthusiastically supported!
Action: By all – commit to attending, consider presenting.

13 Randomised controlled trials
The crush injury and HBO RCT at the Alfred Hospital has been running slowly and has lost its local funding. It is being continued as a multi-centre study. More sites are needed and interest was sought from other Australasian units who might be able to further this important work.
Action: Ian Millar to send on information to a number of interested parties.

14 Other business

14.1 Delay to recompression – The workshop preceding the UHMS meeting will look at the long-term effects of delayed recompression following mild DCS and the natural history of DCS without recompression; a fascinating topic of great relevance to our geographical region. David Elliott will chair this session and is keen to find cases to discuss, so any unit that could provide detail of cases of mild DCS that have had delayed or missed recompression, including details of presentation features and outcome, please contact David Elliott.

14.2 ANZHMG chatline – The provider of our chatline has recently changed and appears to be working well. Anyone who failed to make the transition to the new list, please contact Mike Bennett for reinclusion.

14.3 Research foundation – Discussion is currently taking place with a view to creating a foundation with its goal of supporting research in the field of hyperbaric medicine. No details were available.

14.4 Post-graduate diploma – A post-graduate diploma in diving and hyperbaric medicine has been developed under the auspices of the University of Auckland. It is unclear how it will interact with the SPUMS DipDHM. Some overlap clearly exists; however, it is understood some work can be accredited towards both qualifications. The post-graduate diploma may appeal to a different population as it is not necessary to work in a hyperbaric facility.

Meeting closed at 1210 hours

Dr David Wilkinson
Honorary Secretary ANZHMG

SPUMS Award for HTNA Annual Scientific Meeting Paper

The SPUMS Award for the best presentation by a member at the Hyperbaric Technicians and Nurses Association Annual Scientific Meeting in Hobart, August 2003, was awarded to:

Sue Thurston, Clinical Nurse Manager, Department of Diving and Hyperbaric Medicine, Fremantle Hospital

Sue gave a fascinating presentation on her research into the history of the Broome recompression chamber. We hope to publish her account soon in the Journal.

Annual General Meeting 2004 notice of motion for change to the Constitution

As the New Zealand Chapter of the South Pacific Underwater Medicine Society is no longer active the Committee will move the motion printed below at the Annual General Meeting.

This motion was previously put to the 2002 AGM and endorsed by general acclamation, but no formal vote was taken as required under the constitution. Therefore, it is presented again.

Motion

Proposed that the Statement of Purposes and Rules be amended by altering Rules 22 (a) and 22 (c).
Rule 22 (a) be altered by deleting the words

a representative appointed by the New Zealand Chapter of the South Pacific Underwater Medicine Society Incorporated.

Rule 22 (c) be altered by deleting the words

the representative appointed by the New Zealand Chapter of the South Pacific Underwater Medicine Society Incorporated

in the first sentence and by deleting the words

and the others by the New Zealand Chapter of the South Pacific Underwater Medicine Society Incorporated and

in the second sentence.
Also the word *respectively* at the end of the second sentence.
The deleted words

and the others by the New Zealand Chapter of the South Pacific Underwater Medicine Society Incorporated and

to be replaced by

the other by

The present Rule 22 (a) reads
(a) The Committee shall consist of a President, Immediate Past President, a Secretary, a Treasurer, Public Officer, the Editor of the Journal, an Education Officer, a representative appointed by the New Zealand Chapter of the South Pacific Underwater Medicine Society Incorporated, the Chairman of the Australian and New Zealand Hyperbaric Medicine Group and three other members of the Association entitled to vote.

The present Rule 22 (c) reads
(c) The Editor, the Public Officer, the representative of the New Zealand Chapter of the South Pacific Underwater Medicine Society Incorporated and the Chairman of the Australian and New Zealand Hyperbaric Medicine Group shall be appointed to their positions. The first two by the Committee, the others by the New Zealand Chapter of the South Pacific Underwater Medicine Society Incorporated and the Australian and New Zealand Hyperbaric Medicine Group respectively.

The new Rule 22 (a) will read
(a) The Committee shall consist of a President, Immediate Past President, a Secretary, a Treasurer, Public Officer, the Editor of the Journal, an Education Officer, the Chairman of the Australian and New Zealand Hyperbaric Medicine Group and three other members of the Association entitled to vote.

The new Rule 22 (c) will read
(c) The Editor, the Public Officer and the Chairman of the Australian and New Zealand Hyperbaric Medicine Group shall be appointed to their positions. The first two by the Committee, the other by the Australian and New Zealand Hyperbaric Medicine Group.

Key words
Constitutional amendments

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*

Foundation certificate holders of the Australian and New Zealend College of Anaesthetists Certificate in Diving & Hyperbaric Medicine

Christopher Acott (SA)
Michael Bennett (NSW)
Christopher Butler (Qld)
Roger Capps (SA)
Michael Davis (NZ)
Gregory Emerson (Qld)
Desmond Gorman (NZ)
David Griffiths (Qld)
Jan Lehm (NSW)
Ian Millar (Vic)
Simon Mitchell (NSW)
David Smart (Tas)
Barbara Trytko (NSW)
Margaret Walker (Tas)
Robert Webb (Qld)
David Wilkinson (SA)
Robert Wong (WA)

Dr W R Thompson
Chair, ANZCA Certificates Committee

In memoriam

Paul Tzimoulis and John Cronin, two very influential members of the sport diving industry died recently.

Paul Tzimoulis began diving in the 1950s and soon opened a dive training centre in New England, playing a role in PADI's early growth. Paul will be remembered best by many divers, however, for his long association with *Skin Diver* magazine, as a photo-journalist and then later as the magazine's publisher. *Skin Diver* became one of the most influential voices in recreational diving over many years under Paul's direction.

John Cronin started his career in diving as a salesman in New York State, later joining US Divers to eventually become the company President and CEO. During this time he co-founded the Professional Association of Diving Instructors (PADI) with Ralph Erikson, and for over 30 years was PADI's CEO. As such, his leadership and charisma attracted a team that developed PADI into the largest single commercial sport diving training agency in the world. All those who knew him or worked with him describe him as a remarkable man, who was many things to many people.

Both men are remembered in much more detail in *The Undersea Journal* 2003; 4th quarter.

Dr Carl Edmonds winner of 2003 DAN America Award

Dr Carl Edmonds has been announced as the winner of the 2003 DAN America Award.

This annual award honours significant administrative, scientific or educational contributions on behalf of Divers Alert Network (DAN).

Peter B Bennett, founder, President and CEO of DAN, noted that "His distinguished contributions over many decades to the safety of recreational diving and diving medicine are tremendous and have saved many lives and limbs. Further, his valuable support in the extension of DAN to Australia and the Pacific has been of significant value to the international growth of DAN."

John Lippmann, President of DAN South East Asia-Pacific (SEAP), nominated Dr Edmonds for the honour. He cited research by Dr Edmonds into such areas as ear disorders in diving, recompression treatment tables, underwater oxygen treatment for decompression illness, marine animal injuries and medical contra-indications and diving, among many other fields, as reasons for the award. "Carl has been an ardent supporter of DAN America over many years and, in his role as senior medical advisor to DAN SEAP, has been an enormous advocate and supporter of Divers Alert Network, giving freely of his time and resources to assist, whenever called upon," Lippmann said. "Quite frankly, I believe that there are few people that have contributed as much to diving safety and dive medicine as Carl Edmonds."

Letters to the Editor

Isolated inner ear decompression illness

Dear Editor,

I refer to the recent article by Leverment et al, about isolated inner ear decompression illness, in which the authors present a diver who suffered inner ear decompression illness (IEDCI) and was treated by hyperbaric oxygen therapy (HBO_2).[1]

The literature of the last decade shows that there are a growing number of patients who suffer either isolated IEDCI or neurological DCI combined with inner ear symptoms.

Leverment et al mentioned in their report the retrospective overview of Nachum et al with 24 divers who suffered IEDCI representing 26% of the divers treated for severe DCI during twelve years.[2] In 2002 our working group presented a diver with two episodes of IEDCI combined with a patent foramen ovale who responded well to HBO_2.[3] This year our hypothesis about a possible embolic mechanism leading to inner ear symptoms was confirmed by Cantais et al, who presented 34 divers with IEDCI, of 101 divers who were treated for decompression illness; 24 of the 34 divers had a major right-to-left shunt compared with 25 of 101 healthy divers in the control group ($p < 0.001$).[4]

In the last six years we have examined nine divers with 11 episodes of IEDCI. All nine divers had a right-to-left shunt of high haemodynamic relevance ($p < 0.0001$).[5] In Belgium, Germonpré reported that 25% of divers treated for neurological decompression illness suffered IEDCI (personal communication).

These figures show that IEDCI is not a rare disease in sport divers and that there is a highly significant correlation between divers with IEDCI and the prevalence of a right-to-left shunt.

As mentioned in the article of Leverment et al,[1] the problem is to find the correct diagnosis as HBO_2 treatment is said to be contra-indicated in divers with inner ear barotrauma. To reduce the risk for divers with inner ear barotrauma, if the correct diagnosis remains unclear, we suggest the following treatment concept: performing a paracentesis of both tympanic membranes allows one to treat a diver as fast as possible with HBO_2. A paracentesis is a simple technique that can be performed in a few minutes and is commonly practised by hyperbaric units in cases of unconscious, ventilated patients who cannot perform middle ear equalisation techniques.

After paracentesis the diver does not need to perform a Valsalva manoeuvre during recompression therapy, thus there is no danger of harming a diver who suffers inner ear barotrauma. There is even the possibility that divers with inner ear barotrauma combined with air bubbles in the labyrinth can profit from HBO_2 because of the potential of HBO_2 to reduce inert gas bubbles effectively.[6] When the diagnosis of IEDCI is clear or there are no signs of middle ear barotrauma and the diver can equalise the middle ear without problems there is no need for myringotomy before HBO_2 treatment.

Applying this technique allows one to treat every diver with inner ear symptoms and feasible diagnosis of IEDCI without time lost, and without harmful effects to the inner ear when the final diagnosis turns out to be inner ear barotrauma.

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Key words
Letters (to the Editor), inner ear decompression illness, inner ear barotrauma, right-to-left shunt, hyperbaric oxygen therapy

Risk of pulmonary barotrauma in children

Dear Editor,

I was interested to note on page 86 of the SPUMS Journal, Vol 33 No. 2 June 2003, that PADI's primary reason for their 10-year age limit is the theoretical increased risk of pulmonary barotrauma in children up to eight years old, plus a two-year safety margin.

However, at the same time, Bubblemakers and Seal team divers are allowed to dive to 2 m, from the age of eight, with compressed air.[1] My concern is that these depths are known to cause pulmonary barotrauma. Indeed:

> *"Generalised pulmonary barotrauma may [therefore] result when the ambient water pressure falls by 70 mmHg or more below the intrapulmonary pressure, i.e., with an ascent from a depth of about 1 m to the surface."*[2]

I understand that direct supervision is required at all times with these programmes; however, is this sufficient to prevent breath-holding?

Oliver Sykes
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Key words
Letters (to the Editor), children, pulmonary barotrauma

Reply from Dr Richardson:

Dear Editor,

Dr Sykes brings up a valid concern for the prevention of pulmonary barotrauma in water depths as shallow as two metres. Instructors are highly trained to teach prevention of breath-holding in scuba training and required to closely monitor and supervise children to this end. The empirical experience with these programmes has shown that these techniques in combination have been effective in prevention of pulmonary barotrauma in the Bubblemaker and Seal team programmes. Thank you for the opportunity to comment.

Dr Drew Richardson
President, PADI Worldwide

The Diving Incident Monitoring Study and recreational cave and technical diving

Dear Editor,

I would like to inform the members of SPUMS of an expansion of the Diving Incident Monitoring Study (DIMS) into the area of recreational cave and technical diving. Whilst some data have already been collected for incidents occurring during this kind of diving, no formal survey or analysis has been done as a part of DIMS.

Incident monitoring in diving is nothing new in Australia, with the pioneering work of Dr Douglas Walker (Project Stickybeak) stretching back over several decades. Approximately 10 years ago Dr Chris Acott, at the Royal Adelaide Hospital, South Australia, began the DIMS, which was based on the format developed for anaesthesia by Professor Bill Runciman. A great deal of useful and important information has come out of the DIMS already.

Cave diving in Australia has been increasing in popularity since the 1960s. In recent years, recreational 'technical' diving has seen a large increase in participation levels, with traditional recreational teaching organisations and newer technical agencies offering training for deeper and more challenging environments. These courses involve the use of more sophisticated technologies such as mixed gas and rebreathers. Whilst the techniques are not new, they are now widely accessible and are being taken up by a new demographic of divers.

The expense of this kind of diving, and the time required to achieve the appropriate level of recreational certification, may mean that less-fit, middle-aged, somewhat sedentary individuals might be over-represented in this group. Arguably, just the people who should not be involved in this sometimes strenuous sport! The number of brands of semi-closed and closed-circuit rebreathers available to the recreational diver seems to increase almost daily. With them come reports of diver incidents and fatalities. Whether the bad press that rebreather diving is presently attracting is warranted remains to be seen.

Because of the increasing interest in these types of diving, I have decided to expand the DIMS to look at this area. A new reporting form has been produced and will be available for download from the DAN SEAP web site (<www.danseap.org>), or from myself at the e-mail address below. I thank all members in anticipation of their support of this arm of the study.

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Key words
Letters (to the Editor), DIMS

Breath-hold diving – yet another record

Dear Editor

Further to my previous two letters to the Journal concerning breath-hold diving,[1,2] I am writing to advise that yet another breath-hold diving record has been broken.

Writing in the News section of *The Daily Telegraph* on 22 July 2003, Richard Luscombe reported from Providenciales Island, Turks and Caicos, that Tanya Streeter had the previous day become the first person to dive to a depth of 400 ft in the 'variable ballast' discipline. This is widely regarded as the sport's toughest because it forbids the use of buoyancy aids and compels the diver to return to surface completely under their own power. The descent in this category is, however, assisted by means of a weighted sled.

The previous women's record for the category was 311.7 ft and the men's record, held by Patric Musimu of Belgium, was 393.7 ft. The duration of the dive was 3 min 38 sec.

In October last year a French woman, Audrey Mestre, died whilst attempting to break Streeter's record dive of 525 ft in the 'no limits' category when her inflatable lift bag designed to propel her back to the surface failed.

Luscombe also reported that her feat made Streeter the only female in any sport to better the world record of a male counterpart. Last month the Turks and Caicos Government, which sponsored her most recent attempt, marked her achievements by featuring her on a set of British postage stamps – apparently the first living person other than royalty to be accorded the honour.

Well not quite! In the same paper on 23 July 2003, Charles Heap wrote to the Editor and reported that in 1922 a Miss G W Ballantine caught a 64 lb salmon on the river Tay, in Scotland and, much to the chagrin of many male game anglers, this still stands as the largest salmon ever caught on a rod and line.

Similarly, on 24 July 2003, Kevin Glover wrote to claim that in 1990, whilst he was on secondment to the Foreign and Commonwealth Office from the Royal Navy and serving as the Senior Police Officer, Royal Overseas Police, on the Island of Diego Garcia, he too appeared on a set of postage stamps that celebrated the island's British stewardship. He went on to say that it has often crossed his mind that by doing so he had, inadvertently, broken royal protocol.

The following day, Tom Webb wrote to inform readers that during the siege of Mafeking in 1890 the town ran out of postage stamps. The British commander, Colonel Baden-Powell, famous for founding the Scout movement, used his renowned initiative and had replacements printed: the penny stamp with a picture of one of the boy messengers serving in Mafeking, and the threepenny blue with Baden-Powell's own head on the stamp. Queen Victoria was not amused.

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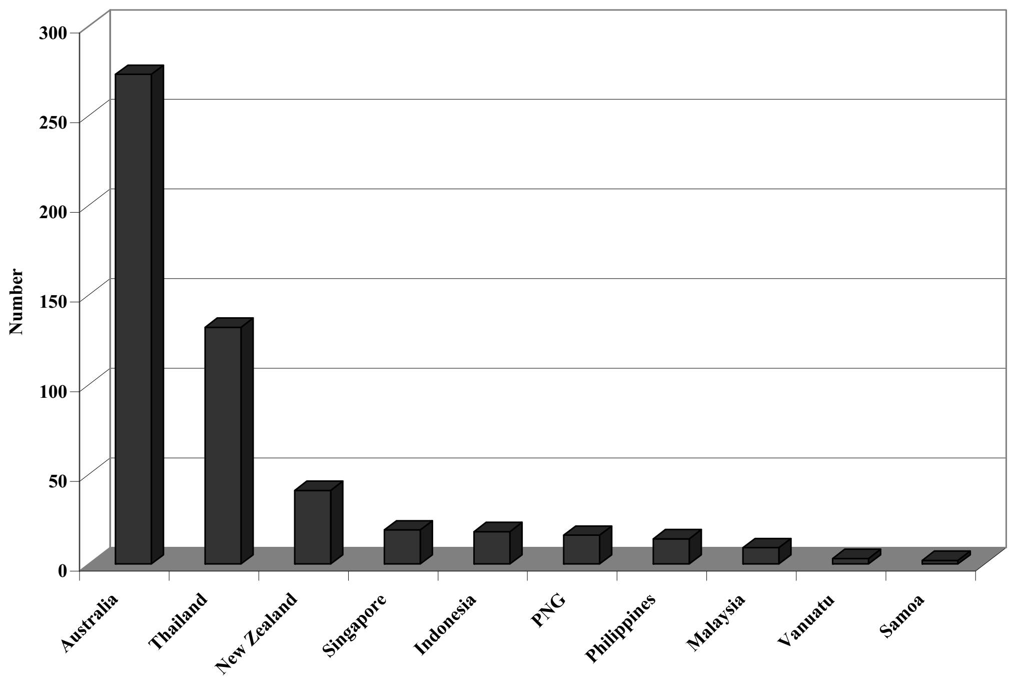
DECOMPRESSION ILLNESS (DCI) in the SE ASIA-PACIFIC REGION in 2002
Divers treated for DCI as reported to DAN-SEAP by recompression chambers



Book reviews

Bennett and Elliott's physiology and medicine of diving, 5th edition

Alf O Brubakk, Tom S Neuman (eds)

864 pages, hardback
5th Edition, 2003
ISBN 0-7020-2571-2
Elsevier Science Limited, 2003
Available from Best Publishing Company, P O Box 30100, Flagstaff, Arizona 86003-0100, USA.
Ph: +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$149.00, postage and packing extra

If you are looking for the 'nitty-gritty', fine print or definitive text on diving medicine, then look no further than this comprehensive classic tome. The 5th edition of *Bennett and Elliott's Physiology and Medicine of Diving* is edited by Alf O Brubakk and Tom S Neuman and at 779 pages is not a book to be stuffed in your dive bag. The first edition was published in 1969 and it is 10 years since the last edition in 1993. The focus of this new edition is on "the physiology of diving and the effects of pressure and gas composition as well as the clinical issues affecting divers". Many new chapters have been included, such as the biochemistry of oxygen under pressure and an important topical chapter on the long-term effects of diving.

Fifteen main chapters, with some further subdivided (seven sub-chapters on decompression, for instance), are divided along mechanistic lines and explore every tiny niche of diving medicine. The book evolves from an opening "Outline of the History of Diving Physiology and Medicine". An agonizing account of crippled Caisson workers and notes on the brilliant pioneering work of Haldane provide a poignant platform on which the text develops. The chapters then provide a detailed dissection of many core topics including decompression, pressure effects and long-term effects of diving. There are fascinating chapters on breath-hold diving, comparative diving physiology and the sobering chapter on the investigation and pathology of diving accidents.

This book is a rich and thorough compilation of diving medicine and physiology and with 45 international expert contributors, it is as good as you will get. Chapters are thoroughly researched and referenced with some having over 400 references.

Of particular note to us in the Antipodes are the excellent contributions to the book from Australasian authors. Bob Wong's chapter on "Empirical diving techniques" provides an international overview of divers who have relied on experience and observation alone in the execution of their dives. Many of these commercial sea harvesters, provoked by economic necessity, push the limits and suffer a high incidence of decompression sickness (DCS) or dysbaric osteonecrosis. Bob's chapter is enriched by his personal experience with the pearl divers from Broome in Western Australia.

James Francis, with Simon Mitchell, demonstrate their expertise in the area of decompression with two chapters on the pathophysiology of DCS and its clinical manifestations. These thoroughly referenced chapters give us a state-of-the-art update on systemic bubble injury at both a cellular and clinical level and are well illustrated with both pathological clinical and microscopic photographs.

Des Gorman, with American Richard Moon, clearly describes the treatment of the decompression disorders, outlining the evaluation of the patient and useful investigations. A thorough literature review of decompression illness and treatments is presented in a long table and there is a comprehensive analysis of both recompression and adjunctive treatments.

This book is a gem. Faults are few; the same photograph of lymphatic DCS is used on pages 584 and 606, and an author encourages the insertion of a padded spacer between the teeth to prevent laceration of the tongue in the management of hyperoxic seizures! The book will have an amazing effect on you...like Frenchman Junod's compressed air in 1835,

> *"the functions of the brain are activated, imagination is lively, thoughts have a peculiar charm and, in some persons, symptoms of intoxication are present."*

Enjoy!

'Sandy' Inglis
Emergency Department, Christchurch Hospital

Key words
Book reviews, textbook, underwater medicine

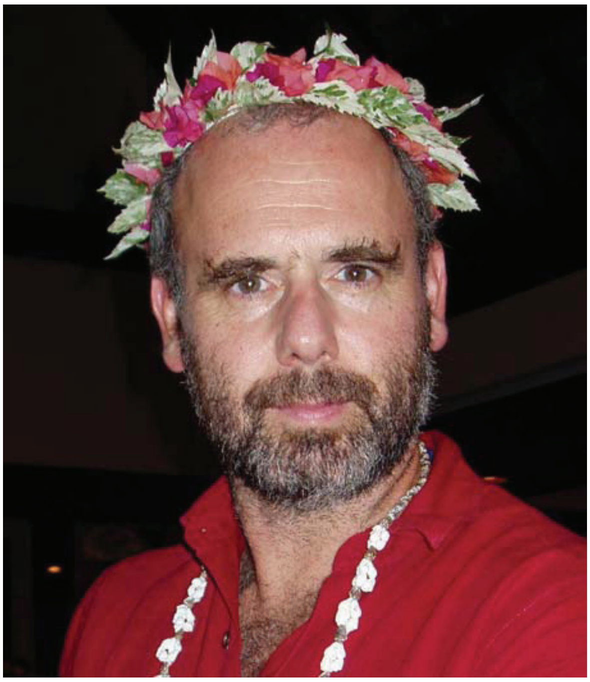
SPUMS ASM 2003, Kuror, Palau

Michael Bennett, Scientific Convenor, above and below with David Vote

Guest Speaker Professor Des Gorman (right) with Geoff Skinner

Cathy Meehan, Conference Convenor, with Geoff Long

David Wilkinson, SPUMS diplomate, wishing everyone a Happy Christmas from the SPUMS editorial team



Des Gorman, left, with the Editor

Barbara Trytko, SPUMS diplomate, with Martin Sayer, UK

The report on the data from the 1998–2000 survey of scuba diving for disabled divers and divers with other conditions that may affect their diving (injuries, surgery and disease)

Susie Shelley, Marguerite St Leger Dowse and Phil Bryson

Soft cover, 208 pages
ISBN 0-9525152-2-9
Plymouth: Diving Diseases Research Centre, 2002
Available from the Diving Diseases Research Centre, Hyperbaric Medical Centre, Tamar Science Park, Research Way, Plymouth PL6 8BU, United Kingdom
Ph: +44-(0)1752-209999; Fax: +44-(0)1752-209115
E-mail: <enquiries@ddrc.org>
Price GBP15.00, postage and packaging extra

This 201-page report presents results from two surveys conducted in the UK. The Training Groups Questionnaire (TGQ) gained perspective on actual numbers of people with 'disabilities' trained to scuba dive either via amateur group clubs, such as the British Sub-Aqua Club (BSAC) or professional dive centres and schools, such as the Professional Association of Diving Instructors (PADI). The Personal Questionnaire (PQ) gained information from individual divers about their condition and others' attitudes towards them. The report was published to make the results of the two surveys accessible to anyone with an interest in this area and readable for non-scientists. A short chapter on diving theory covers the basics to give non-divers an understanding of why diving has aspects that make it different to other sports.

The definition of 'disabled' included people who were "injured, had surgery, or other condition or disease". The disabilities most experienced by the training groups were learning disabilities (41 groups), visual impairment, hearing impairment and amputation. Spinal cord injury was also fairly high (13), with very few groups having experience of cerebral palsy, multiple sclerosis, spina bifida and other such conditions.

There was a high response rate from individual divers completing the PQ (74% return). The majority of divers (60%) had learned to dive after their disability or injury. Interestingly, and somewhat conflicting with the TGQ results, the majority of respondents (54) had a "spinal injury or disease" and only four described themselves as having a learning disability.

Certainly elements of the report would provide valuable reference reading for anyone who already trains people with disabilities, or is considering starting. There are useful statistics and helpful comments regarding facilities, special equipment requirements, additional time required etc., as well as excellent insights from the divers themselves. There are also some useful comments regarding what you can and cannot do under the UK Disability Discrimination Act (1995), and the Act is presented in an appendix; well worth a read if an employer is considering offering diver training for people with disabilities.

For an instructor, the section on diving problems gives insight into how they may be avoided. It was interesting to read of the various restrictions that the training establishments impose: 40% of the groups would impose "must dive with two other divers", 18% would specify "must dive with an instructor", 65% would apply a maximum depth limit, 23% a maximum time limit, and 14% said they would limit the number of dives per day.

For dive training organisations, or disability support groups, insight is gleaned as to customer awareness and satisfaction. The survey asked which organisation the potential diver contacted for advice and how helpful their responses were. A helpline was frequently suggested; however, many potential divers seemed unaware of the support already available from an organisation specialising in training for disabled divers. The agency contacted most frequently was BSAC (62% of the 203 divers) with only 74% reporting that the response was "helpful". BSAC may wish to conduct further consumer feedback to identify opportunities for improvement.

For potential divers with disabilities, existing divers share some practical solutions to equipment modifications, such as the use of webbed gloves, redistribution of weights, positioning of knives and torches for easy access and the use of a retainer to hold in the mouthpiece. I should imagine reading the comments from others with a similar disability would also prove comforting.

For the medical community, the section on medicals and medication provides enlightening (self-reported) comments, and reports advice received by disabled divers from their medical practitioners and the medications they were taking. Where the advice or medication was controversial, or inappropriate, the editors have made comments relating to diving medicine guidelines. It is worth noting that at the time these surveys were conducted (1998–1999) the sports diving medical examination was part of the procedure for entry into scuba diving if learning through the amateur clubs, but in 2001 the system changed to follow the same procedure that PADI has used for a number of years. This is a self-completed medical statement where the prospective trainee generally receives further advice or a full medical examination only if statements arouse concerns over fitness to dive. What this section does highlight are the areas of educational need amongst general practitioners relating to their understanding of diving physiology and changes that occur in the underwater environment.

The report presents a vast array of information. The language is certainly easily understandable, although to make it more reader friendly for the lay person it may have benefited from bullet-point summaries of the main points at the start of each chapter. A particularly helpful addition would have been a checklist of key points for a disabled person who is considering learning to dive, and a checklist for a training group who is considering teaching diving to disabled people. All in all, a lot of information is captured but some of the value may be lost because the report may not be read in detail.

Lynn Taylor
Glaxo Smith Kline, Auckland

Key words
Book reviews, diving, disabilities

Medical assessment of fitness to dive: a physician's guide for recreational diving

J Wendling, R Ehrsom, P Knessl, P Nussberger, A Uské

International edition, translated by P Hendricksen
183 pages, paperback, non-illustrated
ISBN 3-9522284-1-9
Biel, Switzerland: Hyperbaric Editions, 2001

This is the long-awaited English translation of the famous Swiss handbook on diving medical assessment. Australasian readers will see immediately that it has a format very similar to the two textbooks on this subject previously written by Dr John Parker. As such, the text is diagnostically orientated. This is not in keeping with modern trends in health surveillance, but that is not to say that this book is not worthwhile.

Indeed, I would regard this book as having a very significant purpose. This purpose is (as is usually the case) eloquently described by Professor David Elliott in his foreword to the book. He describes this as a book that a purchaser would not read, but would use as a desk reference. I agree entirely with this assessment.

It follows then, that this is not a book that I would recommend highly as a treatise on occupational and/or recreational diving fitness, but one that I would recommend as a desk reference for someone who was interested in undertaking assessments of people's medical fitness for diving.

In that regard, the book is comprehensive, well laid out, and pragmatic in its advice. There are some instances of 'translation difficulty', but overall the text allows rapid assimilation of information. As cited above, the book then has considerable utility.

Des Gorman
Occupational Medicine Unit, University of Auckland

Key words
Book reviews, medical diving, medical conditions and problems

Lonely Planet: Diving and snorkelling New Zealand

Jenny and Tony Enderby

Published by Lonely Planet Publications, 2002
ISBN 1-74059-267-0
Paperback, 160 pages
Price A$25.30
Available from all good bookshops

As a newcomer to both New Zealand and diving, I was interested to read what the Lonely Planet team had to say about the diving and snorkelling experiences on offer in the Land of the Long White Cloud. The country boasts a coastline almost as long as that of the continental United States, from the subtropical waters of the North Island to the subantarctic environment of the South. The diversity of its breathtaking landscape is reflected in the diving possibilities in its waters. "Options range from freshwater lakes, rivers and springs to rocky reefs, towering kelp forests, historic shipwrecks and islands riddled with caves and archways."

Few New Zealanders live further than two to three hours' drive from the coast so it is not surprising that the country is home to more divers per capita than any other in the world. The book has been compiled by two such divers, photojournalists from Auckland, who may be responsible for the high pictorial content of the book.

The book begins in typical Lonely Planet style to those familiar with their format, with an overview of the history and geography of the country and practical information to help the tourist: details of the main travel routes to get here, conditions of entry and helpful tips for what to bring. A brief introduction to the activities and attractions available to the visitor focuses on water sports and a unique marine environment. New Zealand is home to many sea mammals including the Hector's dolphin, the world's smallest marine dolphin and on the ever-growing list of endangered species. Next, an introduction to diving facilities in the country, with tips on pre-trip preparation and listings of emergency contact numbers. With high-quality medical facilities within easy reach, relatively few dangerous marine animals and little endemic disease, NZ is a fairly safe dive destination.

The book carries on to present 75 of the best dive sites around New Zealand (including the 10 best snorkelling sites), split into 13 geographical regions. Each region is introduced in general and features a quick checklist of the dive sites within it, with diving difficulty and suitability for snorkelling listed. A map of the area pinpoints each dive site. More detailed descriptions of each dive site follow, with icon lists for easy reference that highlight particular features (such as strong currents or poor visibility). Exact location, depth range, access arrangements and an expertise rating are given.

Points of general interest are interspersed among the listings, for example, the circumstances surrounding the bombing of the Rainbow Warrior in 1985, now one of the most popular wreck dives in Northland. The reader will also find interesting meteorological and geographical facts, information about unusual examples of sea life and diving tips dotted around.

The book is crammed full of colour pictures and visually very appealing. The checklists and icons make quick reference easy and the listing of the dive sites in short entries make it perfect for repeated quick dips. The format is slim and lightweight, an essential consideration for the traveller. My only criticism would be that the dive site locations are not specific enough. Having navigated the length of the east coast of Australia using a Lonely Planet guide alone, I was disappointed to find that I would have to consult a local to find the dive sites in Kaikoura, despite the fact that I have visited the Peninsula more than once. Having said this, the book finishes with a comprehensive list of the diving services and visitor information centers in each region, and if all else fails those locals I mentioned will undoubtedly be happy to point you in the right direction.

All in all, Lonely Planet appear to have successfully applied their winning formula yet again to this practical and appealing guide for the diving visitor to New Zealand.

Sarah Webb
Editorial Assistant, SPUMS Journal

Key words
Book reviews, tourism, diving

Editor's note: This diving guide book and the book reviewed below allowed us to indulge in some parochialism. Even Chris Acott admitted a few years ago, during the ASM in the Bay of Islands, that the diving was good!

Deep New Zealand: blue water, black abyss

Peter Batson
Principal photography by Kim Westerkov

240 pages, paperback
ISBN 1-877257-09-5
Christchurch, New Zealand: Canterbury University Press, 2003
Price NZ$49.95
Available from all good bookshops

Most of the living space on this planet, the deep sea and the deep ocean floor, has never seen sunlight. Only a tiny portion of this region, by far our largest ecosystem, has been explored so far. New species of animals and plants are discovered on an almost daily basis from deep-sea trawls, submersibles and bottom dredges. The bizarre nature of these life forms, what little is known of their life cycles, their diversity and how the different parts of this huge ecosystem may be linked are the main topics of this wonderful book.

Deep New Zealand is the result of an international cooperative effort brought together by a young marine scientist working for his PhD at Dunedin University. Whilst concentrating on New Zealand's Exclusive Economic Zone, which is one of the world's largest, the messages in this book are far from parochial. This is a truism since no organism recognises man-made boundaries and much of the ocean space the author writes about is shared with our nearest neighbour, Australia; we are both part of the great Southern Ocean system. Batson's style of writing is authoritative and informative but at the same time relaxed. He displays a sense of humour never far below the surface that ensures it is a very lay-friendly book. His sense of wonderment and excitement about the enormous diversity of life in our oceans is decidedly infectious.

The book is beautifully illustrated. Peter and David Batson's pen-and-ink line drawings either as black-on-white or as reverse negatives are superb. Other illustrations range from electron photomicrographs of micro-organisms to formal laboratory pictures of dead specimens such as large fish dredged or trawled from the depths. There are beautiful photos taken from submersibles, by divers, and above the surface of the oceans. Whilst many people, especially marine scientists, have contributed to this collection, a large proportion is the work of an outstanding New Zealand marine photographer, Kim Westerkov. Westerkov's photography undoubtedly has a lot to do with creating the book's atmosphere. The reviewer once dived with Westerkov, being allowed to carry one of his cameras, the housing of which flooded during the dive through no fault of its attendant!

The book is divided into three sections, though the final short one is really a postscript that addresses mankind's current and potential future impact on the life of the oceans, especially through fishing. In the first section, the ocean floor, the water column above it and the overarching ecology of the oceanic system are described with a clarity that has for the first time given the reviewer a real understanding of how the whole system ticks. Batson describes how, despite having a similar productivity to the land (a recent estimate is 48 billion tonnes of organic carbon each year), the ocean contains only a fraction of the biomass of the terrestrial ecosystem.

The key player in this process is the phytoplankton that harvests the sun's energy. The transfer of energy upward through the food web is rather inefficient, with only about 20% of the energy contained in one trophic level making it into the next level up. Almost all of the primary food sustaining life in the ocean column and the seabed sinks from the sunlit zone above. This sinking "particle flux" is made up of a diversity of dead and decaying forms but the majority are minute, such as phytoplankton and copopods. More importantly, Batson explains how complex is the dynamic formation and structure of this "rain" of food.
The second and longest section, divided into 16 chapters, describes the biodiversity of the deep ocean. There are many different varieties of phytoplankton, most of the larger species belonging to one of three groups that are described in the first chapter. The next chapter is devoted to protozoa, and then each phylum from the sponges to the diving mammals is dealt with. Rather than trying to be exhaustive, Batson describes representatives of each to give some idea of the biodiversity within each group. Wherever possible these are illustrated in the drawings and photographs.

"Below a depth of 1,500 metres – less than half the average depth of the Pacific – only a tiny number of biological samples has been collected, mere pinpricks in the ocean's immensity. Who can guess what strange organisms, communities or even ecosystems have yet to be discovered? The challenge – and it is an urgent one – is to find and understand them. Anyone interested?" So says Batson in his final paragraph. This is a superb book, well written and informative, beautifully illustrated and easy to read. Treat yourself and buy one for Christmas.

Michael Davis
Editor, SPUMS Journal

Key words
Book reviews, general interest, marine animals, ecology

Shipwreck heritage: a commentary on the UNESCO Convention on Underwater Cultural Heritage

Patrick J O'Keefe

Price GBP27.00
Available from the Institute of Art and Law, 1–5 Cank Street, Leicester, LE1 5GX, UK
E-mail: <info@ial.uk.com>

The recent article in *Dive New Zealand* by Judy Ann Newton, entitled 'The second battle of Truk Lagoon' goes to the heart of the issues over preservation of underwater cultural heritage. What she records is happening on many other dive sites, where there is war wreckage or other interesting remains, which are a temptation.

While to some divers, the very concept of restrictions on taking objects and treasures from wrecks on the sea floor is unacceptable, many other divers are coming to the conclusions expressed in the Minimum Impact Diving (MID) campaign and the negotiations that have been in course to set up agreements and conventions, which preserve the underwater cultural heritage.

The decision of UNESCO on 2 November 2001 to adopt the Convention on the Protection of Underwater Cultural Heritage has been the subject of comment, not only in *Dive New Zealand* but in many other magazines. This book is the first written commentary that I have been able to find on the Convention and, as such, it provides vital information on the background to the Convention and a detailed analysis of the contents of the Convention.

Dr O'Keefe has been involved in working on legal instruments to protect the underwater cultural heritage for over 30 years. Initially, as an official in the Australian Department of Foreign Affairs, he took part in negotiating the agreement between the Netherlands and Australia, concerning old Dutch shipwrecks in 1971. In 1988 he became foundation chairman of the Cultural Heritage Law Committee of the International Law Association, and it was this committee that prepared a draft convention on the protection of underwater cultural heritage, which was adopted by the ILA in Beunos Aires in 1994 and sent to UNESCO for consideration. It became the basis of the early discussions at UNESCO which were to lead to the Convention itself.

Primarily, this is a textbook with the detailed analysis of the Convention needed by lawyers, diplomats, government departments, salvors, shipowners and insurers. However it also explains the origins of the Convention, the history of underwater archaeology and the politics behind the preparation of the Convention, and is of interest to everyone involved in underwater diving. In the historical introduction, Dr O'Keefe points out that it was only the arrival of the aqualung that allowed for the potentiality of significant underwater research. This, together with manned and remote submersibles, has meant that 98% of all ocean floors can be reached. The invention of the aqualung has also led to diving becoming an increasingly popular recreation.

Underwater archaeology began with the excavation of the Cape Gelidonya wreck in 1960. This wreck was excavated in accordance with longstanding standards of land excavation. A similar painstaking approach was followed in the *Mary Rose* in the Solent and the *Batavia* off the coast of Western Australia. However there were a number of other excavations that showed a less painstaking approach to wrecks. This, and a flurry of court cases over wrecks, led to the desire to establish some form of regime that would control underwater excavations and preserve the heritage of the past.

This book deals with the process by which the ILA draft came into being and the steps taken by UNESCO to reach broad agreement among the governments involved. Only Russia, Norway, Turkey, Venezuela and the USA (an observer) opposed the final Convention wording.

The full text of the Convention and the Rules are printed at the beginning of the book. Dr O'Keefe sets out an overview of the Convention and a detailed analysis of the individual articles in the Convention and the Rules concerning activities directed at underwater cultural heritage, which are attached to the Convention. Also included is an exhaustive bibliography of legal textbooks and articles, and the references to the key court cases.

This book is not expensive and can be purchased from the Institute of Art and Law in the United Kingdom. I believe this book will be of considerable interest and value to dive clubs, professional dive organisations and recreational divers as the UNESCO Convention will become increasingly important around the world.

Piers Davies
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WORKSHOP ON REMOTE MANAGEMENT OF MILD DCI

MAY 25, 26, 2004, SYDNEY, AUSTRALIA

The management of DCI in remote locations where hyperbaric facilities are not available is complicated by the need for costly and logistically demanding evacuations. There is a growing body of expert opinion that mild or marginal cases may be as well served by local treatment with surface oxygen, fluids, and drugs followed by non-emergent evacuation. These issues will be discussed during this UHMS Workshop by a body of experts with the objective of developing consensus guidelines for managing mild DCI in remote locations.

Co-chairs Drs. Simon Mitchell and Richard Vann. Co-editors Dr. David Doolette and Chris Wachholz, R.N.

Continuing Medical Education Units have been applied for in the US and Australia. Attendance fees for the two-day workshop is AUS $350.

For further information contact the Undersea and Hyperbaric Medical Society (UHMS). Phone +301-942-2980; e-mail uhms@uhms.org www.uhms.org or ww.iceaustralia.com/uhms2004/.

DIVING HISTORICAL SOCIETY AUSTRALIA, SE ASIA

All enquiries to:
Diving Historical Society Australia, SE Asia,
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>

SPUMS 2004
Annual Scientific Meeting
Noumea – New Caledonia

Venue - Le Meridien Noumea
30 May – 6 June 2004
(meeting to run 1 – 5 June inclusive)

SPUMS meeting to follow UHMS Sydney 2004

Themes
Marine stingers and marine envenomation
Modelling decompression tables

Guest Speakers
Dr Peter Fenner*, AM*
James Cook University, Queensland
Dr David Doolette*, PhD*
Adelaide University, South Australia

Convener
Dr Guy Williams
P O Box 190, Red Hill South, VIC 3937, AUSTRALIA
Phone: *+61-(0)3-5981-1555*
Fax: *+61-(0)3-5981-2213*
E-mail: *<guyw@surf.net.au>*

Travel Arrangements
Allways Dive Expeditions
168 High Street, Ashburton, VIC 3147, AUSTRALIA
Phone: *+61-(0)3 -9885-8863*
Fax: *+61-(0)3-9885-1164*
Toll Free: *1800338239*
E-mail: *<Allwaysdive@bigpond.com.au>*

Undersea and Hyperbaric Medical Society Annual Scientific Meeting 2004
Four Seasons Hotel, Sydney, Australia
25 – 29 May, 2004

This conference attracts International and National researchers and practitioners from a variety of organisations. UHMS is an International, not for profit organisation serving over 2500 members worldwide.

- Year in Review
- Diving and Hyperbaric Pre-conference Workshops
- Seminar Luncheons
- Poster Presentations
- Military Diving and Submarine Medicine
- 3 days of Concurrent Educational Presentations
- Full Social Program
- Accompanying Persons Program
- Including the Hyperbaric Technicians and Nurses Association Conference

To register for UHMS 2004 Conference or for more information, please visit the conference website
www.iceaustralia.com/uhms2004
or contact the conference organisers:
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Accommodation and Travel available through the conference website

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ANZHMG and ANZCA
INTRODUCTORY COURSE IN DIVING AND HYPERBARIC MEDICINE

Dates: 1 to 12 March, 2004
Venue: Prince of Wales Hospital, Sydney
Cost: A$1,600.00 plus GST ($160.00)

This course is designed for medical graduates with an interest in the practice of general hyperbaric medicine, including relevant aspects of diving medicine. It is designed both for those wishing to pursue a career in the field and those whose primary area of interest lies in related areas. Prior experience is not required but would be of advantage. Extensive pre-reading material will be supplied. The course is limited to 20 participants.

The course is jointly sponsored by the ANZHMG, ANZCA and the UHMS. It is accredited with SPUMS for the Diploma of Diving and Hyperbaric Medicine and attracts 70 US CME points.

Contact: Miss Gabrielle Janik, Department of Diving and Hyperbaric Medicine, Prince of Wales Hospital, Barker Street, Randwick, NSW 2031, Australia
Phone: +61-(0)2-9382-3880
Fax: +61-(0)2-9382-3882
E-mail: <janikg@sesahs.nsw.gov.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

February 2004 3 weeks, 2/2/04 to 20/2/04
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

EUROPEAN UNDERWATER AND BAROMEDICAL SOCIETY
30TH ANNUAL SCIENTIFIC MEETING ON DIVING AND HYPERBARIC MEDICINE

Dates: September 15 to19, 2004
Venue: Ajaccio, Corsica
Convenor: Dr Bruno Grandjean
Congress organisation: Atout Corse
1, rue Saint Roch,
20000 Ajaccio, France

Phone: +33-(0)495-225293
Fax: +33-(0)495-511040
E-mail: <eubs2004@wanadoo.fr>
Web site: www.eubs.org

10TH INTERNATIONAL CONFERENCE ON EMERGENCY MEDICINE (ICEM 2004)

Speakers are invited for this meeting in Cairns in 2004
Dates: 6 to 10 June, 2004 (follows SPUMS ASM)
Venue: Cairns Convention Centre, Queensland
Web site: <www.icem2004.im.com.au>
Contact: Conference Secretariat, Intermedia Convention and Event Management, P O Box 1280, Milton, Queensland 4064, Australia
Phone: +61-(0)7-3858-5535
Fax: +61-(0)7-3858-5510
E-mail: <icem2004@im.com.au>

AUSTRALIAN AND NEW ZEALAND COLLEGE OF ANAESTHETISTS
2004 Annual Scientific Meeting
Preliminary Notice

Diving and Hyperbaric Medicine Special Interest Group
Dates: 1 to 5 May, 2004
Venue: Perth Concert Hall and Duxton Hotel, Perth
Contact: Katie Clarke, Congress West
E-mail: <conwes@congresswest.com.au>

SECOND INTERNATIONAL MEETING OF EMERGENCY MEDICINE IN THE PACIFIC REGION

Dates: 23 to 25 February, 2004
Venue: Tahiti
All information on this meeting can be found on <www.emergency-tahiti.com> and booking can be made online. Papers accepted until 23 November 2003.
Contact: Dr Yann Turgeon

Instructions to authors

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 are acceptable on disk (preferred) or by e-mail. The preferred format is Word 6 for Windows. 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.

The printed copies 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 format in the *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 400 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 rules are to be used. Illustrations and figures should be separate documents in JPG or TIFF format. The firewall has a maximum file size of 5Mbytes. **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 October 2001. <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 Anderson T. RAN medical officers' training in underwater medicine. *SPUMS J* 1985; 15: 19-22
2 Lippmann J, Bugg S. *The diving emergency handbook*. Melbourne: JL Publications, 1985

There should be a space after the semi-colon and after the colon, and no full stop after the page numbers. Titles of quoted books and journals should be in italics. For those using referencing software, the format is the same as the *British Journal of Anaesthesia*. 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

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The toll-free number 0800-4-DES111 can only be used in New Zealand

The DES numbers are generously supported by DAN-SEAP

PROJECT STICKYBEAK

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

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

DIVING INCIDENT MONITORING STUDY (DIMS)

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

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

PROJECT PROTEUS

The aim of this investigation is to establish a data base 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 dependant 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 data base.

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

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All opinions expressed are given in good faith and in all cases represent the views of the writer and are not necessarily representative of the policy of SPUMS.

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