Diving and Hyperbaric Medicine

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

ISSN 1833 - 3516
ABN 29 299 823 713

SPUMS

Volume 37 No. 2
June 2007

Ultrasound in decompression research

Iatrogenic CAGE often undiagnosed

Treating bent divers - a quick guide

More about navy divers - are they hostile?

A thick lip and marine trauma

Malaysian hyperbaric medicine takes off

Edmonds and Pennefather reminisce

Print Post Approved
PP 331758/0015

PURPOSES OF THE SOCIETY

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

OFFICE HOLDERS

President	Dr Chris Acott	30 Park Avenue, Rosslyn Park
E-mail <cacott@optusnet.com.au>		South Australia 5072
Past-President	Dr Robyn Walker	12 Barrallier Street, Griffith
E-mail <Robyn.Walker@defence.gov.au>		ACT 2603
Secretary	Dr Sarah Sharkey	1243 Pittwater Road, Narrabeen
E-mail <spumssec@bigpond.net.au>		New South Wales 2101
Treasurer	Dr Guy Williams	P.O.Box 190, Red Hill South
E-mail <spums@fastmail.net>		Victoria 3937
Editor	Assoc. Prof. Mike Davis	C/o Hyperbaric Medicine Unit
E-mail <spumsj@cdhb.govt.nz>		Christchurch Hospital, Private Bag 4710, Christchurch, NZ
Education Officer	Dr Fiona Sharp	249c Nicholson Road, Shenton Park
E-mail <sharpief@doctors.org.uk>		Western Australia 6008
Public Officer	Dr Vanessa Haller	P.O.Box 8023, Carrum Downs
E-mail <vanessa.haller@cdmc.com.au>		Victoria 3201
Chairman ANZHMG	Dr David Smart	Department of Diving and Hyperbaric Medicine
E-mail <david.smart@dhhs.tas.gov.au>		Royal Hobart Hospital, Hobart, Tasmania 7000
Committee Members	Dr Christine Lee	P.O.Box 862, Geelong
E-mail <clee@picknowl.com.au>		Victoria 3220
	Dr Glen Hawkins	P.O.Box 1674, Maroubra,
E-mail <hawkeye@swiftdsl.com.au>		NSW 2035
	Dr David Vote	P.O.Box 5016, Moreland West
E-mail <r.phillips@pgrad.unimelb.edu.au>		Victoria 3055

ADMINISTRATION

Membership	Steve Goble	C/o ANZ College of Anaesthetists
E-mail <spumsadm@bigpond.net.au>		630 St Kilda Rd, Melbourne, Victoria 3004
Journal	Sarah Webb	C/o Hyperbaric Medicine Unit
E-mail <spumsj@cdhb.govt.nz>		Christchurch Hospital, Private Bag 4710, Christchurch, NZ
		Phone: +64-(0)3-364-0045, Fax: +64-(0)3-364-0187

MEMBERSHIP

Membership is open to all medical practitioners.
Associate membership is open to all those who are not medical practitioners but are interested in the aims of the Society, and/or those engaged in research in underwater medicine and related subjects.
Membership applications can be completed online at the Society's website <www.SPUMS.org.au>

Further information on the Society may be obtained by writing to:
SPUMS Membership,
C/o Australian and New Zealand College of Anaesthetists,
630 St Kilda Road, Melbourne, Victoria 3004, Australia
or e-mail <spumsadm@bigpond.net.au>
or go to <www.SPUMS.org.au>

The Society's financial year is January to December, the same as the Journal year.
The 2007 subscription will be Full Members A$130.00 and Associate Members A$70.00, excluding GST.
There will be a postal surcharge of AUD$8.00 for journal postage for all members living outside Australia.

The Editor's offering

In 1989, at the end of an evening anaesthesia research meeting, a colleague casually asked if I had heard about the young stroke patient in the intensive care unit. I immediately went to the ICU to discover a young woman who had been on a ventilator for the past seven hours with a dense hemiplegia after a Caesarean section. My intensive care colleagues had not considered the diagnosis of cerebral arterial gas embolism (CAGE) and no-one had thought to call me about the case. We spent much of that night treating her on a US Navy Table 6. This was followed by several more hyperbaric oxygen treatments (HBOT) and 10 days later she left hospital with minor problems performing fine hand movements but fully mobile and able to look after her new baby.[1]

This was a clinical experience that I shall never forget. Since then, we have treated over a dozen suspected iatrogenic CAGE patients in Christchurch, the majority of whom have made excellent recoveries. Our post-cardiac surgery cases were reported at the ANZCA 2006 meeting.[2] There is little doubt that Khazei and colleagues are correct that iatrogenic CAGE is "*largely under-diagnosed, under-treated and under-reported*." Failure to correctly manage patients with procedure-associated ischaemic stroke is still reported in the literature as something unusual.[3,4] It has been argued that to do a randomised trial of HBOT in this situation would be unethical. From my own clinical experience of the past quarter century, I would concur with this sentiment; there is now a sufficient body of clinical evidence to conclude that HBOT should be considered in all procedure-associated ischaemic stroke.

In Carl Edmonds' provocative keynote address at this year's Annual Scientific Meeting (ASM), he discussed what he saw as the misuse of diving fatality statistics to suit the purposes of vested interests, whether intentionally or not. Brian Cumming reports 16 fatalities in the UK in 2006.[5] A research agency in Britain undertakes annual surveys on watersports under commission from the Maritime and Coastguard Agency. For 2006, the estimated number of divers was 381,000 (90% CI 317,000–444,000). This would give a fatality rate of 3.6–5 per 100,000 divers for 2006. The most reliable published data are those for Stoney Cove in England, a controlled inland diving site, for which a rate of 2.9 deaths per 100,000 divers per year was reported.[6] In my view, the supposed past distortion of fatality figures is less than Dr Edmonds would have us believe.

David Smart is to be congratulated for turning a personal accident into a learning experience for Society members with his review of the management of injuries sustained in the marine environment and the potential issues that arise in choosing anaesthesia techniques soon after diving. Editors, past and present, have repeatedly reminded members that this is *their* journal, and this is a good example of what we mean. Whilst case reports are sneered at in these days of evidence-based medicine (EBM), many colleagues express the view that they enjoy sharing clinical experiences and that case-based material has real educational value for them. EBM will not lead to the death of the case report any more than computers have done so for books!

The Asian Hyperbaric and Diving Medicine Association was formed a few years ago, and held its third meeting in Bali immediately before the SPUMS ASM. We hope to form strong links with the AHDMA over the coming years. China has had for decades a strong tradition in hyperbaric medicine with an estimated 6,000 hyperbaric facilities, though outside of the country we know little of their work. However, hyperbaric medicine is undergoing rapid development in the Asian region in many other countries, stimulated initially by diving tourism in this region. Some of this development in Malaysia is described in this issue.

The Society was privileged to act as host to the presentation of the 2007 Wyland Foundation Award at the ASM banquet. This award is made each year in New Zealand to an individual who has contributed importantly to the marine environment. The 2007 recipient was Ross Guy. Amongst his many achievements, Ross founded Project Jonah, was a co-author of the 1978 Marine Mammals Act and was instrumental in New Zealand rejoining the International Whaling Commission. Sadly, he died from cancer at the age of 58 earlier this year, and the award was accepted on his behalf by his mother, Nell Guy.

References

1 Davis FM, Glover PW, Maycock E. Hyperbaric oxygen for cerebral arterial air embolism occurring during Caesarean section. *Anaesth Intens Care.* 1990; 18: 403-5.

2 Gibson AJ. Post cardiac-surgical strokes – a role for HBO? [Abstract] *Diving and Hyperbaric Medicine*. 2006; 36: 159.

3 Nayagam J, Ho KM, Liang J. Fatal systemic air embolism during endoscopic retrograde cholangio-pancreatography. *Anaesth Intens Care*. 2004; 32: 260-4.

4 Sviri S, Woods WPD, Van Heerden PV. Air embolism – a case series and review. *Crit Care Resusc*. 2004; 6: 271-6.

5 Cumming B. *NDC Diving Incidents Report 2006*. British Sub-Aqua Club. <http://www.bsac.org/page/805/incident-report-2006.htm> (last accessed 5 July 2007).

6 Hart AJ, White SA, Conboy PJ, Bodiwala J, Quintin D. Open water scuba diving at Leicester: five years' experience. *J Accid Emerg Med*. 1999; 16: 198-200.

Michael Davis

Photo taken at about 50 msw by Simon Mitchell of Greg van der Hulst on his closed-circuit rebreather on a Poor Knights Islands drop-off.

Original articles

Potential missed cerebral arterial gas embolism in patients with in-hospital ischaemic stroke

Afshin Khazei, David Harrison, Riyad B Abu-Laban and Angeli Mitra

Key words
Cerebral arterial gas embolism (CAGE), air embolism, brain injury, hyperbaric oxygen therapy

Abstract

(Khazei A, Harrison D, Abu-Laban RB, Mitra A. Potential missed cerebral arterial gas embolism in patients with in-hospital ischaemic stroke. *Diving and Hyperbaric Medicine*. 2007; 37: 58-64.)
Cerebral arterial gas embolism (CAGE) has been characterised as under-diagnosed, under-treated, and under-reported. It is associated with a number of commonly performed diagnostic and therapeutic procedures, and penetrating trauma to the neck or chest. This study was carried out to determine the frequency with which physicians at a university-based, tertiary-care teaching hospital with a hyperbaric facility considered the diagnosis of CAGE in patients with a stroke occurring during, or shortly after, a procedure known to be high risk for CAGE. A retrospective chart review was undertaken from April 2002 to March 2003 to identify all patients who had suffered an in-hospital ischaemic stroke (IHIS) within four hours of a high-risk procedure or penetrating trauma, and presented with symptoms consistent with the diagnosis of CAGE. Of the 150 cases of "stroke as a post-admit morbidity", 46 were classified as an IHIS. In 15 of these 46, a diagnosis of CAGE could not be excluded. Symptom onset occurred during the procedure in three cases and within one hour in five cases. Procedures most commonly associated with IHIS were percutaneous coronary angioplasty (6) and cardiopulmonary bypass (6). In only one of the 15 cases was CAGE considered in the differential diagnosis. Only two patients were functioning independently at the time of discharge, whilst two died. This study suggests that in our hospital the diagnosis of CAGE is rarely considered in patients presenting with symptoms of IHIS within four hours of a high-risk procedure. These findings are important because untreated CAGE is associated with major mortality and morbidity.

Introduction

Cerebral arterial gas embolism (CAGE) is the introduction of gaseous emboli into the cerebral arterial circulation. It is associated with pulmonary barotrauma from scuba diving, penetrating trauma of the neck and thorax, and with a wide range of surgical and medical procedures.[1]

Vancouver General Hospital (VGH) is a tertiary-care teaching centre affiliated with the University of British Columbia (UBC) in Canada. Although numerous procedures known to be associated with CAGE are performed each year at our institution, a search of the hospital's computer database over the past 21 years (1983–2004) identified only six cases in which the diagnosis of iatrogenic CAGE was made. Features that led to the diagnosis being made in these cases included: intravascular air detected by intra-operative transcranial Doppler, documented injection of air instead of contrast during angiography, and air seen on CT scan.

It has been suggested that clinically significant cases of iatrogenic CAGE are largely under-diagnosed, under-treated, and under-reported.[2] This underlies the difficulty in establishing the true incidence of CAGE and, given the major morbidity and mortality associated with CAGE, it is an important area to address. Hyperbaric oxygen therapy (HBOT) is the current standard of care for clinically significant CAGE,[2–7] and there is some evidence that patients with suspected iatrogenic CAGE who are treated with early HBOT have better outcomes than patients in whom this treatment is delayed.[8]

The primary objective of this study was to determine the frequency with which physicians at a university-based, tertiary-care teaching hospital with an on-site hyperbaric facility consider the diagnosis of CAGE in patients presenting with compatible symptoms after a high-risk procedure or penetrating trauma. A secondary objective was to determine in what proportion of possible CAGE cases HBOT was administered or considered.

Methods

After obtaining ethical approval from UBC and VGH, we undertook a retrospective chart review from April 2002 to March 2003 to identify all patients who had suffered an in-hospital ischaemic stroke (IHIS). The charts were identified through a manual and computer-generated search looking for "stroke as a post-admit morbidity" in the hospital's computer database of diagnostic and procedure codes. The search was conducted by a database analyst specialising in neurology. One hundred and fifty charts were found and reviewed by one of the investigators or research assistants using explicit criteria. The two research assistants were medical students in their final year of school who had received training in chart review and the use of the standardised data collection form. Prior to commencing data collection, a preliminary set of medical records was analysed by the research assistants and the results reviewed by the principal investigator to ensure quality. All patients had been seen by a neurologist and the neurologist's consultation note was used to confirm the diagnosis of stroke.

We defined patients at risk for CAGE as those who were diagnosed as having an ischaemic stroke with onset of signs or symptoms either during a procedure associated with CAGE, within four hours of the end of such a procedure, or within four hours of awakening from anaesthesia after such a procedure. We employed this definition because it represents the criteria by which our hyperbaric oxygen facility at VGH would consider treatment for "possible CAGE". A list of procedures associated with CAGE was defined *a priori* (Table 1). Additionally, we reviewed all identified charts for any evidence of penetrating trauma to the head, neck, or thorax preceding the stroke. One case of IHIS that occurred during a bone marrow biopsy was excluded from our study because the procedure (even though it has been reported as a cause of CAGE) was not on our *a priori* list.

In addition, mortality and morbidity measures were collected for patients in the study group in order to provide some insight into the natural history of untreated procedure-associated IHIS. The same outcome measures are also reported for possible CAGE patients who were treated with HBOT at VGH in 2006. Descriptive statistics were used to present the data generated from this study.

Table 1
Procedures identified *a priori* as associated with risk of cerebral arterial gas embolism (CAGE)

Coronary artery bypass graft (CABG)
Heart valve surgery
Carotid endarterectomy
Central or arterial line insertion/manipulation
Cardiopulmonary bypass
Carotid artery injection/angiogram
Percutaneous coronary angioplasty (PTCA)
Liver transplantation
Haemodialysis
Brain surgery
Hysteroscopy
Thoracotomy
Transthoracic needle
Intra-aortic balloon pump
Laparoscopy
Endoscopy
Arthrography
Hip replacement
Transurethral prostatic resection (TUPR)

Results

The search for "stroke as a post-admit morbidity" identified 150 patients. After direct chart review by the investigators, and using a neurologist's consultation note as our gold standard, 85 patients were excluded because the final diagnosis was a disorder other than stroke (for example, delirium) or was pre-hospital stroke. These 85 charts had been miscoded in the database, leaving 65 patients with a true diagnosis of an in-hospital stroke. The 65 in-hospital stroke patients were further classified as: ischaemic stroke more than four hours after the procedure (19), ischaemic stroke within four hours of procedure (15), haemorrhagic stroke (15), no associated procedure (10), diagnosis unclear from the chart (4), procedure not listed in our *a priori* list (1), or other cause of stroke identified (1). There were no cases of IHIS after penetrating trauma.

Of the 46 cases of IHIS, 15 (32.6%) occurred during or within four hours of a high-risk procedure associated with CAGE. Symptom onset was during the procedure in three cases, within one hour in five cases, between one to four hours in four cases, and within four hours of awakening from post-operative anaesthesia or sedation in three cases. The procedures most commonly associated with CAGE were percutaneous coronary angioplasty (PTCA) (6 cases), and cardiopulmonary bypass for coronary artery bypass graft (CABG) or other cardiac surgery (6 cases) (Table 2). A search of the hospital database revealed that 1,622 PTCA and 556 CABG procedures were carried out during the one-year time period of our study.

In only one of the 15 cases was CAGE documented to be part of the differential diagnosis, and no patients were administered HBOT or referred for consideration of HBOT. The outcomes for these 15 patients are summarised in Table 3 (left-hand column). Of the 13 patients who survived, the median hospital stay was 18 days, and only two patients were independent at the time of discharge, the majority going to long-term care and all requiring rehabilitation.

Discussion

This study suggests that in our tertiary-care teaching hospital where HBOT is readily available, the diagnosis of CAGE is rarely considered in patients presenting with symptoms of IHIS within four hours of a procedure known to be associated with CAGE. Our results are limited by the use of a retrospective chart review methodology; however, they provide compelling evidence that the diagnosis of CAGE is rarely considered in at-risk patients.

A major limitation of our retrospective study is that some cases of IHIS may have been missed by our search methodology due to improper diagnostic coding or under-reporting of peri-operative complications. This would tend to cause an under-estimation of the number of "possible CAGE" cases.

Table 2. Clinical data for IHIS patients having symptom onset during

Age	Sex	Procedure	Time to onset	Clinical presentation
78	M	PTCA	During procedure	R hemiplegia, arm worse than leg, aphasia
77	F	PTCA	During procedure	Hypotension during procedure, L homonymous hemianopsia
82	F	CPB, CABG, CL, AL, valve surgery	During procedure	L arm weakness, LoC
55	M	PTCA	13 min	R hemiplegia, R facial weakness, aphasia
75	M	PTCA	15 min	LoC during procedure, L arm flaccid
80	M	PTCA	25 min	R hemiplegia
68	F	Thoracotomy, CPB, aortic valve replacement, CL, AL, laparotomy	25 min	LoC, R hemiplegia, aphasia
83	M	CPB, Aortic arch dissection repair	30 min	Hypotension, aphasia, R sided weakness
73	F	CPB, CL, AL, valve surgery, IABP	75 min	L hemiplegia (arm worse than leg)
57	F	Craniotomy	138 min	Seizure, L arm weakness
70	M	CABG	150 min	Unable to follow commands
69	F	Bronchoscopic laser debridement of thoracic tumour	150 min	Aphasia, L sided weakness, dyspnoea
73	M	CPB, CABG, valve surgery	8 h (SED)	R hand weakness, aphasia
69	F	PTCA	10 h 40 min (SED)	Frontal headache, L hemiparesis, L facial weakness
63	F	CL, AL, thoracotomy	19 h (SED)	R sided weakness, aphasia, dysarthria, R sided neglect

ACA, MCA, PCA – anterior, middle and posterior cerebral artery; AF – atrial fibrillation; AL – arterial line insertion; CABG – coronary artery bypass hypertension; IABP – intra-aortic balloon pump; ICA – internal carotid artery; LoC – loss of consciousness; PTCA – percutaneous coronary

It could be argued that some of the 19 patients who had IHIS after a procedure associated with CAGE but with onset of symptoms more than four hours after the procedure may still have benefited from HBOT. We agree that the four-hour cut-off is arbitrary and HBOT may prove beneficial in these cases; however, an *a priori* threshold had to be chosen for this study. It was felt, after surveying all the hyperbaric physicians at our institution regarding which patients they would elect to treat and the likelihood of a temporal cause/effect relationship, that a four-hour cut-off was reasonable. As a result, our methodology may be under-representing the extent of this clinical problem.

HBOT influences the physiologic effects of CAGE by a number of mechanisms, including reduction in the size of intravascular gas bubbles by the direct physical effect of increased ambient pressure, enhanced nitrogen diffusion out of the bubble created by a steep diffusion gradient, improved oxygenation of ischaemic tissues, and decreased cerebral oedema.[9]

The consequences of bubble passage and vascular occlusion by air bubbles include endothelial damage, platelet activation, and alteration of white blood cells, leading to sludging and further vessel occlusion.[10] Several animal studies collectively suggest that HBOT blocks the leukocyte-mediated no-reflow phenomenon seen following tissue ischaemia.[11–13]

or within four hours of a procedure associated with CAGE (N = 15)

CT/MRI	Baseline risk factors
Normal	HT, HC, AF
Acute to subacute R PCA infarct; bilateral patchy low densities in frontal lobes in keeping with cardioembolic origin	HT, HC, carotid US: R ICA 40–60%, L ICA 0–40%
Multiple nonhaemorrhagic subacute infarctions in both cerebellar hemispheres and the left occipital lobe	HT, HC
Acute large L MCA and ACA ischaemic infarcts	HT, HC, smoker; R ICA stenosis 80%, L ICA 50%
Acute large R MCA ischaemic infarct	DM, HT, HC
Acute R thalamic and L posterior frontal ischaemic infarct	HT, HC, DM, R ICA 60%, L ICA 50%
Bilateral multifocal acute MCA territory infarcts	CT-angiogram Circle of Willis: normal vessels
Acute L parietal infarct	No risk factors
Acute multifocal infarcts R MCA distribution, embolic	Mitral regurgitation, HT
Pneumocephalus, venous infarct bilateral R > L	None
Acute mutifocal infarcts R and L cerebellum	DM
No acute changes	Carotid US normal
No acute changes	Smoker, carotid US normal
Acute multifocal infarcts L parietal, L frontal, L temporal	DM, HC, prior bilateral carotid endarterectomy
Acute multifocal infarcts L frontal, L parietal. Acute infarct L PCA watershed area	HC carotid US: L ICA 70–80%, R ICA 0–40%

graft; CL – central line insertion or manipulation; CPB – cardiopulmonary bypass; DM – diabetes mellitus; HC – hypercholesterolaemia; HT – angioplasty; SED – onset within 4 hours of awakening from post-operative sedation or anaesthesia; US – ultrasound

A study of 2,108 patients undergoing CABG found that 6.1% had adverse cerebral events.[14] Another study of 2,972 patients undergoing CABG, with or without valve surgery, reported a stroke incidence of 1.6%.[15] The risk factors for peri-operative stroke overlap with those for stroke in the general population.[14,15] These studies suggest that neurological dysfunction after these procedures is not a rare occurrence.

It is difficult to determine in which cases symptoms are due to CAGE as opposed to solid emboli. However, it is known that arterial gas embolism is a common phenomenon in open-heart surgery and left-heart catheterisation for percutaneous coronary angioplasty. A study using transcranial Doppler (TCD) provided evidence of cerebral arterial gas embolus in 10 of 10 patients undergoing open-heart valve procedures.[16] In 72 patients undergoing left-heart catheterisation, of whom 29 underwent coronary intervention, all had evidence of microembolic signals on TCD.[17] Of these events, 67.5% occurred during contrast or saline injection (mean rate of occurrence: 95 +/- 45 microembolic signals per patient), and 32% occurred during wire or catheter manipulations. A further study of 127 patients undergoing CABG documented microembolic signals related to either specific cardiopulmonary bypass (CPB) events (air emboli) or surgical manipulations (solid emboli).[18] It was concluded

Table 3
Summary outcome data for patients with procedure-associated IHIS not treated with HBOT and patients with suspected CAGE treated with HBOT

	Patients with procedure-associated IHIS not treated with HBOT (N = 15)	Patients with suspected CAGE treated with HBOT (N = 6)
Acute length of stay (days)		
Mean, Median	20.5, 18	6, 2
(SD, IQR)	(13.78, 11)	(7.10, 14)
1-year mortality	2/15 (13%)	0/6 (0%)
Discharge to long-term care	9/13 (69%)	0/6 (0%)
Discharge home	4/13 (31%)	6/6 (100%)
Chronic length of stay (days)		
Mean, Median	43, 32	0, 0
(SD, IQR)	(49.26, 50)	(N/A, 0)
Neurological status on discharge*	1 = 2/15 (13.3%)	1 = 0/6 (0%)
	2 = 0/15 (0%)	2 = 0/6 (0%)
	3 = 11/15 (73.3%)	3 = 0/6 (0%)
	4 = 2/15 (13.3%)	4 = 2/6 (33.3%)
	5 = 0/15 (0%)	5 = 4/6 (66.7%)
Rehabilitation needed	13/13 (100%)	2/6 (33.3%)

CAGE – cerebral arterial gas embolism; IHIS – in-hospital ischaemic stroke; HBOT – hyperbaric oxygen therapy
SD – standard deviation; IQR – interquartile range
*neurological status as per the Glasgow Outcome Scale[32]:
1 – death; 2 – persistent vegetative state; 3 – severe disability (conscious but disabled and dependent on others for care); 4 – moderate disability (some disabilities but independent); 5 – good recovery

that although CPB-induced embolic events are more common than surgically-induced embolic events they are better tolerated by the patient.

There is no definitive test for CAGE. CT scan has been reported to identify cerebral bubbles in only 25% to 75% of patients with gas embolism[19] and MRI has not been documented to be reliable in identifying gas embolism.[20]

Although microemboli in the cerebral circulation may be identified by intra-operative TCD, conventional TCD does not distinguish between solid and gaseous emboli.[21] A technique for distinguishing between gaseous and solid emboli has been described using bilateral dual depth, dual frequency TCD.[22] It was able to distinguish between solid and gaseous emboli with 80% accuracy. Although this technique shows promise, it is not widely used during procedures that may cause CAGE.

The effect of hyperbaric oxygen on an undifferentiated population of patients presenting with stroke (CAGE and thromboembolic) with onset shortly after a high-risk procedure capable of causing CAGE is unknown, due to the lack of prospective studies. However, HBOT is considered the standard of care for known cases of CAGE. The consensus guidelines from the Hyperbaric Oxygen Committee Report (HOCR) recommend HBOT as the definitive treatment for CAGE.[1] These recommendations are based on the physiologic mode of action of HBOT on CAGE and a large number of human case series, human case reports and animal studies showing reversal of neurological deficits and cardiovascular compromise by HBOT. There are also reports of excellent clinical outcomes in patients treated with HBOT up to 60 hours after the event.[23–31] Based on this body of evidence, it has been suggested that a prospective randomised trial comparing HBOT to no HBOT for patients with CAGE would be unethical because the control group would be deprived of the benefits of HBOT.[8]

The lack of a reliable diagnostic test to identify or exclude CAGE has important implications for the management of patients such as the 15 identified in our study. If it is assumed that none of these patients have CAGE, then routine stroke management is appropriate. However, it is likely that some of these patients may have in fact suffered CAGE, in which case failing to consider the diagnosis as a cause of their symptoms could deny them access to a therapy that has the possibility of completely ameliorating an otherwise devastating injury.

This represents a potentially important area of preventable morbidity and mortality.[30]

The data we have gathered in this study for potential CAGE patients provide some insight into the natural history of IHIS occurring within four hours of a high-risk procedure. From the 15 patients observed, prognosis for untreated IHIS is seen to be poor.

Following this study, our hospital saw an increase in diagnosed cases of CAGE as well as awareness of HBOT as a treatment for CAGE. In 2006, six cases of CAGE were treated with HBOT at VGH. We have provided a brief summary of outcome measures for these patients, in addition to those of the 15 study patients who did not receive HBOT (Table 3, right-hand column). From this it is apparent that patients treated with HBOT for CAGE had consistently more favourable outcomes than procedure-associated IHIS patients who did not receive HBOT.[8,19,23,24,31] Although this study was not designed for comparison of these two groups, limiting interpretation, we feel that the results are of interest and are hypothesis generating. Many questions arise from these observations pointing to the need for future research.

Conclusions

This study suggests that in our tertiary teaching hospital, where HBOT is readily available, the diagnosis of CAGE is rarely considered in patients presenting with symptoms of IHIS within four hours of a high-risk procedure. This may represent an important area of preventable morbidity and mortality, which could be influenced by simply increasing awareness of CAGE and the role of HBOT in treating diagnosed CAGE cases. Further study is needed to determine if our results arise from an institutional anomaly or if they indicate a more widespread deficiency in the diagnosis and management of this potentially treatable condition.

Acknowledgements

Dr Riyad B Abu-Laban is supported by a Clinical Scholar Award from the Michael Smith Foundation for Health Research. We thank Ms Susan Sirret, Dr Jeff Bishop, and Dr Angela Naismith for their assistance in data collection for this study.
Funding sources: None
Conflicts of interest: None

References

1 Feldmeier JJ (editor). *Hyperbaric Oxygen 2003: Indications and results: The Hyperbaric Oxygen Therapy Committee Report.* Kensington, MD: Undersea and Hyperbaric Medical Society; 2003. p. 5-7.
2 Tovar E, Campo CD, Borsari A. Postoperative management of cerebral artery gas embolism: gas physiology for surgeons. *Ann Thorac Surg.* 1995; 60: 1138-42.
3 Curley MD, Schwartz HJ, Zwingelberg KM. Neuropsychologic assessment of cerebral decompression sickness and gas embolism. *Undersea Biomed Res.* 1988; 15: 223-36.
4 Boussages A, Blanc P, Molenat F. Prognosis in iatrogenic gas embolism. *Minerva Med.* 1995; 86: 453-7.
5 Hart GB, Strauss MB, Lennon PA. The treatment of decompression sickness and air embolism in a monoplace chamber. *J Hyperbaric Medicine*. 1986; 1: 1-7.
6 Hart GB. Treatment of decompression illness and air embolism with hyperbaric oxygen. *Aerospace Med.* 1974; 45: 1190-3.
7 Joiner JT. *US Navy: National Oceanic Atmospheric Association diving manual,* 4th edition. Flagstaff: Best Publishing Company; 2001. p. 3-18.
8 Blanc P, Boussages A, Henriette K. Iatrogenic cerebral air embolism: importance of an early hyperbaric oxygenation. *Intensive Care Med.* 2002; 28: 559-63.
9 Colonna S, Colucci B, Micella A, Gismondi A. Hyperbaric oxygen therapy in acute cerebral edema. *Minerva Anestesiologica.* 1991; 57: 976-7.
10 Philp RB, Inwood MJ, Warren BA. Interactions between bubbles and components of the blood: Implications in decompression sickness. *Aerosp Med*. 1972; 43: 946-53.
11 Helps SC, Gorman DF. Air embolism in the brain of rabbits pretreated with mechlorethamine. *Stroke*. 1991; 22: 351-4.
12 Swindle PF. Occlusion of blood vessels by agglutinated red cells, mainly as seen in tadpoles and very young kangaroos. *American Journal of Physiology.* 1937; 120: 59-74.
13 Zamboni WA, Roth AC, Graham RC, Suchy H, Kucan JO. Morphologic analysis of the microcirculation during reperfusion of ischemic skeletal muscle and the effect of hyperbaric oxygen. *Plastic Reconstr Surg*. 1993; 91: 1110-23.
14 Roach GW, Kanchuger M, Mangano M, Newman M, Nussmeier N, Wolman R, et al. Adverse cerebral outcomes after coronary bypass surgery. *N Engl J Med.* 1996; 335: 1857-63.
15 Hogue CW, Murphy SF, Schechtman KB, Davila-Roman VG. Risk factors for early or delayed stroke after cardiac surgery. *Circulation.* 1999; 100: 642-57.
16 Van Der Linden J, Casimir-Ahn H. When do cerebral emboli appear during open-heart operations? A transcranial doppler study. *Ann Thor Surg.* 1991; 51: 237-41.
17 Fischer A, Ozbek C, Bay W, Hamann GF. Cerebral microemboli during left heart catheterization. *Am Heart J*. 1999; 137: 162-8.
18 Clark RE, Brillman J, Davis DA, Lovell MR, Price TR, Magovern GJ. Microemboli during coronary artery bypass grafting. *J Thorac Cardiovasc Surg.* 1995; 109: 249-57.
19 Benson J, Adkinson C, Collier R. Hyperbaric oxygen

therapy of iatrogenic cerebral arterial gas embolism. *Undersea Hyperb Med.* 2003; 30: 117-26.
20 Claus M, Shank E. Gas embolism. *N Engl J Med.* 2000; 342: 476-82.
21 Abu-Omar Y, Balacumaraswami L, Pigott D. Solid and gaseous cerebral microembolization during off-pump, on-pump, and open cardiac surgery procedures. *J Thorac Cardiovasc Surg.* 2004; 127: 1759-65.
22 Brucher R, Russell D. Automatic online embolus detection and artifact rejection with the first multifrequency transcranial Doppler. *Stroke*. 2002; 33: 1969-74.
23 Bitterman H, Melamed Y. Delayed hyperbaric treatment of cerebral air embolism. *Israel J Med Sci*. 1993; 29: 22-6.
24 Wherret CG, Mehran RJ, Beaulieu MA. Cerebral gas embolism following diagnostic bronchoscopy: delayed treatment with hyperbaric oxygen. *Can J Anesth.* 2002; 49: 96-9.
25 Mader JT, Hulet WH. Delayed hyperbaric treatment of cerebral air embolism: report of a case. *Arch Neurol.* 1979; 36: 504-5.
26 Massey EW, Moon RE, Shelton D, Camporesi EM. Hyperbaric oxygen therapy of iatrogenic air embolism. *J Hyperbaric Medicine.* 1990; 5: 15-21.
27 Armon C, Deschamps C, Adkinson C. Hyperbaric treatment of cerebral air embolism sustained during an open-heart surgical procedure. *Mayo Clin Proc*. 1991; 66: 565-71.
28 Lau K, Kam PK. Systemic air embolism: a complication of ventilator therapy in hyaline membrane disease. *Clin Radiol.* 1991; 43: 16-18.
29 Rusyniak DE, Kirk MA, May JD, Kao LW, Brizendine EJ, Welch JL. Hyperbaric oxygen therapy in acute ischemic stroke, results of the Hyperbaric Oxygen in Acute Ischemic Stroke Trial pilot study. *Stroke.* 2003; 34: 571-4.
30 Mirski MA, Lele AV, Fitzsimmons L, Toung JK. Diagnosis and treatment of vascular air embolism. *Anesthesiology*. 2007; 106: 164-77.
31 Walker MB. Iatrogenic arterial gas embolism in Australia – a demographic perspective. *Diving and Hyperbaric Medicine*. 2006; 36: 158.
32 Jennett B, Bond M. Assessment of outcome after severe brain damage. *Lancet*. 1975; 1: 480-4.

Afshin Khazei, MD, FRCPC-EM, ABEM, CCFP, AAFP, ABPM-HB, is Attending Physician, Department of Emergency Medicine, and Hyperbaric Oxygen and Diving Medicine Consultant, Vancouver General Hospital, and Clinical Associate Professor, Department of Surgery, University of British Columbia
David Harrison, MD, CCFP(EM), FRCPC, is Medical Director, Vancouver General Hospital Hyperbaric Unit and Clinical Associate Professor, Department of Surgery, University of British Columbia
Riyad B Abu-Laban, MD, FRCPC, is Attending Physician and Research Director, Vancouver General Hospital Department of Emergency Medicine, and Scientist, Centre for Clinical Epidemiology & Evaluation
Angeli Mitra, BScN, MSc, Department of Surgery, University of British Columbia, and Research Coordinator, Hyperbaric Unit, Vancouver General Hospital

Address for correspondence:
Angeli Mitra, Research Coordinator
Vancouver General Hospital Hyperbaric Unit
85 West 12th Avenue
Vancouver, BC V5Z 1M9, Canada
Phone: *+1-604-875-4033*
Fax: *+1-604-875-5294*
E-mail: *<Angeli.Mitra@vch.ca>*

Does hostility facilitate success in military diving?

Charles H van Wijk

Key words
Psychology, personality, military diving, occupational diving, survey

Abstract

(Van Wijk CH. Does hostility facilitate success in military diving? *Diving and Hyperbaric Medicine*. 2007; 37: 65-7.)
Previous studies suggested that divers are more aggressive than non-diver controls, and this study investigated whether hostility scores (measured by the Hostility and Directed Hostility Questionnaire) would distinguish navy divers from comparable general naval personnel and civilian sport divers. Naval divers indicate a stronger need to act out hostility, while civilian divers tend to display less projected hostility and more intrapunitive tendencies. Extrapunitive hostility appears to be a general military attribute, and not particular to diving. The hypothesis that naval divers would report more hostility is not supported.

Introduction

Military diving is dangerous. Military divers habitually engage in high-risk behaviour, and work in a high-risk environment. Previous studies found that military divers, possibly due to the nature of their environment, appear to have more aggressive tendencies than civilians, suggesting that hostility might facilitate success in military diving operations.[1] This hypothesis is supported by older studies that found United States Navy (USN) divers to be more unsympathetic and aggressive than their control group, with a tendency toward social aggressiveness.[2–4] It has been reported that South African Navy (SAN) divers have a strong need to externalise ('act out') aggression, and a tendency to be very critical towards others.[1] Their overall hostility scores were significantly higher than those of sport divers. Sport divers in turn also score high on measures for aggressive behaviour in social situations.[5]

This study compares naval divers with published norm groups and comparable samples to examine whether hostility facilitates success in military diving.

Methods

PARTICIPANTS

The study protocol was approved by the ethical committee of the South African Military Health Service. Three samples participated: naval divers, general (non-diving) naval personnel, and civilian sport divers. Participation in this study was voluntary, and each participant provided written informed consent before participating.

A total of 115 SAN divers (92% of those invited to participate) completed the Hostility and Directed Hostility Questionnaire (HDHQ). They were all qualified clearance divers, and each had 12 years of formal schooling. They were all male. The HDHQ was completed during their annual diving medical examination. In order to determine success in military diving, participants were included in analysis when a number of criteria were met:

- none of the participants had any previous psychiatric history, and all were medically healthy;
- all divers were functionally qualified in their specialty;
- they were all operationally employed in their field for at least the previous two years;
- all participants were past their initial two-year contract (indicating good service in the Navy as divers, and the lack of serious breaches of military discipline).

A sample of 219 general naval personnel (70% of sailors invited to participate) had no diving training or experience. They consisted of sailors from a corvette squadron (N = 180) and harbour protection units (N = 39). All had 12 years of formal schooling; the group included 17 women (7.8%). The HDHQ was completed during their annual health assessment.

The civilian sport divers (N = 22) had no military background, included four women (18%), and had on average three years of tertiary education. Sport divers were recruited from local dive schools, and responded to an invitation by the author to participate in this study. All participants were medically healthy and did not have any history of psychiatric illness.

INSTRUMENT

The Hostility and Directed Hostility Questionnaire (HDHQ) is derived from the Minnesota Multiphasic Personality Inventory (MMPI). It measures two factors of hostility, namely a) a general factor of hostility with various manifestations, and b) a bipolar factor where self-directed and other-directed hostility oppose each other.[6] It consists of five scales, of which three, namely the urge to act out hostility (AH), criticism of other (CO), and projected hostility (PH), are measures of extrapunitive hostility. The other two scales, namely self-criticism (SC) and guilt (G), are measures of intrapunitive hostility. The total hostility score is the sum of the subscales. The direction of hostility (extrapunitive versus intrapunitive) is calculated using a formula.

The original manual provided norms, based on study scores.[6] The HDHQ has strong discriminant validity and good test-retest reliability.[7,8] It has been said to be the best MMPI-derived measure of hostility.[9] The HDHQ has shown good stability across different samples and different countries, which led to its use with the South African divers.[8,10]

DATA ANALYSIS / STATISTICAL ANALYSIS

All scores were analysed using STATISTICA 7.[11] Descriptive statistics were generated for the HDHQ subscales. The navy divers sample was compared with published results using t-tests for single samples. The scores of the three samples were compared using 1-way ANOVA, with Tukey's HSD test for post hoc comparisons of means. Age and hostility scores were correlated using Pearson's correlation.

Results

The descriptive statistics of the three samples and the reference group are to be found in Table 1. The sample of general naval personnel was older than both the navy and civilian diver samples (both $p < 0.01$).

The naval divers were first compared with the original norm group.[6] Their CO subscale was significantly higher than the original group ($p < 0.0001$), and was raised above the original cut-off point, indicating a tendency to be very critical towards others. The PH subscale was also significantly higher than the original norm group ($p < 0.0001$), but still within normal limits. The other subscale scores did not differ significantly from the norm group.

The total hostility score was slightly elevated, differing significantly from the original norm group ($p < 0.01$). The direction of hostility was in the middle of the scale, indicating neither strong intrapunitive nor extrapunitive tendencies. However, when the naval divers were compared with later norms groups, their total hostility scores were comparable to those of the general population.[7]

In this study, there were significant differences between the three samples in the scores for the urge to act out hostility [$F(2,353) = 8.47$; $p < 0.001$], projected hostility [$F(2,353) = 8.18$; $p < 0.001$], and the direction of hostility [$F(2,353) = 7.56$; $p < 0.001$]. Naval divers had significantly higher scores for the urge to act out hostility than the general naval sample ($p < 0.01$) and the civilian diver sample ($p < 0.05$). The sport divers tended to project their hostility less than military divers ($p < 0.05$) and general navy personnel ($p < 0.01$); further, civilian divers displayed more intrapunitive hostility than naval divers ($p < 0.01$) and the general naval sample ($p < 0.01$) (although it was still within normal limits).

Projected hostility was the only subscale to correlate significantly with age. Older participants reported slightly higher scores than younger divers ($r = 0.20$; $p < 0.05$).

Discussion

The degree of hostility of navy divers is comparable to that of the general population, general naval personnel, and civilian sport divers. The naval divers did report a stronger urge to act out hostility than the other two sample groups. As suggested previously, their environment – referring to both the military context and the physical nature of military diving – may explain why raised AH would be contextually appropriate.[1]

Table 1
HDHQ means and standard deviations of the study samples and reference groups
(see text for statistical relationships)

	Norms group[6] (N = 77)	SAN divers (N = 115)		SAN non-divers (N = 219)		Civilian (sport) divers (N = 22)	
	Mean	Mean	SD	Mean	SD	Mean	SD
Age		23.73	3.88	28.05	5.78	24.23	3.61
AH	3.73	3.54	2.01	2.71	1.89	2.32	1.46
CO	3.07	4.44	2.49	4.74	2.49	4.18	1.97
PH	0.60	1.56	1.31	1.83	1.22	0.77	0.69
SC	3.00	2.43	2.20	2.58	2.20	3.09	2.16
G	2.00	1.73	1.16	1.68	1.03	1.64	0.90
Degree of H	11.40	13.69	6.82	13.80	7.57	12.09	4.63
Direction of H	-1 to +1	1.10	4.74	1.58	4.63	-2.45	4.31

(AH – urge to act out hostility; CO – criticism of other; PH – projected hostility; SC – self-criticism; G – guilt; H – hostility)

Does hostility facilitate success in military diving? If success is measured by good adaptation to the military diving environment (e.g., renewed contracts, etc.), then successful naval divers do not seem to have particularly raised hostility scores, and theirs were no higher than other naval personnel, or civilian sport divers. However, the urge to act out hostility did characterise the naval divers in this study, and may be an important construct in examining personality-trait requirements for success in military diving. The finding that civilian divers displayed less projected hostility and directed it more intrapunitively than the two military samples, suggests that external expression of hostility may be an attribute of military samples, and may facilitate success in the military context generally, though not necessarily in the diving environment specifically.

References

1 Van Wijk CH. Levels of anxiety and hostility in South African navy divers. *Undersea Hyperb Med.* 2002; 29: 271-8.

2 Biersner RJ. Social development of navy divers. *Aerosp Med.* 1973; 44: 761-3.

3 Biersner RJ, Cameron BJ. Betting preferences and personality characteristics of Navy divers. *Aerosp Med.* 1970; 41: 1289-91.

4 Beckman TJ, Lall R, Johnson WB. Salient personality characteristics among Navy divers. *Mil Med.* 1996; 161: 717-9.

5 Martin WS, Myrick FL. Personality and leisure time activities. *Res Q.* 1976; 47: 246-53.

6 Caine TM, Folds GA, Hope K. *Manual of the Hostility and Directed Hostility Questionnaire.* London: University of London Press; 1967.

7 Philip AE. Assessing punitiveness with the Hostility and Directed Hostility Questionnaire. *Br J Psychiatry.* 1973; 123: 435-9.

8 Moreno JK, Fuhriman A, Selby M. Measurement of hostility, anger, and depression in depressed and nondepressed subjects. *J Pers Assess.* 1993; 61: 511-23.

9 Spielberger CD, Jacobs G, Russell S, Crane RS. Assessment of anger. In: Spielberger CD, Butcher JN, editors. *Advances in personality assessment* (Vol 3). Hillside: Laurence Erlbaum; 1983. p. 89-131.

10 Ross S, Heath NL. Two models of adolescent self-mutilation. *Suicide Life Threat Behav.* 2003; 33: 277-87.

11 StatSoft. *Statistica Version 7*. Tulsa, OK: Statsoft; 2004.

Charles H van Wijk, PhD, Department of Psychology, Institute for Maritime Medicine, Simon's Town, South Africa

Address for correspondence:
17 Twelfth Avneue
Fish Hoek 7975
South Africa
Phone: *+27-21-787-4541*
E-mail: *<chvanwijk@gmail.com>*

Review article

Use of ultrasound in decompression research

Neal W Pollock

Key words
Diving, bubbles, Doppler, echocardiography, equipment, decompression sickness, review article

Abstract

(Pollock NW. Use of ultrasound in decompression research. *Diving and Hyperbaric Medicine*. 2007; 37: 68-72.)
Techniques for ultrasonic assessment of decompression stress continue to evolve in concert with technological development. While aural Doppler remains a staple, imaging techniques are gaining in popularity. Current initiatives to increase the resolution of three-dimensional and dual-frequency imaging hold promise to expand our monitoring capabilities. An appreciation of the limitations and strengths of ultrasonic assessment is important to interpret existing work on decompression and to appropriately design new studies.

The formation of gas emboli (bubbles) in response to decompression was first observed in the eye of a snake by Robert Boyle almost 350 years ago. Forming in a variety of tissues, bubbles may be transient or persistent, varying with the exposure and the individual, and potentially capable of exhibiting both mechanical and biochemical effects. While the exact role bubbles play in the development of decompression sickness (DCS) remains to be determined, their formation is generally accepted as an indicator of decompression stress.

Ultrasound transducers emit sound waves (acoustic energy) when excited electrically. Sound waves transmitted through the body generate echoes when changes in density are encountered. Bubbles are easily identified because of the highly reflective nature of the liquid–gas interface. Echoes return to the transducer receiver and the acoustic energy is transformed back into electrical energy, processed, and presented aurally in the case of Doppler devices and visually with two-dimensional imaging devices.

Doppler

Doppler ultrasound is the principal tool for monitoring decompression stress outside of symptom development. Doppler was first used to detect bubbles circulating in blood more than 40 years ago.[1] The beginnings of formalised techniques to detect decompression-induced bubbles were reported in 1968.[2,3] A more quantitative categorical grading scale described by Spencer and Johanson in 1974 is still in use today (Table 1).[4]

Early measures were made with subjects remaining at rest. The Spencer and Johanson protocol was subsequently refined to include ‘at rest’ and ‘movement’ monitoring.[5] Movement promotes transient increases in identifiable bubble activity, potentially increasing the sensitivity of the monitoring. The most commonly employed movement was a deep knee bend.[6] Concerns over the aggressive physical effect and the difficulty in holding the transducer in position resulted in a range of alternatives being used. We currently employ seated, sequential limb motion as the movement case.[7] Upon the completion of ‘at rest’ measurement, subjects are asked to complete three cycles of movement with each limb. Each movement is supposed to involve every joint and contract every muscle in the limb during the approximately 1.5 sec flexion/extension cycle. Muscular effort is a combination of isometric and isotonic contractions. The technician listens for an audible change in the cardiac rate to confirm a satisfactory degree of effort. Monitoring continues for a minimum of 10 cardiac cycles or until the heart rate returns to approximately baseline before movement of the next limb is signaled. This approach to the movement case provides a moderate physical effort, makes it easier for the technician to conduct the monitoring, and provides additional information on regional origins of any bubbles.

The Kisman–Masurel method was developed after the

Table 1
Spencer scale of Doppler-detected bubbles[4]

Grade	Definition
0	No bubble signals
I	Occasional bubble signal; great majority of cardiac cycles signal-free
II	Many but less than half of the cardiac cycles contain bubble signals
III	All cardiac cycles contain bubble signals, but not obscuring signals of cardiac motion
IV	Bubble signals sounding continuously throughout systole and diastole and obscuring normal cardiac signals

Spencer scale to evaluate bubble signals on a 0–4 scale for each of three distinct parameters: frequency, percentage/duration and amplitude.[8] Frequency characterised the number of bubbles per cardiac period. Percentage/duration characterised the percentage of cardiac periods with specified bubble frequency at rest and following movement, respectively. Amplitude characterised the bubble sounds compared to normal background cardiac sounds. The parameter scores combine to yield a single 0-IV grade that includes '+' and '–' modifiers on non-zero values (note: there is no '+' associated with grade IV bubbles). Kisman–Masurel grades can be converted to equivalent Spencer grades but the reverse is not possible. The Kisman–Masurel scale provides a more sophisticated and subtle gradation of bubbles, but it requires more time to train and maintain the proficiency of technicians. While the Kisman-Masurel scale is favoured by some research groups, the Spencer scale is the most widely used.

Learning to record interpretable Doppler signals is relatively straightforward. The challenge comes in making the interpretation, and, even more so, in reliably interpreting the signals in real time. Sawatsky and Nishi reported on inter-rater reliability among a well-trained group of technicians.[9] They determined that good agreement could be achieved, particularly with Spencer grade III or IV bubbles, but that the training to get to this point can take months.

Common sites for Doppler monitoring include the pulmonary artery, subclavian vein and carotid artery. Less common sites include the femoral vein and inferior vena cava. Precordial monitoring of the pulmonary artery is probably the single best monitoring choice. It provides a single sampling site of all blood returning from the body en route to the lungs. Developments in transducer technology have made it easier to reliably capture pulmonary artery signals in subjects with a reasonable range of anatomical variation. The precordial site is also the only one that is truly compatible with the Spencer or Kisman–Masurel grading scales. Grades III and IV are determined by the interaction between bubble signals and background heart sounds. Heart sounds cannot be discerned at most other monitoring sites. The limitation of focusing on a single site is that some transient bubbles that might be identified at other sites could be missed.

Doppler bubble detectors can employ continuous wave (CW) or pulsed wave (PW) technology. CW systems use two or more transducers, one transmitting and one or more receiving. All moving particles in the beam are detected. Key advantages of CW systems are simplicity and relatively low cost. PW systems use a single transducer that alternates between transmitting and receiving modes, allowing calibration so that only signals originating from a target depth are registered. PW systems require more complicated electronics and are more expensive than CW. Calibration for individual subjects can be effective, but this may not be feasible if a unit must be used to scan multiple subjects sequentially.

Two-dimensional echocardiography

Two-dimensional echocardiography combines ultrasound imaging and Doppler flow detection technology to provide a visual display of scans. 'Gain' controls adjust the amplification of returning echoes to optimise the image, balancing sensitivity and visual clutter. Originally, transducers transmitted and received the same frequency. More recently, transducers have been developed to transmit one frequency and receive a higher harmonic frequency. The transmitted frequency is the fundamental or first harmonic; the received frequency is an integer multiple of the fundamental frequency. For example, a device might transmit a 2 MHz fundamental frequency and receive a 4 MHz second harmonic frequency. Such 'harmonic processing' improves image resolution and is generally employed as a standard when available.

Two-dimensional transducers are available to conduct transoesophageal echocardiographic (TEE) or transthoracic echocardiographic (TTE) scans. The resolution of TEE is generally greater than TTE, but practical issues of placing and leaving a probe in the oesophagus make TTE a more attractive alternative for the prolonged or repeated measurement expected for decompression research and thus the focus of this discussion.

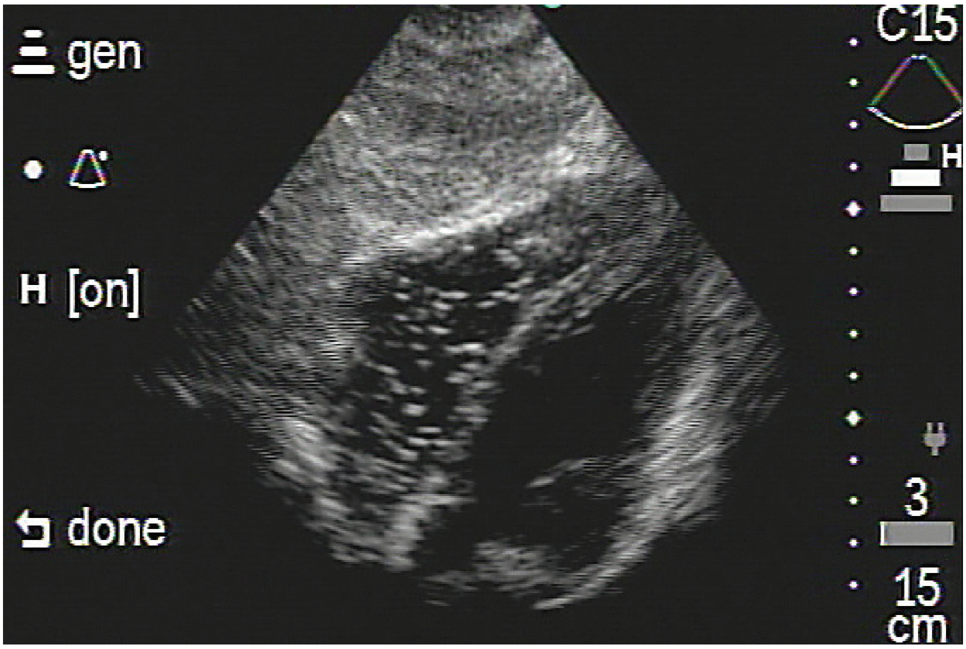
TTE imaging can provide a cross-sectional view of multiple heart chambers and major vessels (Figure 1). Apical or subcostal long axis views can allow good visualisation of the right atrium and ventricle to monitor the blood volume prior to it entering the pulmonary artery. In this way, TTE can serve as a tool similar to Doppler. Visual grading systems have been developed to conceptually match the Spencer scale for Doppler signals. The highest degree of quantification is found in the Eftedal and Brubakk scale (Table 2).[10,11] When developed, it was expected that grades 0–4 would apply to human subjects; grade 5 had been observed only in animal subjects at the time. Boussuges et al described a dual-use scale to reconcile Doppler and two-dimensional image scoring (Table 3).[12] The scale paralleled the established 0–IV Spencer range.

The Eftedal and Brubakk scale provided more objective criteria for grading than the scale of Boussuges et al. This

Table 2
Two-dimensional echocardiographic imaging scale[10,11]

Grade	Definition
0	No observable bubbles
1	Occasional bubbles
2	At least one bubble every four cardiac cycles
3	At least one bubble every cardiac cycle
4	At least one bubble·cm^{-2} in every image
5	'White-out', single bubble cannot be discriminated

Figure 1
A two-dimensional long axis view of the four chambers of the heart (transducer positioned subcostally). Visible structures include nearly complete chamber margins (wall and septum) of both atria and ventricles, and both mitral and tricuspid valves. The valves are better seen in motion. The image is inverted, with the atria at the bottom. A substantial number of bubble signals are evident on the right side of the heart (appearing on the left side by convention). No bubble signals appear in the left heart.



is important in order to facilitate inter-rater reliability. The inclusion of a sixth grade in the Eftedal and Brubakk scale was also a positive step, recognising the capacity of two-dimensional echo to be more sensitive to differences at high bubble concentrations than aural Doppler. The magnitude of the jump between the definitions of grade 4 and grade 5 scores, however, was larger than necessary. Scale references are provided on the displays of most two-dimensional imaging systems to facilitate rapid density estimates. It is reasonable for a trained technician to differentiate an intermediate state between the top two Eftedal and Brubakk scores.

A new grading scale, described in Table 4, employs objective criteria and accommodates the capability of two-dimensional imaging systems to differentiate between high bubble loads. The grading for this proposed scale is based on the peak group of 10–30 consecutive cardiac cycles for resting measures and the peak group of 10 consecutive cardiac cycles following movement. 'New' bubbles are specified since fractional cardiac ejection may leave some bubbles within the ventricle for multiple cardiac cycles. Views should

Table 3
Dual-use Doppler and two-dimensional echocardiographic imaging scale[12]

Grade	Definition
0	Complete lack of bubble signal (two-dimensional echo [2D] and pulsed wave Doppler [PW])
1	Occasional bubbles, the great majority of cardiac periods are free of bubbles (2D & PW)
2	Flow of bubbles (2D), many but less than half of the cardiac periods contain bubble signals singularly or in groups (PW)
3	Flow of bubbles (2D), majority of the cardiac periods contain bubble signals singularly or in groups (PW)
4	Bubbles fill cardiac chambers (2D), all the cardiac periods contain bubble signals in groups (PW)

Table 4
Proposed new two-dimensional echocardiographic imaging scale (see text for more detailed explanation)

Grade	Definition
0	No observable bubbles
I	Occasional bubbles
II	At least one new bubble every four cardiac cycles
III	At least one new bubble every cardiac cycle
IV	At least one bubble·cm^{-2} in every image
V	At least two bubbles·cm^{-2} in every image
VI	At least 80% of visible lumen obscured by bubble cloud; single bubbles cannot be discriminated

be optimised so that the maximum cross-sectional lumen is visible in the image field and reference structures are clearly discernible. The target for visualising reference structures for the apical/subcostal views include: > 80% of ventricular margins (septum and wall), mitral valve, and > 25% of atrial lumen area. The proposed scale is directly comparable to the Spencer Doppler scale only for grades 0 and I bubble signals. The new scale could be applied, however, to Doppler signals through grade III. The scale would allow greater differentiation of high bubble loads than is possible with the Spencer scale. The need for the additional increment will grow as the resolution of imaging systems continues to improve. The use of Roman numerals is preferred to remind users that the grade categories are non-linear and that scores cannot be averaged.

One of the ways that two-dimensional imaging surpasses Doppler technology for decompression studies is in the ability to directly monitor the left side of the heart. Left ventricular gas emboli (LVGE) are in a position to be distributed systemically and are implicated as causative agents in neurological DCS. While the absolute risk of DCS is not known, the conservative approach during altitude decompression research trials is to establish the presence of LVGE, regardless of symptom status, as a test-termination criterion. Researchers at the Brooks Air Force base in New Mexico may have been the first to use TTE to simultaneously monitor gas phase on the right side of the heart (RVGE) and LVGE during decompression studies. They used a powerful clinical-standard TTE machine positioned outside the chamber with a transducer introduced to the chamber through a wall penetrator and deployed by either a robotic arm or an inside technician. In our laboratory, we use Doppler equipment to monitor RVGE and portable TTE devices that reside within the chamber for use by inside technicians to monitor for LVGE during altitude decompression studies. We have observed LVGE in two cases out of more than 700 person-exposures monitored. Both subjects were immediately compressed to ground level and remained asymptomatic.

The future of ultrasonic assessment

THREE-DIMENSIONAL ECHOCARDIOGRAPHIC IMAGING

One of the limitations of two-dimensional imaging is that bubbles passing above or below the focal plane may be missed during scanning. Identification requires bubble targets to pass close to or through the plane. Three-dimensional echocardiographic imaging has the potential to improve current capability. Current systems can capture 60° x 15° sections that are indexed to the cardiac cycle. A gated scan can capture four cardiac cycles and accumulate a 60° x 60° wedge that can be stored electronically and then manipulated for subsequent study. The volume can be progressively sliced in any plane to capture target structures. The resolution of the current systems is lower than that achieved with two-dimensional settings, but the potential for future improvements is promising.

DUAL-FREQUENCY ULTRASOUND

Another limitation of ultrasonic assessment of bubbles is the focus on intravascular locations. The ability to monitor extravascular locations could provide additional information. Dual-frequency ultrasound was proposed to overcome this limitation more than 20 years ago.[13] The approach requires two transducers: one employing a pump frequency to stimulate existing bubbles to vibrate, and a second employing an image frequency to capture the vibrating bubbles.[14] Frequency sweeping, discussed 30 years ago, could provide size information.[15] The resonance frequency of a bubble is inversely proportional to its diameter. Sweeping through a frequency range could provide the size information not available with current Doppler, two-dimensional or three-dimensional technologies. Practically technical problems are still being overcome but these techniques may ultimately provide reliable measures of the presence and sizes of bubbles in extravascular locations not in close proximity to bony structures.

Limitations and uses of ultrasound measures

The role that bubbles play in the development of clinical DCS is not clear. Bubbles can be found much more often than DCS following decompression. The interpretation of bubble data is generally based on relatively little DCS.[6,16] The highest incidence of DCS is seen with altitude studies. A review of altitude DCS cases noted that the absence of VGE was highly correlated with an absence of DCS symptoms, with a negative predictive value of 0.98.[17] Conversely the presence of Spencer grade III and IV VGE had a positive predictive value for DCS of only 0.39.[17] The data are more limited for diving decompression but the observed relationship is similar. The absence of bubbles is more strongly associated with decompression safety than the presence of even high grade bubbles is associated with DCS. It is important to appreciate, however, that this observation may be partially confounded by the limitations of our monitoring capability.

The chief limitation is that standard monitoring is limited to a small number of intravascular sites. It is possible that the presence of bubbles in unmonitored vascular or extravascular locations may be important. Instrument resolution is also an issue. While various authors have speculated on the size of decompression-induced bubbles that may be identified, there is little to validate these estimates or to document the size range of decompression-induced bubbles. At the small size extreme, the reflectivity of a 2.0–5.0 µm second-generation, stabilised gas microsphere may be quite different from that of a spontaneously arising decompression-induced bubble. It is possible that the latter bubbles are far less visible. The monitoring schedule may also be problematic. Inter-measurement intervals of 15–60 min are reported.

Much can be missed during the unmonitored interval, particularly with less frequent sampling. Variations in monitoring protocols can also have an influence. The specifics employed to generate a movement case vary substantially in the magnitude and duration of physical effort and motion.[7,18] Some investigators choose to report at-rest data only.[11,18] At-rest monitoring is expected to underestimate grades achieved following movement. Finally, the large inter-individual variability in bubble formation can adversely affect the outcome of any but the largest studies.

Advancement in technology and methodology may ultimately strengthen the measurable relationship between observable bubbles and DCS. Even without that achievement, bubble data will remain attractive to those institutions uncomfortable with experimental studies that carry a clear expectation of generating some DCS. While bubble data cannot currently be used to determine absolute decompression stress, they can be used to estimate relative stress. Repeated measures designs with subjects as their own controls can be used to address a number of questions while restricting exposures to those with less risk of DCS.

Conclusions

Techniques for ultrasonic assessment of decompression stress continue to evolve. While aural Doppler remains a staple, imaging techniques are gaining in popularity. Current initiatives to increase the resolution of three-dimensional and dual-frequency imaging hold promise to expand our monitoring capabilities. An appreciation of the limitations and strengths of ultrasonic assessment is important to interpret existing work and to design appropriate studies.

References

1 Franklin DL, Schlegel W, Rushmer RF. Blood flow measured by Doppler frequency shift of back-scattered ultrasound. *Science*. 1961; 134: 564-5.

2 Spencer MP, Campbell SD. Development of bubbles in venous and arterial blood during hyperbaric decompression. *Bull Mason Clin*. 1968; 22: 26-32.

3 Gillis MF, Karagianes MT, Peterson PL. In vivo detection of circulating gas emboli associated with decompression sickness using the Doppler flowmeter. *Nature (London)*. 1968; 217: 965-7.

4 Spencer MP, Johanson DC. *Investigation of new principles for human decompression schedules using the Doppler blood bubble detector*. Washington: Office of Naval Research Tech Rep ONR Contract N00014-73-C-0094; 1974.

5 Kisman KE, Masurel G, Guillerm R. Bubble evaluation code for Doppler ultrasonic decompression data. *Undersea Biomed Res*. 1978; 5(Suppl 1): 28.

6 Gardette B. Correlation between decompression sickness and circulating bubbles in 232 divers. *Undersea Biomed Res*. 1979; 6: 99-107.

7 Pollock NW, Natoli MJ, Gerth WA, Thalmann ED, Vann RD. Risk of decompression sickness during exposure to high cabin altitude after diving. *Aviat Space Environ Med*. 2003; 74: 1163-8.

8 Eatock BC, Nishi RY. Procedures for Doppler ultrasonic monitoring of divers for intravascular bubbles. Toronto: Department of National Defence, Defence and Civil Institute of Environmental Medicine (DCIEM) Report No. 86-C-25; 1986.

9 Sawatzky KD, Nishi RY. Assessment of inter-rater agreement on the grading of intravascular bubble signals. *Undersea Biomed Res*. 1991; 18: 373-96.

10 Eftedal O, Brubakk AO. Agreement between training and untrained observers in grading intravascular bubble signals in ultrasonic images. *Undersea Hyperb Med*. 1997; 24: 293-9.

11 Brubakk AO, Eftedal O. Comparison of three different ultrasonic methods for quantification of intravascular gas bubbles. *Undersea Hyperb Med*. 2001; 28: 131-6.

12 Boussuges A, Carturan D, Ambrosi P, Habib G, Sainty JM, Luccioni R. Decompression induced venous gas emboli in sport diving: detection with 2D echocardiography and pulsed Doppler. *Int J Sports Med*. 1998; 19: 7-11.

13 Newhouse VL, Shankar PM. Bubble size measurements using non-linear mixing of two frequencies. *J Acoust Soc Am*. 1984; 75: 1473-7.

14 Buckey JC, Knaus DA, Alvarenga DL, Kenton MA, Magari PJ. Dual-frequency ultrasound for detecting and sizing bubbles. *Acta Astronautica*. 2005; 56: 1041-7.

15 Nishi RY. The scattering and absorption of sound waves by a gas bubble in a viscous liquid. Acustica 1975; 33: 65-74.

16 Vann RD, Pollock NW, Freiberger JJ, Natoli MJ, Denoble PJ, Pieper CF. Influence of bottom time on preflight surface intervals before flying after diving. *Undersea Hyperb Med*. 2007; 34: 211-20.

17 Conkin J, Powell MR, Foster PP, Waligora JM. Information about venous gas emboli improves prediction of hypobaric decompression sickness. *Aviat Space Environ Med*. 1998; 69: 8-16.

18 Boussuges A, Molenat F, Carturan D, Gerbeaux, Sainty JM. Venous gas embolism: detection with pulsed Doppler guided by two-dimensional echocardiography. *Acta Anaesthesiol Scand*. 1999; 43: 328-32.

Neal W Pollock, PhD, is a Research Associate at the Center for Hyperbaric Medicine and Environmental Physiology, Duke University Medical Center
Durham, NC 27710, USA
***Phone:** +1-919-684-2948, ext. 225*
***Fax:** +1-919-493-3040*
***E-mail:** <neal.pollock@duke.edu>*

Dr Pollock was the Guest Speaker at the 2007 SPUMS Annual Scientific Meeting at Tutukaka, New Zealand.

SPUMS Annual Scientific Meeting 2007

Treatment of decompression illness in the 21st century: a brief overview

Simon J Mitchell

Key words
Decompression illness, decompression sickness, arterial gas embolism, recompression, non-steroidal anti-inflammatories, lignocaine, blood substitutes, review article

Abstract

(Mitchell SJ. Treatment of decompression illness in the 21st century: a brief overview. *Diving and Hyperbaric Medicine*. 2007; 37: 73-5.)
Definitive treatment of decompression illness usually involves recompression and the administration of hyperbaric oxygen. Little recent progress has been made in the development of recompression strategies. The 'short oxygen table' remains the mainstay, though variations in pressure, duration of treatment, and respired gas have their advocates. Other 'adjuvant' treatments are sometimes employed. Only one adjuvant treatment, a non-steroidal anti-inflammatory agent, is supported by directly relevant human data. The value of intravenous fluids is often self-evident in serious decompression illness, but benefit is less certain in mild disease. There are data of indirect relevance supporting the use of lignocaine in arterial gas embolism. Other agents such as nitric oxide donors and intravenous perfluorocarbon emulsions await testing in humans.

Introduction

Treatment of decompression illness (DCI) had its beginnings in the recompression of sufferers who simply returned to work under pressure. It evolved through the development of therapeutic recompression schedules utilising air breathing, and subsequently oxygen breathing. There has also been much interest in adjuvant strategies that are mainly pharmacological in nature.

Recompression

Despite the lack of any evidence beyond non-randomised studies, recompression and administration of hyperbaric oxygen remain the mainstays of modern treatment for DCI. Compression reduces bubble volume in accordance with Boyle's Law, and oxygen breathing hastens the elimination of inert gas. Remarkably little recent progress has been made in the development of recompression protocols. The so-called 'short oxygen tables' such as the US Navy Table 6, which were popularized in the 1960s, remain the most commonly used to this day. These treatments utilise oxygen breathing at a pressure (typically 2.8 ATA) chosen to optimise the 'oxygen window' whilst maintaining the risk of oxygen toxicity within acceptable limits.

Other parameters of recompression may be varied

Most practitioners recognise the utility of varying the duration of recompression in accordance with the severity and clinical response in individual cases. The most common approach is the prescribed 'extensions' to US Navy Table 6 (Royal Navy Table 62), which allow extended periods at both 2.8 and 1.9 ATA during decompression; but there are many variations, including controversial 'saturation' treatments for very serious and refractory neurological disease.[1]

There is also the option of compressing to greater pressures, at which oxygen breathing would not be appropriate. While there is supportive anecdote and some data from case series,[2] this option is also controversial. The previous fashion for an initial 'deep' spike (usually to 6 ATA) for serious DCI or those cases perceived to be caused by arterial gas embolism (AGE) has waned. This has occurred in the light of conflicting animal evidence on the effects of greater pressure on arterial bubble redistribution, the logistical and safety implications of these 'deeper' tables, and the lack of any convincing demonstration of significant benefit.[1] Nevertheless, 'deep' treatments still have their advocates,[2] and treatment protocols that specify escalating treatment depth in the face of refractory and serious disease are sometimes used at appropriately configured hyperbaric units.

In the treatment of DCI following air diving there are theoretical advantages in utilising helium as the diluent gas during periods where the F_iO_2 is lowered to minimise the risk of oxygen toxicity. This is especially so during 'deep' treatments at pressures greater than those where 100% oxygen can be safely used. There is some experimental evidence[3] and limited clinical data[4] in support of this practice, but it cannot be considered proven.

The somewhat extraordinary issue with all of these combinations and permutations of recompression strategy remains the near total absence of strong evidence to facilitate objective choices. Notwithstanding the strength of anecdote, the same could be said for the efficacy of recompression *per se* in treating DCI. Indeed, in the absence of any controlled data the use of recompression and hyperbaric oxygen has evolved into an impregnable 'standard of care' for DCI of virtually any severity. It is therefore notable that a recent consensus of experts found that the final outcome for patients with mild DCI (strictly as defined in the consensus) is not compromised by not being recompressed.[5] This has significant implications for the management of mild or equivocal cases in remote locations where accessing recompression would involve very costly and inconvenient evacuation.

Adjuvant therapies

The well-recognised potential for incomplete resolution of DCI, especially the more serious forms, has led to much interest in adjuvant therapy that might improve outcome.

Intravenous fluid administration has long been considered important, and its necessity is self-evident in those rare severe cases that present with haemoconcentration and shock.[6] It is much less clear whether fluid administration is useful in milder cases. There are no relevant human data.

A fashion has developed for the use of intravenous lignocaine in the treatment of severe DCI. This is based on a series of *in vivo* experiments that demonstrated neuroprotection by lignocaine in arterial gas embolism (AGE) and in numerous other models of brain injury. These various studies are summarised by Mitchell.[7] In addition, two small randomised double-blind controlled trials demonstrated less post-operative neurocognitive impairment in humans given lignocaine during heart surgery.[8,9] Whilst there are some parallels between brain injury in cardiac surgery and diving, the extrapolation of these results to AGE in diving is drawing a long bow since in both studies the lignocaine was given prophylactically and clearly this cannot be the case in diving. Nevertheless, the Adjuvant Treatments Committee of the Undersea and Hyperbaric Medical Society considers the use of lignocaine to be potentially beneficial in cases of AGE presenting early for treatment.[10] A bolus and infusion regimen as per guidelines for an antiarrhythmic effect is recommended, and the infusion should be continued for 24 to 48 hours.

Administration of non-steroidal anti-inflammatory drugs (NSAIDs) has anecdotally been associated with quicker recovery from DCI. This issue was addressed in a randomised double-blind controlled trial of tenoxicam versus placebo (the only such trial of *any* intervention in DCI) involving 180 divers conducted at Prince of Wales Hospital in Sydney.[11] This study demonstrated no improvement in final outcome with tenoxicam but the median number of recompression treatments was significantly reduced in the NSAID group. Treatment of five patients with tenoxicam was required to prevent one hyperbaric treatment. NSAIDs are the only 'proven' adjuvant treatment for DCI.

There has been much speculation that potent steroids may improve outcome in DCI. There are no relevant human data, but a recent study of methylprednisolone administration in pigs with DCI demonstrated worse outcome with steroid treatment.[12] Steroids are not recommended in the treatment of DCI.[10]

One interesting and recent development has been the finding of reduced venous bubble formation after decompression in pigs[13] and humans[14] pre-treated with standard doses of nitrate agents. This line of research arose out of the hypothesis (which was subsequently disproved) that a reduction in bubble formation induced by appropriately timed pre-dive exercise might be a result of upregulation of NO production by endothelial cells. Pre-dive exercise appears to impart its benefit by a different mechanism, but the initial misattribution to NO effects has inadvertently sparked a new line of research that might be relevant to treatment of DCI. If the reported nitrate effect is confirmed in humans, and given the rapid kinetics of NO donation by nitrate drugs, it is perhaps only a matter of time before nitrates are tested in early presentations of DCI as a potential means of limiting ongoing bubble formation.

Perhaps the most exciting unrealised prospect for adjuvant therapy in DCI is the use of intravenous perfluorocarbon emulsions (PFCEs). These are chemically inert, water-insoluble aromatic or aliphatic compounds with fluorine substituted for all hydrogen atoms.[15] They have low surface tension and high solubility for gases. Oxygen is 100 times more soluble in PFCEs than plasma, and this has generated interest in their use as 'blood substitutes'. Their related ability to accelerate inert gas transport in blood has resulted in interest in their use to treat DCI – either in isolation or as an adjuvant to hyperbaric oxygen. Latson has summarised the numerous *in vivo* studies that have demonstrated significant benefit in both DCS and AGE.[15] Since that review there have been two further relevant studies that demonstrated benefit.[16,17] The lack of a reliable source of PFCEs licensed for human use has hampered human research in DCI to date.

A final recent development is that the field of DCI treatment now has its own Cochrane Review.[18] Although there are few studies suitable for inclusion in such a review at this point, it is hoped that future iterations will include randomised controlled studies of some of these promising prospects for adjuvant treatment.

References

1 Moon RE, Gorman DF. Treatment of the decompression disorders. In: Brubakk AO, Neuman TS, editors. *Bennett and Elliott's physiology and medicine of diving*. London: Saunders Publishers; 2003. 600-50.

2 Smerz RW, Overlock RK, Nakayama H. Hawaiian deep treatments: efficacy and outcomes 1983-2003. *Undersea Hyperb Med*. 2005; 32: 363-73.
3 Hyldegaard O, Moller M, Madsen J. Effect of He-O_2, O_2, and N_2O-O_2 breathing on injected bubbles in spinal white matter. *Undersea Biomed Res*. 1991; 18: 361-71.
4 Shupak A, Melamed Y, Ramon Y, Bentur Y, Abramovich A, Kol S. Helium and oxygen treatment of severe air-diving-induced neurologic decompression sickness. *Arch Neurol*. 1997; 54: 305-11.
5 Mitchell SJ, Doolette DJ, Wacholz C, Vann RD, editors. *Management of mild or marginal decompression illness in remote locations – Workshop proceedings*. Washington, DC: Undersea and Hyperbaric Medical Society; 2005.
6 Trytko B, Mitchell S. Extreme survival: a deep technical diving accident. *SPUMS J*. 2005; 35: 23-7.
7 Mitchell SJ. Lidocaine in the treatment of decompression illness: a review of the literature. *Undersea Hyperb Med*. 2001; 28: 165-74.
8 Mitchell SJ, Pellett O, Gorman DF. Cerebral protection by lidocaine during cardiac operations. *Ann Thorac Surg*. 1999; 67: 1117-24.
9 Wang D, Wu X, Li J, Xiao F, Liu X, Meng M. The effect of lidocaine on early postoperative cognitive dysfunction after coronary bypass surgery. *Anesth Analg*. 2002; 95: 1134-41.
10 Moon RE, editor. *Adjunctive therapies for decompression illness: Proceedings 53rd workshop of the Undersea and Hyperbaric Medical Society*. Kensington MD: UHMS; 2003.
11 Bennett MH, Mitchell SJ, Dominguez A. Adjunctive treatment of decompression illness with a non-steroidal anti-inflammatory drug reduces compression requirement. *Undersea Hyperb Med*. 2003; 30: 195-205.
12 Dromsky DM, Weathersby PK, Fahlman A. Prophylactic high dose methylprednisolone fails to treat severe decompression sickness in swine. *Aviat Space Environ Med*. 2003; 74: 21-8.
13 Mollerlokken A, Berge VJ, Jorgensen A, Wisloff U, Brubakk AO. Effect of a short-acting NO donor on bubble formation from a saturation dive in pigs. *J Appl Physiol*. 2006; 101: 1541-5.
14 Dujic Z, Palada I, Valic Z, Duplancic D, Obad A, Wisloff U, Brubakk AO. Exogenous nitric oxide and bubble formation in divers. *Med Sci Sports Exerc*. 2006; 38: 1432-5.
15 Latson GW. Intravenous perfluorocarbon emulsions in the treatment of decompression sickness and arterial gas embolism: a review of evidence of therapeutic benefit. In: Moon RE, editor. *Adjunctive therapies for decompression illness: Proceedings 53rd workshop of the Undersea and Hyperbaric Medical Society*. Kensington MD: UHMS; 2003. p.138-44.
16 Dromsky DM, Spiess BD, Fahlman A. Treatment of decompression sickness in swine with intravenous perfluorocarbon emulsion. *Aviat Space Environ Med*. 2004; 75: 301-5.
17 Dainer H, Nelson J, Brass K, Montcalm-Smit E, Mahon R. Short oxygen prebreathing and intravenous perfluorocarbon emulsion reduces morbidity and mortality in a swine saturation model of decompression sickness. *J Appl Physiol*. 2007; 102: 1099-104.
18 Bennett MH, Lehm JP, Mitchell SJ, Wasiak J. Recompression and adjunctive therapy for decompression illness (Review). In: The Cochrane Library, Issue 2. Chichester: John Wiley & Sons, Ltd; 2007.

Simon J Mitchell, MB ChB, PhD, DipDHM, DipOccMed, is a consultant in diving and hyperbaric medicine, and a Fellow in the Department of Anaesthesiology, Auckland City Hospital, Auckland, New Zealand
Phone: *+64-(0)9-814-9999*
Phone (mobile): *+64-(0)27-414-1212*
Fax: *+64-(0)9-814-9982*
E-mail: *<dr.m@xtra.co.nz>*

The need for a 90-metres' sea water depth capability for science diving [Abstract, Findings and Recommendations]

Michael A Lang

The Ocean Action Plan calls for federal agencies to employ an ecosystem-based approach to studying and managing the marine environment. A majority of the marine ecosystem habitats of interest are located in waters of up to 120 metres' sea water (msw) depth, which roughly corresponds to the continental shelf and the photic zone. A trained scientific eye underwater provides research value and flexibility that unmanned systems do not.

Shallow-water coral reefs are well understood, as are the linkages between adjacent mangroves and seagrass beds and their contributions to the reef ecosystem. Akin to limiting a tropical rainforest biologist from climbing higher than 10 metres (thereby missing the majority of biodiversity that resides in the canopy), a scientific diver cannot effectively study the biodiversity and contributions of the deep reef to the shallow-reef system, due to technological and training limitations. Our understanding of the reef ecosystem, *in toto*, is, therefore, vastly impaired. Other examples of research priorities in this depth range that were mentioned during the Workshop are the study of the enhanced biodiversity associated with cold-water coral reefs; the archaeological investigation of submerged landscapes; and the examination of deep Lander performance closer to the actual depths of deployment by using deep diving techniques.[1]

The 2006 Advanced Scientific Diving Workshop, held at the Smithsonian Institution, Washington, DC, assessed the applicability of existing diving technologies for scientific divers to once again work at depths down to 300 feet sea water (fsw; 91 msw). Scuba diving conducted by scientists is an invaluable research tool, and Scripps Institution of Oceanography's first scientific diver was Chinese biologist Cheng Kwai Tseng, who in 1944 used Japanese surface-supplied abalone gear to collect algae off San Diego.

When Scripps organised its scientific diving programme in 1951, the maximum depth certification for open-circuit, compressed air scuba was 300 fsw (91 msw), based on the US Navy's maximum PO_2 limit of 2.0 ATA (202.6 kPa) at the time. Safety concerns have gradually eroded this depth limit to what has become a 190 fsw (60 msw) operational compressed-air window for scientific diving, as published by the Department of Labor (OSHA) in 1982 and 1985 (29 CFR 1910). OSHA does not regulate the scientific diving community with regard to technology, which provides us with the operational flexibility to employ mixed gases (through surface supply and rebreathers) and underwater habitats in our research methodology to meet the US national marine science needs. Reliable commercial diving technology exists to reach these depths, but is not routinely employed in the scientific community.

What would it take to train a competent scientific diver in surface-supplied, mixed-gas diving, where the dive, gas mix, depths, bottom times, voice communication, and decompression are controlled from the surface? Would the limitations of diving on a hose under these constraints outweigh the advantages of immediate access to 90 msw? Attempts to introduce rebreathers into mainstream scientific diving programmes have met with inertia and significant safety concerns due to issues of reliability, availability, time investment in training, and proficiency requirements.

The Workshop focus was, therefore, not on rebreathers *per se*, as they have received much attention through numerous venues over the past 15 years and should continue to evolve on a parallel track. Rather, the focus was on enabling an effective, robust, scientific diving capability to conduct research between 60 and 90 msw by evaluating a re-expansion of the scientific diving envelope through mixed-gas and surface-supply techniques.

Findings

For sub-saturation diving exposures:

- There is a national need for scientific divers to perform research at depths beyond the 190 fsw compressed air scuba limit.
- [*Closed-circuit rebreathers*] CCRs and open-circuit trimix are currently being used in the scientific community.
- Properly controlled mixed-gas surface-supplied diving offers a reduced-risk method to conduct such dives.
- Some marine science objectives may not be met by surface-supplied diving.
- Surface-supplied/supported CCRs and [*semi-closed rebreathers*] SCRs warrant further consideration.
- Scientific diving beyond 190 fsw will require increased funding allocations.
- There are increased decompression sickness (DCS) risks associated with deep mixed-gas dives.
- Mixed-gas diving requires adequate thermal protection.

Recommendations

- A phased programme using existing assets should be initiated, starting with training exposure of scientists to standard air surface-supplied diving.
- Appropriate operational and emergency response methods, including consideration of on-site chamber availability, need to be incorporated to mitigate the increased DCS risks.
- Existing military and commercial decompression procedures are acceptable; consideration should be given to the development of new decompression procedures to better fit the scientific diving mission.
- Mixed-gas diver selection, training and proficiency requirements are necessarily more stringent than for air diving.

Reference

1 Lang MA, Smith NE, editors. *Proceedings of the Advanced Scientific Diving Workshop*. Washington, DC: Smithsonian Institution; 2006.

Michael A Lang, BSc, is the Director of the Smithsonian Marine Science Network and Scientific Diving Program. He is a previous Guest Speaker of the Society.

Address for correspondence:
Smithsonian Institution
Office of the Under Secretary for Science
PO Box 37012 - MRC 415
Washington DC, 20013-7012, USA
E-mail: *<Langm@si.edu>*

Parts of the Proceedings of the 2006 Workshop are reproduced here with kind permission.
The full meeting proceedings are available in pdf format at <www.si.edu/dive>.
Hard copies are available through <www.aaus.org>.

Key words
Scientific diving, deep diving, meetings, abstract

Under-ice research: results of the International Polar Diving Workshop [Abstract]

Michael A Lang

Abstract

Approximately four decades ago, scientists were first able to enter the undersea polar environment to make biological observations for a nominal period of time. Since those first ice dives in wetsuits without buoyancy compensators and double-hose regulators without submersible pressure gauges, technology has advanced. Today's scientific ice divers have the potential of extending their observational and experimental depths and times to limits never before available. Novel ice diving techniques have expanded the working envelope based on scientific need to include use of dive computers, oxygen-enriched air, rebreather units, blue-water diving, and drysuit systems. With the advent of new technology, greater scientific productivity is achieved while maintaining the scientific diving community's exemplary safety record. The basis for this diving safety research project is the 1991 Polar Diving Workshop (Lang and Stewart, editors, 1992, available online at <www.si.edu/dive>), supported by the National Science Foundation, Smithsonian Institution, and the American Academy of Underwater Sciences. Fifteen years of experience later we confront the need to re-evaluate and update those 22 polar diving recommendations through the combined international, interdisciplinary expertise of participating diving scientists, manufacturers of drysuits and thermal protection, physiologists and decompression experts, and diving safety officers. In preparation for the International Polar Year (March 2008–2009), an increased level of attention will be focused on the Arctic and Antarctic, and this project constitutes a contribution from the international polar scientific diving community.

Michael A Lang, BSc, is the Director of the Smithsonian Marine Science Network and Scientific Diving Program.
Smithsonian Institution, PO Box 37012-MRC 415
Washington DC, 20013-7012, USA
E-mail: *<Langm@si.edu>*

The Proceedings of the Workshop are in preparation.

Key words
Antarctica, ice, operations - diving, logistics, safety, diving research, abstract

Decompression safety in recreational diving professionals using self-reported diving exposure and health status: a work-in-progress report [Abstract]

Greg van der Hulst

Abstract

The Poor Knights Islands, Northland, is the busiest recreational diving location in New Zealand. As a result, the recreational diving instructors and dive guides who work there are required to perform extensive, repetitive and multi-day diving. Many of these divers utilise digital dive computers to manage their decompression requirements. Most generically available decompression models originate from the military and have not been proven reliable for the typical profiles conducted by recreational diving instructors and guides. The recent development of a scoring system for the self-assessment of health status after diving has been shown to be a useful measure of diving outcome with respect to decompression illness in tuna farm divers, and in a small group of Australian recreational cave divers.[1,2] This tool has not been used with occupational divers in the recreational diving industry. The aims of this study are to describe the practices of recreational diving instructors and dive guides using down-loadable miniature depth-time recorders, and to review these practices against existing decompression models. In so doing, we aim to evaluate the Diver Health Score (DHS) for collecting self-reported field decompression data in a group of occupational divers in the recreational diving industry, with the hypothesis that DHS health status is indicative of decompression stress.

References

1 Doolette DJ, Gorman DF. Evaluation of decompression safety in an occupational diving group using self reported diving exposure and health status. *Occup Environ Med*. 2003; 60: 418-22.
2 Doolette D. Decompression practice and health outcome during a technical diving project. *SPUMS J*. 2004; 34: 189-95.

Greg van der Hulst, BSc, MB, BS, is a registrar in the Emergency Department, Whangarei Base Hospital, Northland, New Zealand
E-mail: *<gvdh@slingshot.co.nz>*

Key words
Health surveillance, occupational diving, recreational diving, abstract

Hawaiian Deep Tables: historical development and usage over 20 years [Abstract]

Richard Smerz

Abstract

Recompression therapy utilising oxygen is the cornerstone of treatment for decompression illnesses. While there is no debate regarding the use of oxygen vis-à-vis air in treatment, the question as to the optimal treatment depth required to obtain maximal benefit remains controversial. The US Navy oxygen treatment tables are the predominant therapeutic interventions employed worldwide. In the 1970s, Dr EL Beckman observed that recreational divers in Hawaii treated on US Navy tables achieved complete recovery in only 59% of cases (48% of serious cases). Similar observations were noted by other investigators.[1,2]

Based upon bubble dissolution studies undertaken with Drs David Yount and Thomas Kunkle, Beckman and Kunkle demonstrated that the time required to dissolve bubbles with a given overpressure was directly proportional to the size of the bubble, and bubbles grew to a size of 1 mm in diameter in about 5 hours. An overpressure of 283 kPa (18 msw) required 80 minutes to dissolve bubbles whereas at 774 kPa (66.6 msw), 17 minutes was needed.[3] A combination of maximal pressurisation and optimal PO_2 seemed the best solution and led to the development of the "Hawaiian Deep Tables". Initially tested in animals, use of the tables in humans began in 1983 and resulted in empirically better outcomes. A formal report addressing their efficacy and outcomes was published in 2005.[4]

The HTC tables achieved complete functional recovery in 92.9% of all cases reviewed (N = 889) and 76.4% of serious cases (N = 250). Ninety per cent of all cases had been treated using a deep table either singly or in combination. Complications associated with use of these tables were low. Statistics reported by DAN for US cases have steadily shown that only 70–75% of cases achieved full recovery. Eighty per cent of those cases had been treated on US Navy tables. The Hawaiian Deep Tables resulted in 20% better outcomes over that same period of time.

References

1 Erde A, Edmonds C. Decompression sickness. A clinical series. *J Occup Med*. 1975; 17: 324-8.
2 Davis JC. Treatment of decompression accidents among sport scuba divers with delay between onset and compression. In: Davis JC, editor. *Treatment of serious decompression sickness and arterial gas embolism. UMS Workshop Rep. No.34*. Bethesda: Undersea Medical Society; 1979.
3 Beckman EL. Treatment of decompression sickness based on bubble dissolution physics. In: *The 2nd Japan working divers symposium*. Tokyo: Shudan-Hojin-Kaishu Gijitsu-Kyokai; 1980. p. 259-68.
4 Smerz RW, Overlock RK, Nakayama H. Hawaiian deep treatments: efficacy and outcomes, 1983-2003. *Undersea Hyperb Med*. 2005; 32: 363-73.

Richard Smerz is Medical Director of the Hyperbaric Treatment Center, University of Hawaii John A Burns School of Medicine, Honolulu, Hawaii
E-mail: *<rsmerz@htchawaii.com>*

Key words
Decompression sickness, decompression illness, scuba accidents, treatment, hyperbaric oxygen therapy, abstract

Hyperbaric oxygen therapy in cyclophosphamide-induced acute haemorrhagic cystitis: report of six cases [Abstract]

Michael Davis, Christopher Sames and Heather Macdonald

Abstract

Cyclophosphamide-induced haemorrhagic cystitis (CHC) occurs in 2–40% of patients. This is due to a toxic metabolite, acreolein, excreted in the urine. Intravenous Mesna in high doses may be used for prophylaxis, but treatments such as alum, prostaglandin F2 or formalin bladder instillations are often painful, have low success rates and have the potential for toxicity. Total cystectomy carries an important morbidity and mortality.

There are only a few isolated case reports of hyperbaric oxygen (HBO) used for treatment of CHC. Six cases are presented here. These range from an 82-year-old male with chronic myeloma to a 15-year-old female with antiphospholipid syndrome, secondary SLE and bilateral renal vein thromboses on anticoagulation. All six patients had grade four haemorrhagic cystitis (massive haematuria requiring instrumentation for clot evacuation and/or causing urinary obstruction) requiring major blood transfusion, in one case 35 units of resuspended red cells.

The patients received 20–38 daily HBO treatments at 203 or 243 kPa. Four of the six had major risk factors for hyperbaric therapy, such as severe emphysema or a history of spontaneous pneumothoraces. Bleeding ceased in all

six patients during HBO. Four patients remained free of haematuria at latest follow up (six months to two years). One patient returned to her pre-cyclophosphamide state with intermittent mild haematuria associated with recurrent urinary tract infections and one patient relapsed at three months post-HBO.

With their complex underlying pathologies and severe CHC, these patients presented considerable management challenges for HBO. All six patients, having been referred following failed 'conventional' therapy over weeks or months, responded well to HBO.

Where it is available, HBO should be considered in all cases of grade three or four cyclophosphamide-induced haemorrhagic cystitis.

Drs Davis, Sames and Macdonald are the Medical Directors respectively of the Hyperbaric Medicine Unit, Christchurch Hospital, Christchurch, the Slark Hyperbaric Medicine Unit, RNZN Hospital, and Oxygen Therapy Limited, Auckland
Contact for correspondence:
E-mail: *<mike.davis@cdhb.govt.nz>*

Key words
Hyperbaric oxygen therapy, drugs, clinical toxicology, case reports, abstract

The diving doctor's diary

A case of unilateral facial swelling

Greg van der Hulst

Key words
Underwater medicine, scuba diving, treatment, decompression sickness, barotrauma, case reports

Abstract

(Van der Hulst G. A case of unilateral facial swelling. *Diving and Hyperbaric Medicine*. 2007; 37: 79-81.)
A case of recurrent unilateral facial swelling subsequent to diving in a fit, young, male recreational diver is presented. The right side of his upper lip has become swollen several times over a two-year period immediately following deep recreational dives. A definite diagnosis remains to be made.

Case report

Mr T is a regular diver with about 10 years' experience. His first dive of the day was to 36 metres' sea water (msw) for a total dive time of about 40 minutes, his computer profile staying well out of decompression. At the start of the safety stop on the anchor rope, the rope lifted up and Mr T found himself at the surface, thus not doing a safety stop, and the last four or five metres' ascent having been fairly quick.

Back on the boat, Mr T's face was noted to be swollen as though he had been to the dentist, or been bitten or punched (Figure 1), and this worsened over several hours. He said that he knew at about eight metres on the ascent that it was going to happen because of how his face felt. He suffered no pain, shortness of breath, paraesthesia, or numbness during or after his ascent. He did note a feeling of "gas going under the skin" in the affected area. The site of swelling did not contact any fitting or piece of equipment. His dive buddy reported that about ten hours later, the area was oozing a tiny amount of clear fluid.

Mr T is 37, in good general health, fit and active and on no medications. He had a "dodgy" dive about two years previously, when he came up much too fast from about 20 msw after a dive to 30 msw. Since doing a DAN oxygen providers course, he now thinks that he might have been 'bent' on that occasion, as he felt "pretty crook" the next morning. At the time, being bent did not cross his mind.

Over the previous two years or so he has had swelling of the right upper lip within minutes of surfacing on at least four occasions following deep dives. The swelling takes a couple of days to settle, and sometimes initially feels a bit "crinkly". Mr T has never experienced similar cutaneous eruptions anywhere else. Mr T knows in the final part of his ascent it is about to occur, but finds it difficult to clearly describe the sensation. He experiences this sensation only on the dives where he has developed the 'rash'. There is no associated pain in his face, teeth or sinuses. The dives in question have all been 20 msw or deeper, but have all been within his computer's no-stop limits. He has dived many times between these incidents and experienced no other symptoms.

Figure 1
Diver T soon after a dive to 36 metres' sea water

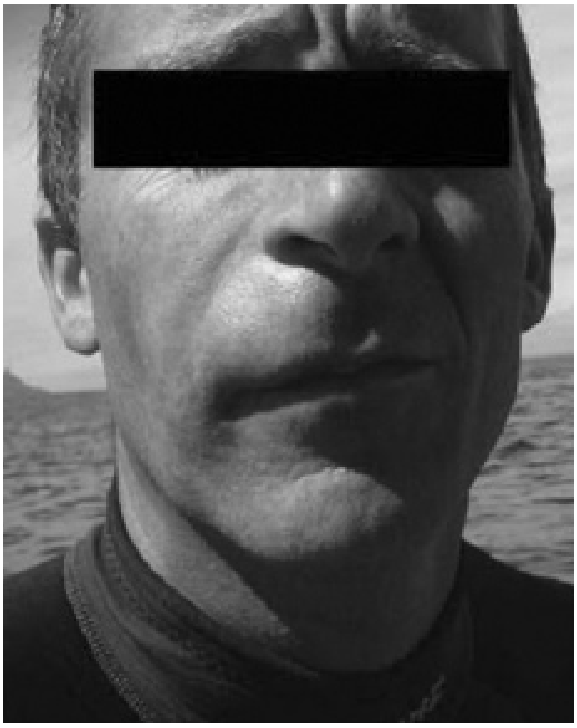


Figure 2
Diver T 40 hours after he surfaced from the dive

In summary, the pattern is always the same: his right upper lip swells quickly, can worsen over the first few hours, then resolves over a period of days, often weeping yellow, serous liquid in a manner similar to a minor burn.

On examination some 40 hours after he had surfaced from the dive in question, he was completely well, except for his erythematous, swollen right lower face (Figure 2). The swelling extended laterally to involve the tissue of his medial cheek. There appeared to be a dependent oedema forming a 'jowled' appearance as it tracked inferiorly past the mouth to involve the lateral part of his right chin. It was difficult to identify the exact tissue plane involved, but there was no swelling or discoloration of the upper gum, nor of the buccal mucosa. No skin crepitus was palpable over the affected area, although Mr T and his dive buddy both report this being present earlier. There was no subcutaneous air detectable in the neck.

Discussion

The cause of this diver's unilateral facial swelling has yet to be diagnosed. The trigger appears to be dives in the deeper part of the recreational diving range.

Differential diagnoses include:

1 Localised subcutaneous air: no confirmed subcutaneous air (via imaging) but history is suggestive. Rupture of a maxillary sinus or dental cavity into the soft tissues is a possible mechanism.
2 Cutaneous lymphatic obstruction secondary to decompression sickness (DCS): in the absence of associated, more generalised manifestations of DCS, this seems unlikely.
3 Marine envenomation: the consistent anatomical site makes this diagnosis unlikely.
4 Irritant dermatitis to unknown allergen: possible, but to which allergen?

This diver is awaiting a full dental assessment including dental X-rays. Intermittent tissue air may well be related to a tooth root cavity, though the lack of pain suggests otherwise. Sinus X-rays and a sinogram will be considered if the problem persists. Facial subcutaneous emphysema is rare, even in post-operative ENT and dental populations, and it is almost always associated with pneumomediastinum.[1] The isolated nature of this diver's symptoms makes associated chest pathology unlikely, leaving one lacking a plausible mechanism for introduction of air into facial soft tissues.

Cutaneous lymphatic obstruction secondary to DCS has been reported, though little is known about it.[2,3] It is assumed that soft-tissue swelling in these cases is secondary to lymphatic obstruction from bubbles. In the absence of other manifestations of DCS in this case, other diagnoses must first be ruled out.

Marine envenomation cannot be excluded despite the diver having four episodes of this 'rash' in the same location as stings are common around the lips in scuba divers. They may not be acutely painful and the marks they leave are not always initially visible.[4]

References

1 Ramchandar K, Carr MM. Spontaneous facial subcutaneous emphysema. *Ear Nose Throat J*. 2006; 85: 744-6.
2 Edmonds C, Thomas RL. Medical aspects of diving. 4. *Med J Aust*. 1972; 2: 1367-70.
3 Hamilton RW. Decompression sickness of the skin and lymphatic system. In: Nashimoto I, Lanphier EH, editors. *What is bends? Proceedings of the 43rd UHMS Workshop*. Bethesda, MD: Undersea and Hyperbaric Medical Society; 1991. p. 99-106.
4 Edmonds C, Lowry C, Pennefather J, Walker R, editors. *Diving and subaquatic medicine*, 4th ed. London: Arnold; 2002. p. 325-52.

Greg van der Hulst, BSurv, MBChB, is a registrar in the Emergency Department
Whangarei Base Hospital
Northland, New Zealand
***Phone:** +64-(0)9-438-1294*
***E-mail:** <gvdh@slingshot.co.nz>*

This case report was presented at the SPUMS 2007 ASM in Tutukaka, New Zealand.

Dr Carl Edmonds comments:

I have encountered three divers with swelling of the upper lip post-dive; one was an international phone consultation, but I personally saw the other two. I tracked down this poor photograph of the first (Figure 1). The presumptive diagnosis was lymphatic decompression sickness (DCS) of the face.

Figure 1
Unilateral upper lip swelling after scuba diving

All three divers had conducted moderately deep (> 30 msw) air dives, with bottom times close to the 'no-stop' limits, and surfaced without staging or safety stops. Decompression computer profiles were not available. Of the two seen by me, one responded to recompression therapy, but the other was not recompressed, due to the delay in presentation. The appearance of unilateral upper lip swelling lasted a couple of days in both divers. Both were 'repeat offenders' from similar dives; I have noticed this predictability in other cases of DCS lymphoedema. For the international diver, I suggested treatment with 100% oxygen (O_2), but was not informed of the result.

Why the upper lip? Perhaps the parotid gland is relevant in temporarily obstructing lymph flow.

> "*Lymphatic drainage from the upper lip is unilateral except for the midline. The lymphatics coalesce to form* [five] *primary trunks that mainly lead to the ipsilateral submandibular nodes, with some drainage also going to the periparotid lymph nodes. The submandibular and parotid lymph nodes are the first echelon nodes for the lips*."[1]

What treatment is most cost effective? In delayed cases or in remote areas where hyperbaric facilities are not available, I would still try 100% O_2 for 3–4 hours, but with reservations. It will remove all intra-vascular bubbles, but will it remove intra-lymphatic bubbles? Recompression therapy (100% O_2 for two hours at 203 kPa) is preferred. It is possible that normobaric O_2 may not be as effective as in other DCS presentations if the lymphatic drainage is totally blocked and so de-nitrogenated perfusion of the area may not be achieved. This is a unique situation, and warrants investigation.

Why did I not perform lymphangiograms? Because they were not easily done in the 1970s when these divers presented.

Reference

1 Jahan-Parwar B, Blackwell K. Lips and perioral region anatomy. *Medicine from WebMD*. <www.emedicine.com/ent/topic7.htm> (Last updated: 17 October, 2005; last accessed: 19 May, 2007).

Dr Carl Edmonds is the Foundation President and a Life Member of SPUMS.
***E-mail:** <puddle@bigpond.com.au>*

Trauma in the marine environment requiring surgery after diving

David Smart

Key words
Injury. accidents, infectious diseases, anaesthesia, safety, decompression sickness, pulmonary barotrauma, case reports

Abstract

(Smart D. Trauma in the marine environment requiring surgery after diving. *Diving and Hyperbaric Medicine*. 2007; 37: 82-4.)
The author reports a personal injury when after two dives he fell from the dive boat, sustaining a deep laceration to the arm. This required surgical repair under general anaesthesia approximately six hours later while the diver was still offgassing nitrogen. The report reviews the use of antibiotics for marine wounds, and the choice of anaesthesia for a diver when residual inert gas is present. Wounds sustained in the marine environment should be cleaned, irrigated, debrided and foreign material removed. Prophylactic antibiotics are recommended if injuries penetrate the dermis, and when the patient has immune compromise or other medical co-morbidities. A theoretical risk of nitrous oxide precipitating decompression illness is supported by basic scientific literature, and should be avoided after diving. The incidence of pneumothorax from parascalene block is low in modern anaesthesia.

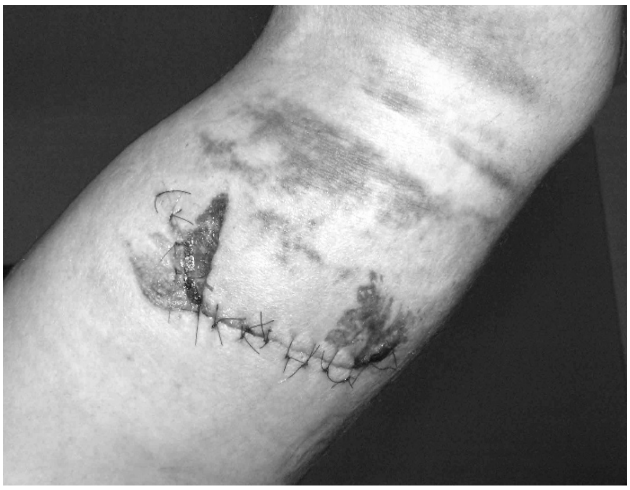
A previously healthy 45-year-old male undertook two dives on the third day of a multi-dive week at the 2006 SPUMS conference at Pacific Harbour in Fiji. A total of 20.5 hours had lapsed since completion of the previous day's diving. The boat was anchored on a site in Beqa lagoon, 20 km off Fiji's main island, Viti Levu. The entry time of the first dive was 0845 hours and it was undertaken to 26 metres' sea water (msw) as a multi-level dive for a total time in the water of 53 minutes. The dive finished in 10 msw and ascent was commenced at 48 minutes with 3 minutes spent at 5 msw before surfacing at 0938 hours. A second dive was commenced, after a surface interval of 84 minutes, at 1102 hours. The maximum depth of this dive was 15.7 msw with a multi-level profile; ascent was commenced from 8 metres at 1152 hours. Five minutes were spent at 5 msw, before surfacing at 1158 hours (in-water time 56 minutes).

Soon after completing the second dive, the diver whilst returning from the bow of the dive boat slipped from the port-side gunwale, lacerating the inner aspect of his upper left arm. He fell into the sea and swam to the rear of the boat to seek assistance from other divers. The laceration exposed biceps and brachialis muscles and created a distally based flap that was 10 cm across the base. It had been exposed to tropical sea water. Fortunately, there was no significant blood vessel or nerve trauma. A first-aid dressing was applied and he was evacuated to Suva Private Hospital for surgical assessment, arriving around 1345 hours. The injured diver declined a generous offer of surgical repair under local anaesthesia at the conference venue, despite the eminent qualifications of conference delegates.

Pethidine, tetanus vaccination and ceftriaxone were administered. Initial surgical assessment indicated that the wound was likely to need debridement and delayed primary closure because of the risk of tropical marine infection. At this point, the diver contacted Divers Alert Network South East Asia-Pacific (DAN SEAP) to seek assistance with return travel to Australia. Within 90 minutes DAN SEAP had authorised a return flight by commercial aircraft to Melbourne, if required.

Surgical debridement under general anaesthesia was undertaken at 1730 hours. The diver received fentanyl, midazolam and propofol anaesthesia, spontaneously breathing via a laryngeal mask. Fortunately, the wound was judged to be suitable for primary closure (Figure 1). Metronidazole was administered intravenously during the procedure and post-operatively, and further ceftriaxone the next morning. At 2045 hours, the diver was contacted by DAN SEAP, and the flight was cancelled as primary closure had been successful. After review by the surgeon, the diver was discharged on the following day, and commenced oral ciprofloxacin 750 mg b.d. The diver then returned to the

Figure 1
Laceration of left arm following suture



conference and travelled home with the conference group as planned. The wound has since healed uneventfully. Costs were all fully covered by the diver's travel insurance.

Discussion

This case illustrates two issues worthy of consideration for the treatment of a diver sustaining trauma in the marine environment.

INFECTION RISK AND ANTIBIOTIC MANAGEMENT

The marine environment carries a number of *Vibrio* species (*alginolyticus*, *damsela*, *fluvalis*, *holliisae*, *parahaemolyticus* and *vulnificus*), *Alteromonas* species (*espejiana*, *haloplaktis* and *macleodii*), *Pseudomonas marina*, *Mycobacterium marinum*, *Erysipelothrix rhusiopathiae* and *Delaya venustus*. Bacterial counts and species vary, depending on proximity to human habitation.[1] Faecal bacteria may contaminate sea water where untreated sewage is discharged into the sea, creating a higher risk of wound infection.[2]

There is a paucity of literature on the question of prophylactic antibiotics for marine wounds. A structured literature search using the headings *marine wound, marine trauma*, *antibiotic prophylaxis* or *treatment* identified 11 papers over 20 years; nine were case histories or small case series and two were reviews. A broadened search to include specific marine organisms identified a further 29 case reports (32 subjects, 18 of whom sustained marine wounds). Reports were biased towards wounds that were contaminated, and therefore complicated, resulting in the affected individual seeking hospital treatment. No prospective series of marine wounds were identified.

It is not possible to assess the incidence of contamination from marine injuries. It is likely that the majority of marine wounds are uncomplicated. Despite the focus in the literature on marine organisms, data from a larger series of contaminated wounds acquired in the tropics demonstrated that marine organisms were causative in less than 40% of cases.[1] The most common organisms were *Staphylococcus aureus*, pyogenic *Streptococcus* and enteric bacilli (Table 1). The largest series, reported in 1993, involved 93 soft-tissue infections caused by marine *Vibrio* species; 76 had definite sea water contact with wounds.[3] Nearly 60% of affected individuals had underlying conditions that compromised their immunity, for example: liver disease, diabetes, steroid use, and cancer. Factors affecting risk of infection included the degree of contamination of the marine environment, the depth of wound and tissue planes crossed, presence of foreign material, host defences and delay since injury. A recent review recommended "*trauma occurring in brackish or salt water should be treated with doxycycline or ceftazidime, or a fluoroquinolone*",[2] and also indicated the need for appropriate wound management.

An additional hazard of marine wounds is the potential for marine animal venoms (e.g., from stingrays) to cause delayed tissue necrosis. Isbister recommended that prophylactic antibiotics are typically not necessary for venomous marine fish spines unless there has been a residual foreign body or the patient is immunosuppressed.[4]

The level of evidence for recommended treatment of marine wounds is level 4 (case data) or level 5 (expert opinion/ consensus guidelines). The following general principles apply:

- All wounds should be cleaned, irrigated and foreign material removed.
- If a marine spine such as a stingray barb has penetrated skin, retained foreign material should be excluded by imaging (ultrasound or plain X-ray).
- Surgical exploration or excision should be undertaken, particularly when an underlying deep structure might be penetrated.
- Debridement of dead or devitalised tissue should occur, including the possibility of excising the wound track if the spine or barb was likely to have venom surrounding it.
- For minor wounds not penetrating the dermis, wound care only is required and antibiotics are not considered necessary.
- For injuries penetrating the dermis or when the patient is immune compromised, antibiotic prophylaxis is recommended. Single antibiotic therapy is recommended using doxycycline, co-trimoxazole, the fluoroquinolones or third-generation cephalosporins. When samples are taken from marine wounds for microbiological evaluation, the laboratory should be informed so they can perform specific cultures for marine organisms that may require varying salt concentrations and incubation temperatures for growth.[1–3]

Table 1
Sea-water contaminated injuries requiring hospital treatment in Northern Queensland during 1990–1991 (N = 41)[1]

Mechanism	**Number**
Coral cuts	25
Fish spines	2
Fish hooks	6
Boating mishap	3
Other injuries	5
Infections indentified	**Number**
Streptococcus pyogenes	19
Staphylococcus aureus	20
Enteric Bacilli	17
Marine Vibrios	12
Aeromonads	4

MANAGEMENT OF ANAESTHESIA SOON AFTER DIVING

This issue caused the author (patient) some concern. Despite offers of debridement/repair by SPUMS colleagues at the conference venue, the flap was quite large and would have involved high doses of local anaesthetic for infiltration anaesthesia. This may have been the only option if a properly constituted operating theatre with sterile equipment was not available.

Two other methods of anaesthesia had the potential to precipitate diving-related illness, or impact on diving in the future. Nitrous oxide (N_2O) is often still used as part of inhalation anaesthesia. A literature search using the headings *nitrous oxide*, *anaesthesia*, and *decompression sickness* identified 11 papers: one case report, one letter and nine basic science studies. Three laboratory studies showed N_2O has the potential to diffuse into pre-existing nitrogen bubbles, potentially precipitating decompression sickness (DCS).[5–7]

The case report recorded a six-day interval between the diving and onset of symptoms consistent with DCS, which appeared after anaesthesia for an elective ENT procedure. Symptom resolution occurred with recompression.[8] In the author's personal case the temporal relationship between diving and anaesthesia was much closer. According to US Navy, DCIEM, and dive computer tables, there were significant amounts of residual nitrogen creating a risk of diffusion of nitrous oxide into nitrogen micronuclei. The author's impassioned request to the anaesthetist to refrain from using N_2O was granted.

Regional anaesthesia using a parascalene brachial plexus block was also discussed. The risks to divers of this procedure stem from the potential to cause pneumothorax – a possible contra-indication to further diving. The author identified ten papers specifically examining the incidence of pneumothorax associated with this procedure; the two largest series were evaluated.[9,10] An incidence of 0.8% was reported in1,248 blocks performed without ultrasound or nerve stimulator, and no cases in a second series of 2,810 blocks using a nerve stimulator.[9,10] Neither a nerve stimulator nor an ultrasound was available for the procedure, so this method of anaesthesia was declined.

Conclusions

Cleansing, decontamination and debridement form the basis of marine wound management. Level 4/5 evidence suggests prophylactic antibiotics are required for injuries penetrating the dermis or in patients with immune compromise. Single antibiotic therapy is recommended: doxycycline, co-trimoxazole, fluoroquinolones or a third-generation cephalosporin. A theoretical risk exists of N_2O precipitating DCS and its use should be avoided after diving. The incidence of pneumothorax from parascalene block is low in modern anaesthesia.

Acknowledgements

The author acknowledges the support of conference colleagues, employees from Aquatrek, Fiji, Allways staff and Suva Private Hospital staff. It was reassuring that evacuation to an Australian health facility was an option with the support of DAN SEAP.

References

1 Ashdown L. Callanan V. Marine wound infections. In: Williamson JA, Fenner PJ, Burnett JW, Rivkin JF, editors. *Venomous and poisonous marine animals. A medical and biological handbook*. Sydney: University of New South Wales Press; 1996. p. 88-97.
2 Noonberg GE. Management of extremity trauma and related infections occurring in the aquatic environment. *J Am Acad Orthop Surg*. 2005; 13: 243-53.
3 Howard RJ, Bennett NT. Infections caused by halophilic marine *Vibrio* bacteria. *Ann Surg*. 1993; 217: 525-31.
4 Isbister GK. Venomous fish stings in northern Australia. *Am J Emerg Med*. 2001; 19: 561-5.
5 Hyldegaard O, Madsen J. Influence of heliox, oxygen and N_2O-O_2 breathing on bubbles in adipose tissue. *Undersea Biomed Res*. 1989; 16: 185-93.
6 Hyldegaard O, Moller M, Madsen J. Effect of He-O_2, O_2, N_2O-O_2 breathing on injected bubbles in spinal white matter. *Undersea Biomed Res*. 1991; 18: 361-71.
7 Butler BD, Conkin J, Luehr S. Pulmonary haemodynamics, extravascular lung water and residual gas bubbles following low dose venous gas embolism in dogs. *Aviat Space Environ Med*.1989; 60: 1178-82.
8 Acott CJ, Gorman DF. Decompression illness and nitrous oxide anaesthesia in a sport diver. *Anaesth Intens Care*.1992; 20: 249-50.
9 Thompson AM, Newman RJ, Semple JC. Brachial plexus anaesthesia for upper limb surgery: a review of eight years' experience. *J Hand Surg [Br]*. 1988; 13: 195-8.
10 Monzo Abad E, Baeza Gil C, Galindo Sanchez F, Hajro M, Gonzales Menendez A, Kim-Darov V. Parascalene brachial plexus block: experience of 10 years. *Rev Esp Anestesiol Reanim*. 2004; 51: 61-9.

Associate Professor David Smart, MB, BS, FACEM, MD, is the joint Medical Director of the Department of Diving and Hyperbaric Medicine, Royal Hobart Hospital
Hobart, Tasmania
Australia
Phone: *+61-(0)3-6222-8193*
E-mail: *<david.smart@dhhs.tas.gov.au>*

This case report was presented at the SPUMS 2007 ASM in Tutukaka, New Zealand.

The world as it is

British Sub-Aqua Club (BSAC) diving incidents report 2006

Compiled by Brian Cumming, diving safety and incidents advisor

<http://www.bsac.org/page/805/incident-report-2006.htm>

Summary of the 2006 report prepared by Colin Wilson

Over a number of years the British Sub-Aqua Club (BSAC) have recorded and collated an annual report on UK diving incidents, which they make available on the Internet.[1] The report is produced in the interests of informing, educating and highlighting common problems, on the basis that understanding these failures and mistakes helps to promote safer diving practice. They obtain details of UK sports diving incidents as best they can, but also record incidents involving BSAC members that occur around the world. These details are either reported directly by BSAC members or are taken from reports from the Coastguard, Royal National Lifeboat Institution and the press.[2,3]

There were fewer incidents in 2006 than in previous years, 379 in the various categories (440 in 2005).[1,4] These numbers have been relatively constant for the past eight years, but have doubled from the early 1990s. The highest number is in the decompression illness (DCI) category, amounting to 105 (110 in 2005), and similar to previous years. This is followed by ascent problems (99) in which DCI had not developed. Reported incidents are at their most frequent, understandably, in the summer months of June to August with another peak at Easter time. The dive depths, when recorded, are mainly in the range of 20–40 metres' sea water (msw), though 10 occurred at over 50 msw. BSAC continues to advise that no air dive should be deeper than 50 msw in appropriately trained and qualified divers. They also advise a 35 msw maximum in those trained to the Sports Diver level and an 80 msw maximum for mixed-gas diving for those holding an appropriate, recognised qualification.

Fatalities

Sadly there were 16 fatal incidents recorded in the UK during 2006[1] (average 17.7 for the last 10 years, peak 25 in 2004). A summary of these cases follows, though understandably cases may appear in more than one category:

- One case involved a diver who had a heart attack. This may have been the end result as the diver had been diving solo in a cave and was not found until 24 hours later.
- Three cases were, or became, negatively buoyant and sank, one of these being at the surface.
- Seven cases involved separation. In all these cases, this was not planned and in four cases the victims were found floating on the surface, conscious or semiconscious.
- Two cases were solo diving; one case was using a rebreather, the other was a cave diver.
- Three cases involved rebreathers.
- Three cases involved difficult water currents.
- Three cases involved divers with DCI. Two had suffered fatal pulmonary embolisms, with the other suffering a gas embolism. Two of these cases had uncontrolled ascents, but the other one had a normal dive.
- Two cases involved divers diving as a threesome.
- One case involved a dive to 66 msw, where the diver surfaced having missed all decompression stops.
- One case was swept out to sea from a causeway while conducting a shore dive.

Unfortunately in eight cases (50%) there was insufficient information available to be clear about the exact chain of events. There appears to be an over-representation of deep diving and those using rebreathers compared with the number of these dives that are carried out.

Decompression illness

In this group, 105 incidents were recorded, but some were multiple cases amounting to a total of 112 divers. This is a marked decline from the peak of 173 cases in 2002 and seems to fit with the experience of others worldwide. These DCI cases have returned to numbers similar to the 1990s. Causal factors in the 2006 cases follow (some cases involve more than one cause):

- 35 cases deeper than 30 msw (31%)
- 30 cases with rapid ascents (27%)
- 27 cases following repetitive diving (24%)
- 15 cases with missed decompression stops (13%)

Cases of abnormal ascents (rapid ascent and/or missed stops) appear to have increased over the years.

Ascent-related incidents

There are 99 recorded cases of ascent-related incidents that did not result in DCI. Although this was the highest number ever recorded, it was only slightly up from 2005 (98 cases).[1,4] Rapid ascent was noted in 88 cases and missed decompression stops in 32 cases; some incidents involved both. Causal factors were:

- 18 cases of drysuit or BCD problems
- 16 cases of delayed surface marker buoy (SMB), mask or fin problems
- 12 cases with regulator free flows
- 10 divers ran out of air
- 6 cases had weight-related issues
- 2 divers were in training

However, in 53% of cases a simple loss of buoyancy control seemed to have been the only cause. As in the past, poor training and lack of skills are the only explanations. More attention to this is required by divers and diving instructors. Each case report varies in length and detail, depending on its source. As a number of them provide interesting reading, I have included the following extracts as illustrations.

From the fatalities section:

Case 1

"A diver and her instructor entered the water from the shore. They dived to a maximum depth of 4 msw. The diver developed a problem and ascended to the surface. The instructor tried to assist her but she sank again without her mouthpiece in place. The instructor had experienced a free flow and was unable to re-descend as he now had no air. The alarm was raised. The instructor was recovered into a boat and others found and recovered the missing diver. Resuscitation [was] *applied and the casualty was taken by ambulance to hospital where she was pronounced dead."*

Case 2

"*Two divers conducted a dive on a wreck to a maximum depth of 66 msw. After 31 min they made an ascent to 50 msw. At this point one of the pair appeared to develop a problem. He then deployed a delayed SMB and commenced a rapid ascent to the surface. His buddy tried to assist during part of the ascent then re-descended, from an intermediate depth, to complete his stops. The diver who made the rapid ascent arrived at the surface missing 90 min of decompression stops. He was recovered into the boat and the Coastguard was alerted. The diver was suffering from chest pains accompanied by shallow breathing. He was airlifted to hospital but pronounced dead at the landing site. The diver had been using trimix. The cause of death was a pulmonary embolism*."

From the decompression illness section:

Case 1

"Two divers conducted a 50 min dive to 45 msw with an 8 min stop at 3 msw. Three hours 58 min later they dived to 33 msw for 50 min with a 13 min stop at 3 msw. Both dives included stops that were longer than required by their computers. Once back on the boat, one of the pair reported that he had twisted his right hip. This diver had a history of slight arthritic pain in this joint. Five minutes later he reported that the pain was spreading down his right thigh. He lay down and was placed on oxygen. His right thigh then developed numbness and tingling. The Coastguard was alerted and the boat returned to the shore. The diver was given fluids. He was then airlifted to a recompression facility where he received treatment for DCI."

Case 2

"*A diver conducted a series of dives over a three-day period. His maximum depth was 42 msw and he used both air and nitrox. He then took two days without dives. On the next day he dived to 36 msw for a total of 62 min with the following stops: 2 min at 15 msw, 3 min at 12 msw, 4 min at 9 msw, 6 min at 6 msw and 9 min at 3 msw. His dive gas was nitrox 22* [Editor's note: one wonders if this is an error of reporting]. *Three hours later he conducted a drift dive to 15 msw using nitrox 33. His dive duration was 60 min including a safety stop. Twenty hours 30 min later he boarded a plane for a short flight. On arrival at the destination airport he felt unwell with nausea, dizziness, numbness in his right arm, tingling in his face and right arm and hand, weakness in his right hand and pain in his right arm and elbow. He sought advice from a recompression facility and was recommended to make his way to them. He was taken by ambulance, on oxygen, to the recompression facility where he received a series of three sessions of treatment for a neurological DCI*."

Finally a miscellaneous incident demonstrates pranks that may have gone too far:

"*A number of live-aboard dive boats were moored up together. During the night, divers from one of the boats poured hot chilli sauce into a number of divers' regulators on one of the other boats. The sauce was found the following morning prior to any diving and attempts were made to clean it out. Some of the regulators subsequently required new mouthpieces. The divers expressed concerns about the effects that this would have had if the sauce were to have been inhaled at depth*."

The report is again a full and comprehensive collation of the year's incidents with a sensible analysis. Brian Cumming and the BSAC have now collected a considerable amount of data over a number of years. The continuation of this activity is important and I applaud their work. For those wishing to access previous reports from 1989 to 2003, they can be found at: <http://www.chime.ucl.ac.uk/~rmhiajp/diving/ndcrephf.htm>.

References

1 Cumming B. *NDC Diving Incidents Report 2006*. British Sub-Aqua Club. <http://www.bsac.org/page/805/incident-report-2006.htm> (last accessed 5 July 2007).
2 Her Majesty's Coastguard. <http://www.mcga.gov.uk/c4mca/mcga-newsroom/mcga-press-releases.htm> (last accessed 25 June 2007).
3 Royal National Lifeboat Institution RNLI. <http://www.rnli.org.uk/> (last accessed 25 June 2007).
4 Wilson CM. British Sub-Aqua Club (BSAC) diving incidents report 2005. *Diving and Hyperbaric Medicine.* 2006; 36: 99-100.

Colin M Wilson, MB, ChB, FRCA, is Medical Director, Dunstaffnage Hyperbaric Unit, Scottish Association for Marine Science, Dunbeg, Oban, Argyll PA37 1QA, Scotland
E-mail: *<colinwilson@tiscali.co.uk>*

Key words
Recreational diving, accidents, diving deaths, abstracts

Development of recompression chamber facilities in Malaysia

Rozali Ahmad, Mohd Zin Bidin, Sherina Mohd Sidik, Khairuddin Husain and Sulaiman Abdullah

Key words
Hyperbaric facilities, hyperbaric oxygen therapy, decompression sickness, general interest

Abstract

(Rozali A, Mohd Zin B, Sherina MS, Khairuddin H, Sulaiman A. *Diving and Hyperbaric Medicine*. 2007; 37: 87-9.)
Development of recompression chamber facilities in Malaysia began hand-in-hand with the development of the Royal Malaysian Navy (RMN). The period from 1960 to 1990 saw the installation of several facilities to treat diving emergencies among military divers. With the establishment of the Institute of Underwater and Hyperbaric Medicine at the Armed Forces Hospital in Lumut, RMN Naval Base, this first hospital-based recompression chamber facility has introduced hyperbaric oxygen therapy (HBOT) not only to treat diving-related illnesses but also non-healing diabetic ulcers, carbon monoxide poisoning, gas gangrene, chronic osteomyelitis and crush injuries. In the early 2000s, continuing development saw a university hospital and several private health centres setting up recompression chamber facilities in their premises. The growth of recreational and commercial diving activities together with the expansion of the RMN will have a positive effect on the development of hyperbaric medicine in Malaysia. This paper discusses the development of recompression chamber facilities in Malaysia, giving a brief historical overview and some thoughts on the future direction of HBOT in Malaysia.

Historical overview

Development of recompression chamber facilities in Malaysia began in the early 1960s with the establishment of the Royal Malaysian Naval (RMN) base in Woodlands, Singapore. There was a multiplace recompression chamber facility used by the British Royal Navy before they left this country and it was used to treat diving emergencies among RMN divers. The Malaysian Armed Forces (MAF) also started to send diving and medical officers overseas to be trained in diving, diving medicine and chamber operations in Australia, New Zealand and the USA.[1]

In 1978, the Institute of Underwater Medicine (IUM) was established in the Malaysian Army Special Training Forces in Sg Udang Camp, Melaka. The IUM acquired a multiplace recompression chamber from the Australian government as part of bilateral military cooperation between the two countries. It became the referral centre for the treatment of diving emergencies among the Special Forces (Commando).[2,3]

In 1979, the RMN installed its first multiplace recompression chamber on board a hydrographic naval vessel. This was followed by the installation of another on board a class support ship. In 1982, the RMN installed several recompression chambers (multiplace and monoplace) at the naval bases in Lumut, Kuantan and Labuan. Later, in 1985, monoplace recompression chambers were installed in each of the RMN's four mine-hunter vessels. These on-board facilities were used to support military diving operations, to treat diving emergencies and to transport injured divers to the nearest hospital.[1] During the period from the 1960s to 1990 recompression therapy was limited to the treatment of diving emergencies among military divers such as decompression illness (DCI) and barotrauma. Prior to 1996, diving emergencies among civilian divers in Malaysia were also treated at military recompression chamber facilities.[4]

Current developments

MILITARY RECOMPRESSION CHAMBER FACILITIES

The first hospital-based recompression facility was established at the Armed Forces Hospital in Lumut in 1996 (Figure 1). This facility is equipped with a three-compartment multiplace recompression chamber and is manned by two diving physicians and twenty-nine paramedics trained in underwater medicine. Although its main aim is to support military diving operations, this facility also treats diving emergencies in commercial and recreational divers.[5] From 1996 to 2004, 173 injured divers, mainly suffering decompression illness (DCI), were treated. The majority of cases came from commercial diving activities (particularly underwater logging operations at several dams in peninsular Malaysia), followed by recreational and military diving.[6]

Realising the medical needs of the non-military diving community, in May 2000 this facility collaborated with the Divers Alert Network (DAN), to establish a 24-hour emergency hotline. Enquiries are transferred to a diving physician on call, who provides emergency advice and assistance in evacuation and subsequent recompression treatment.[4]

The facility was also upgraded to become the Institute of Underwater and Hyperbaric Medicine (IUHM) in 2002 and expanded the use of hyperbaric oxygen therapy (HBOT) to treat other clinical conditions such as non-healing diabetic foot ulcers, carbon monoxide poisoning, gas gangrene, chronic osteomyelitis and crush injuries.[5] Educational training programmes on dive safety and first aid have also been developed for the Malaysian diving community.[4]

Meanwhile, the RMN embarked on its expansion programme, transforming itself from a coastal brown-water navy into a blue-water navy with a fleet now ranging from corvettes to frigates and submarines. New naval bases have been built and more recompression chamber facilities made available. The diving school in Lumut has been upgraded, equipped with state-of-the-art diving equipment and commissioned as KD "Kapal DiRaja" Duyong in early 2005 (personal communication, AG Othman, August 2005). The RMN has also developed a new submarine naval base in Sepanggar Bay, Sabah (East Malaysia). The first Scorpene submarine will be delivered at the beginning of 2008 and is expected to be operational in 2009. This newest naval base has medical facilities that include a recompression chamber facility for training and treatment.[7]

CIVILIAN RECOMPRESSION CHAMBERS

At present, there are no recompression chambers in any of the Malaysian Ministry of Health (MOH) hospitals. However, the Malaysian Science University Hospital (HUSM) became the first university hospital in Malaysia to install recompression chamber facilities, with a monoplace recompression chamber in 2004, and treats mainly non-healing diabetic foot ulcers, post-radiotherapy tissue injury and radiation myelitis (personal communication, NAR Nik Hisamuddin, November 2005).

A few private medical centres have also set up recompression chambers in their premises. Currently registered are four private clinics and one private hospital. The first was set up in 2001 in Ipoh, followed by others in Kuala Lumpur.[8] The locations of existing recompression chambers in Peninsular Malaysia, Sabah and Sarawak are shown in Figure 2.

Future directions

The growth of recreational and commercial diving activities has brought about a need to expand recompression chamber facilities in Malaysia. With the expansion of the RMN and the arrival of the first submarine in 2008, the need for more recompression chamber facilities and trained manpower will increase. The scope of treatment has also expanded from treating just dysbaric diving diseases to the clinical management of ischaemias to improve tissue oxygenation, and is expected to expand further to the next level in the form of submarine medicine.

With increased awareness of HBOT among doctors and patients, it is expected to become a popular alternative or adjunctive modality of treatment in Malaysia. However, this will depend on the availability and accessibility of recompression chamber facilities in Malaysia as well as expertise in handling them. Cost is an important issue that can determine the development of recompression chamber facilities, where a considerable sum of money is needed to develop them as well as to maintain their operations. There is a need to network among the related agencies and institutions of higher learning to develop current knowledge into a well-recognised subspecialty.

Acknowledgements

We thank Colonel (Dr) Abd Halim Mohamed of the Institute of Underwater and Hyperbaric Medicine (IUHM), Captain

Figure 1
The three-compartment multiplace recompression chamber in the Institute of Underwater and Hyperbaric Medicine (IUHM) at Armed Forces Hospital in Lumut (source: IUHM)

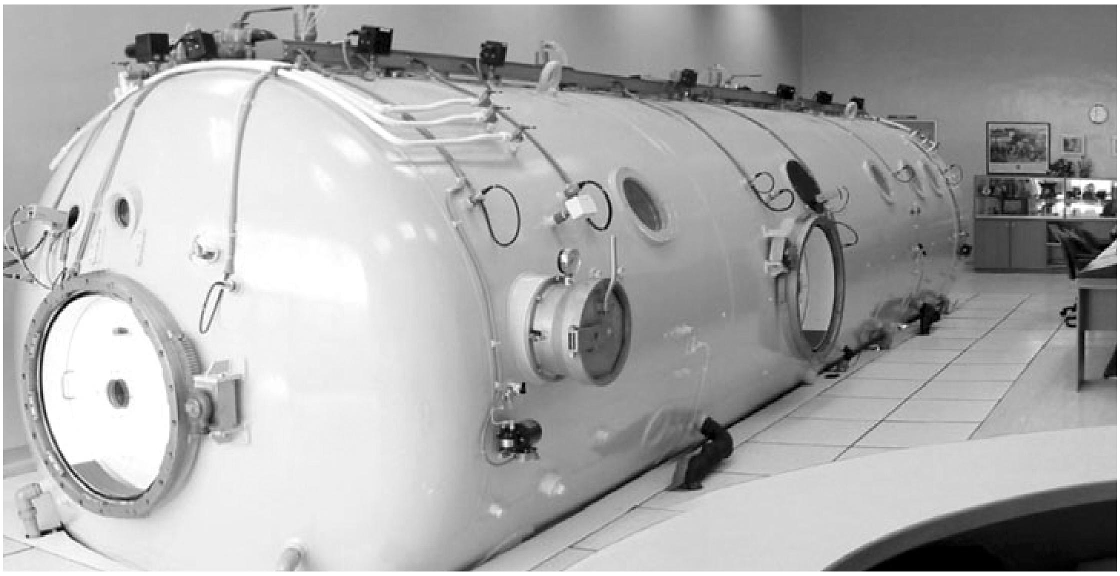


Figure 2
Recompression facilities (*) in Peninsular Malaysia, Sabah and Sarawak

Abd Ghani Othman of the Royal Malaysian Navy (RMN) and Dr Nik Hisamuddin Nik Abd Rahman of the Malaysian Science University Hospital (HUSM) for their assistance.

References

1 Rozali A, Rampal KG, Mohd Zin B, Sherina MS, Khairuddin H, Abd Halim M, Sulaiman A. Development of underwater and hyperbaric medicine in Malaysia. *Med J Malaysia*. 2006; 61: 558-61.
2 Mohd Zin B. The armed forces health services support system. In: Rampal KG, Noor Hassim I, editors. *Occupational safety and health in Malaysia*. Bandar Baru Bangi: NIOSH; 1996. p. 121-7.
3 Junaidi MT. *History of the Malaysian Medical & Dental Corp – 25th Anniversary*. Kuala Lumpur: Malaysian Medical & Dental Corps; 1992.
4 Abd Halim M. Underwater medicine in Malaysia. In: Malaysia's Health 2001. *Technical report of the Director-General of Health*. Kuala Lumpur: Ministry of Health Malaysia; 2001. p. 255-63.
5 Angkatan Tentera Malaysia. *35 Tahun Kor Kesihatan DiRaja*. Kuala Lumpur: Perkhidmatan Kesihatan Angkatan Tentera; 2003. p. 108-9.
6 Rozali A, Khairuddin H, Mohd Zin B, Sherina MS, Yaakob K, Sulaiman A. Diving-related illnesses treated at the Armed Forces Hospital Lumut. *Journal of Occupational Safety and Health*. In press, 2007.
7 Wikipedia, the free encyclopedia. Royal Malaysian Navy (online) <http://en.wikipedia.org/wiki/Royal_Malaysian_Navy> (last accessed 4 September 2005).
8 Scuba.com. Malaysian hyperbaric facilities (online): <http://www.scuba.com/divmalay.htm> (last accessed 24 August 2005).

Rozali Ahmad MComm.Med(Occup Health), Mohd Zin Bidin MPH, Health Services Division, Malaysian Armed Forces
Sherina Mohd Sidik MMed (Fam Med), Department of Community Health, Faculty of Medicine and Health Science, Universiti Putra Malaysia (UPM)
Khairuddin Husain MMed (Occup Med), Armed Forces Health Training Institute, Malaysian Armed Forces
Sulaiman Abdullah MPH, Health Services Division, Malaysian Armed Forces

Address for correspondence:
Dr Rozali Ahmad
No 16, Jalan Budiman 4/1
Taman Putra Budiman
43200 Seri Kembangan
Selangor Darul Ehsan
Malaysia
Phone: *+60-12-296-0365*
E-mail: *<rozaliahmad@yahoo.com>*

Now and then – tales from SUMU

John Pennefather

Key words
Autobiography, diving research, military diving, history, general interest

If this bores you, blame the Editor – he asked for a memoir of my time in the field, claiming that some might be interested. I think he is short of material or a spy for my pay master, the Royal Australian Navy (RAN), who wants to know what the old fool does.

My main academic interest at university was animal climate physiology. The postgraduate part of this had me involved with oxygen sensors in an attempt to measure the oxygen consumption of grazing sheep. A rural recession dried up the research funds and meant that there was small chance of work in this area. So, in an attempt to find a job, I looked for other areas where my experience could be used.

As part of this search, I developed the idea of a rebreathing set with gas analyser control of the oxygen concentration. I sent an outline of it, to "The RAN, Canberra". Eventually my letter reached someone called Edmonds, from the School of Underwater Medicine (SUMU). He said it was a good idea, but I was too late as the USN and Walter Stark were testing prototype sets that worked that way. He also said to come and have a chat if I was in Sydney and he would tell me more. We met, I laughed at his jokes, the possibility of a job was mentioned, and eventually I arrived at SUMU in 1972 as the new scientific officer. If I last till my proposed retirement date, it works out at over 36 years in a job that I might do for nothing, if I were rich and needed a hobby, because it has generally been fun.

I count all the 20 Officers-in-Charge, and nearly all the other staff I worked with, as friends. Of these, Carl Edmonds and Des Gorman, both ex-presidents of SPUMS and frequent writers in this journal, will be better known to readers than most of the others.

Carl was hoping that we could develop a telemetry system to monitor divers and diving sets. It never reached the stage of being a reliable tool because of waterproofing problems and the difficulties in transducer design for conditions of fluctuating temperature and pressure. When working with Carl, you soon get involved in several tasks. One day he announced that we were going to rewrite and expand the RAN diving medical guidance notes. Chris Lowry and I said "Yes, Boss". When we had finished, the Navy showed no interest in having such a comprehensive guide, and the first edition of *Diving and subaquatic medicine* came out as a private venture. Under the modern rules, the Navy would censor it and take any profits. I cannot see them being happy with a book that is dedicated to a dead dog and cites *Penthouse* as a reference.

Carl was also interested in diving audiology, so Frank Blackwood and I spent time trying to develop a device to measure the pressure a subject needed to exert to perform the Valsalva manoeuvre. Eventually we reverted to impedance audiometry as we could not get any of the published designs to work reliably.

This was one of several occasions where I spent months on a method and found that it did not work for me. Another is the use of jelly to simulate tissue gas uptake and bubble formation. This has been reported in the literature several times, but I tried for months and never got repeatable results. Are some scientists like chefs, who omit a key ingredient from a recipe to preserve their advantage? I believe "typical results are shown in Figure 1", often means "the best result we ever got is shown in Figure 1". I am a modest chap, but not modest enough to accept the other explanation (that I am not very smart).

In about 1975, we were asked to develop a new oxygen diving set with longer endurance than those available on the market. We got to working prototypes several times. But each time the officer who tasked us to do the work had moved on and his replacement had different ideas on what was needed. So, we kept changing it and eventually people got sick of waiting and a German set, with lower endurance and lacking other features the Navy wanted, was purchased. I still regret this, as there was a chance for an Australian firm to do well in diving gear production.

Late one morning during a trial dive an admiral came past, so the diver was called up to show off the new set. The diver took the mouthpiece out and promptly threw up all over the great man's shoes. The admiral assumed this was caused by the set and was not impressed. My subsequent questioning revealed that the diver's morning tea had been two pies and a milkshake – convincing proof of the need for the rule on eating before diving.

Another task from that time came from a statement from the Officer-in-Charge of the RAN Diving School. He thought his trainees were not getting enough food, and their falling body weights tended to support this belief. The Navy rules would not allow more money for food without proof, so we studied a diving course in detail. We found that during intensive training, they were about 4000 kJoules per day short of balance. The divers said thanks, that result would allow them to buy more food. I said a food shortage was only one of the possible conclusions; they were getting five hours of sleep and about 15-minute meal breaks, so possibly they were too tired or too rushed to eat.

We repeated the study, with agreement that they could have more time for sleep and longer meal breaks. This time they were about 2000 kJoules short, except for one man who ate about half a loaf of bread each day with butter and jam. The outcome was that they got more food and sleep, and the students were better trained. Another interesting and unexpected outcome was that diving time per day also increased markedly. I think the old way left people too tired to work well.

When Des Gorman came along we developed a greater interest in gas embolism, because it was the topic of his PhD thesis. His experiments were conducted on rabbits and the rabbit population probably thought there was a new disease that eliminated any animal that strayed into Mosman.

Des had developed this interest through being involved with submarines and submarine escape with the Royal Navy (RN). As a result, we also became a centre of information on submarine escape, rescue and atmosphere control. After Des and others who had started us in the field moved on, it became one of my areas of interest. This has been fun as I have gone to Canada, the UK, USA, Sweden, Germany and Malaysia for submarine-related conferences. At most of these I presented papers (Figure 1).

My early work was on emergency scrubbing methods that did not need a ship's power. The first of these was a man pedalling on a stationary bike and driving a pump that used Frank Blackwood's wife's old vacuum cleaner as an air pump. That system could scrub air for a complete crew, but was hard work, which might have been difficult for a survivor on short rations. My other proposed system was to have a portion of the crew exhaling through a carbon dioxide-removing canister. They inhaled the CO_2 put into the atmosphere by the rest of the crew and scrubbed it for them, about half the crew needed to be using canisters. Later I became interested in the limits for when to escape; for example, the gas limits for situations where one had to choose between high risks of gas toxicity in the boat or of drowning on the surface.

My standard rule to make travel worthwhile is to take at least a week of leave with the trip, to get over the jetlag and reduce the risk of sleeping during the less interesting papers. I nearly caused a diplomatic incident at a Swedish conference. The speakers were sitting in order along the front row. The man who was to speak two after me was accompanied by a woman who did not shut up during any of the papers. If an opportunity had been available, I would have suggested that she gossip outside. Fortunately the speaker she was talking to got his turn before I got a chance to mouth on. He was the designer of the *Kursk* and she was his simultaneous translator!

I have several regrets – the first is the lost opportunity in possibly providing a better treatment for decompression sickness (DCS). Carl was/is a strong believer in choosing the treatment pressure that was needed for satisfactory relief, rather than a depth in a table. He combined it with a continuous bleed pressure reduction, minimum or no air breathing breaks, and aggressive use of IV fluids. His treatments were conducted in a very noisy chamber; this often had a strong aversive power, so the sufferer may have denied any remaining symptoms, and improved his results.

The next few medical officers (MOs) tended to follow Carl's line. Then it was suggested that there was no comparison trial between this treatment and the standard ones to prove that the Edmonds approach was better, so we should be using the free world standard, USN Table 6/RN 62, as this was widely accepted as "best practice". If you look at the first papers on those tables, they came into use with far less preliminary work than Carl's efforts. Also there is no logic in 18 metres rather than 10 or 15 metres, and a good case can be made for minimum or no air breaks.

A comparison trial would have been great, but was not contemplated at the time. I later considered a paper based on trying to match cases treated both ways, but decided that it was not reliable because some results may indicate only the variable bias of MOs toward reporting a good result. If you have spent $X,000 of the taxpayers' money, there is little incentive to say after the treatment that the clown (patient) was probably suffering a pulled leg muscle and an anxiety attack, not DCS, and you did not pick this up before you treated him. Also, some of the reports read: name, (rank and number, if from the RAN), date, suffering DCS, treated with Table N, discharged well, signed X; end of report. This is hardly enough clinical evidence to base any analysis on.

My next regret is the growth of regulations and regulatory bodies who take little account of the real world. Before the Canadian (DCIEM) tables came along, the RAN was using air decompression tables from the RN. With them, the incidence of decompression sickness was unacceptable in some dives. Our preferred option was to use a short, deep stop, within the tables, expecting that would improve their safety with little effort. The alternative offered was to spend several years in a trial that would have given numerous cases of DCS. We hoped that the bosses would take the deep stops option. But some giant brain took the proposal to mean that we really wanted to bend many divers. So they saddled us with an experimental diving ethics procedure, borrowed from the UK, which made no allowance for degrees of risk. It considered a dive with a real risk and a dive to verify that a procedure, like the deep stop, should be safer than normal, as equally risky experimental dives. The other loser was the taxpayer, as it combined experimental dives and deep dives together, for extra pay. For a while there was a rush to do any deep dive for the cash.

Now we have a medical ethics procedure that covers the whole defence area. I accept that in some areas it serves a vital need, for example in drug trials. But the paperwork tends to discourage small and interesting, harmless experiments. Also, the rules tend to require one to have some expertise to start work in an area. Under this process, Carl and Des would have found it difficult to start on the work they produced, as they started as beginners. Experts have to develop; they are not born "expertised". Also, often at the beginning, Carl had no clear idea of the answer to some of the problems he solved, so if he had submitted an ethics proposal, it would probably have been stamped: REJECTED. Reasons: no clear hypothesis, statistics lacking, shows little knowledge of the topic.

Both of them would now find their animal work difficult because of the animal protection rules. To do any animal work in New South Wales, the institution is now required to meet 14 pages of legislative rules. The rabbits that had the honour of being the subjects in the Gorman experiments came here in a standard cage, warm and dry, waited for a couple of hours nibbling some lettuce, and then were anaesthetised, and did not wake. I think they were better off than my neighbour's pet rabbits – they live outside, occasionally they get out and some have been eaten by dogs.

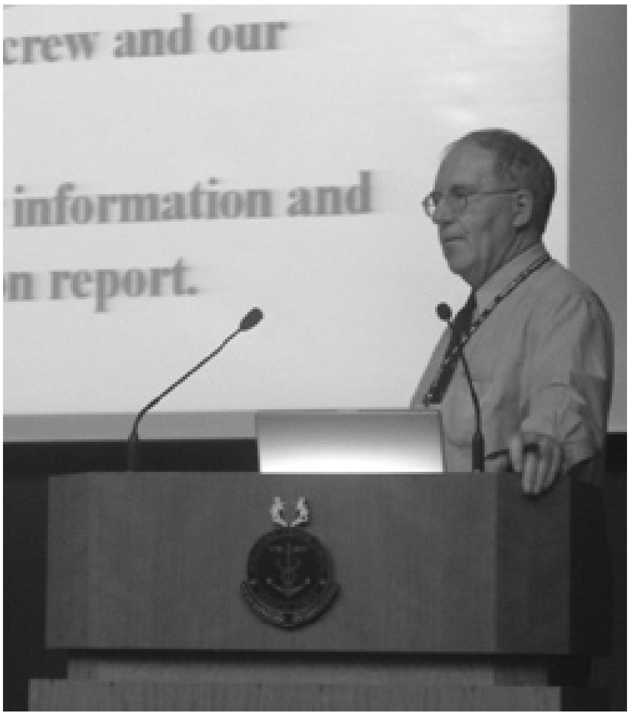
Now we would be required to have an animal house, a vet, and lots of other animal protection devices. So, small places are excluded from animal work. If I read the law correctly, you cannot enrol in a degree and use an approval from the university to cover work away from the university – the place where the experiment is being conducted is the area to be certified.

I offer these comments in the hope that any reader who serves on an ethics committee will have some sympathy for the investigator who is trying to start out, or who proposes a low-risk experiment. If you take the argument back further, Boyle, Bert, both Haldanes and Donald would all now be stopped by the RSPCA or an ethics committee. Haldane senior, allowed Haldane junior, then aged about 14, to dive in RN gear from a RN ship in an experimental diving trial. The child welfare department would have also given Haldane senior a hard time.

Carl had a one-man ethics committee. He experimented on himself first and, if he survived without injury, the experiment was repeated on his staff, with care, then on divers. I think self-preservation makes this one-man, golden-rule ethics committee the best in many circumstances, and the paperwork is a lot simpler! Other ethics committees, with rules similar to Carl's, approved the experiment that got Barry Marshall his Nobel Prize. I will admit that they did not serve John Hunter well.

The Beryl Turner, Pennefather and Peter Sullivan paper on bluebottle stings was performed on ourselves, the staff and a few divers who were near the door when we decided we needed a few more cases to build up the numbers. The words "volunteer" and "ethics" had not been invented.

Figure 1
John Pennefather, in a lecturing pose many have seen/slept through (photo courtesy of Singapore Navy)



There was recently an amusing spin off from this work. I went to a well-researched lecture on marine injuries; the speaker listed vinegar as one "cure" for bluebottle stings. I stood on my hind legs and said I disagreed with that statement. He started to challenge me, saying it was from a paper in a refereed journal and what right did I have to criticise it. When I confessed that I was a co-author, he agreed that I could question it.

Another interesting aspect of my job is the strange requests one receives. One was made long ago, before the wreck protection laws were passed. A diver, who is now dead, came to me with a lump of coral. He wanted my assistance with the chemistry needed to dissolve the rock. When I asked why, he invited me to look at it closely. I did so and could see metal. When we dissolved the rock, some old silver coins were revealed. I believe he retired soon after and lived well, so I wonder how many other rocks he treated.

A question from a fish exporter, on whether rebreathing equipment technology could be used to improve the efficiency of exporting live fish, earned me the splendid payment of 2 kg of scallops and some wine. If you put a lot of fish in a tank and seal it with oxygen in the air space, the carbon dioxide (CO_2) dissolved in the water eventually kills them. I suggested soda lime, with a battery-powered aerator to draw air through the canister and bubble it into the water, as a method of removing CO_2. Trials showed that it worked well, but the Hong Kong live-fish buyer decided that he would migrate instead of becoming a Chinese communist citizen, and the Australian end of the deal did not proceed. Somewhere in the fisheries literature is a paper on improving the survival of fish in a congested tank, with my name on it. I took the scallops and wine payment, as there are rules on people like me accepting money for outside work, but there was nothing in the rules then about gifts. Now the politicians have been greedy and this loophole has been closed.

My last story from this era took place during Des' time at SUMU. A diving instructor came in and said he was hoping to go into business building small recompression chambers (RCCs). We tried to talk him out of it, but he persisted and I gave him some advice. This was to consider a cone-shaped shell to give good stress-resistant properties with minimum weight. Because a head-down position was in fashion for cases of cerebral arterial gas embolism, I suggested that it be designed to tilt, to give head-down posture if needed. Somewhere there is a lapsed US Patent with my name on it for a tilting RCC. The basic design passed to Cowan Engineering, who employed Eric Fink to improve it, and then sold numerous chambers to the US Navy and RAN.

SUMU has always investigated equipment faults in military diving equipment. More recently we have assisted police and coroners with civilian diving deaths on rebreathing equipment. One of these was particularly sad. The lawyer for each party asked me questions that showed he had not read my report, and was trying only to prove that his client had been perfect. The only intelligent questions came from the father of the deceased, who had leave to represent the family. Sadly his son probably unintentionally caused his own death by assuming that rebreathing equipment does not need obsessively careful maintenance.

Life continues to be interesting. Most days give me a new question to answer. When my phone rings, it could be an admiral with a policy question, or an able seaman wanting help with an assignment on maths that I last used about 40 years ago.

Your Editor asked if I could provide a bibliography. I cannot track some of my old efforts, but a few are listed below. Also, if I have done anything useful, it has been to make divers and submarine crews a bit safer, mainly through the efforts of the MOs whom I have helped to train, not writing a dusty paper that is now best forgotten. I offer my best wishes for a healthy life to all of them and my other friends who read this.

John Pennefather, B.Sc (Hons), is Professional Officer at the Royal Australian Navy Submarine and Underwater Medicine Unit
HMAS PENGUIN
Middle Head Road, Mosman 2088
Australia
E-mail: *<john.pennefather@defence.gov.au>*

Selected bibliography

- Edmonds C, Lowry C, **Pennefather J**. *Diving and subaquatic medicine*. Sydney: Diving Medical Centre; first edition 1976; second edition 1981. Third edition, Oxford: Butterworth-Heinemann; 1992.
- Edmonds C, Lowry C, **Pennefather J**, Walker R. *Diving and subaquatic medicine,* fourth edition. London: Arnold; 2002.
- **Pennefather J**, McKenzie BJ. A new type of carbon dioxide absorbent canister. *RAN School of Underwater Medicine Report 1/77*; 1977.

Comment: A canister design where the gas to be scrubbed went through a part of the canister twice. It gives better utilisation of the soda lime than normal flow patterns.

- Turner B, **Pennefather J**, Edmonds C. Cardiovascular effects of hot water immersion (suicide soup). *Med J Aust*. 1980; 2: 39-40.

Comment: An examination of the possible problems with using a hot water bath for hypothermia treatment that showed some cardiovascular problems for the 'hot tub' fans.

- Edmonds C, **Pennefather J**, Blackwood F. Manometric audiometry for the evaluation of Eustachian function. *RAN School of Underwater Medicine Report 3/80*; 1980.

Comment: An early demonstration that an impedance audiometer can be used to demonstrate successful ear clearing in a person in whom the examiner is not confident from visual examination that this has occurred.

- **Pennefather J**. Some recent research at the RAN School of Underwater Medicine. *SPUMS J*. 1984; 14: 23-5.

Comment: This article provides details of the diver diet and exercise study mentioned above and an experiment with Beryl Turner and Peter Sullivan on treating bluebottle stings.

- **Pennefather J**. A transportable recompression chamber system. *Proceedings of IX International Congress on Hyperbaric Medicine*, Sydney, Australia; 1987. p. 242-8.

Comment: The 'birth' announcement of what became the Cowan two-man RCC.

Much of John's other work is in inaccessible publications. He would be happy to look for papers for interested readers.

Opinion

Diving medicine: from art to pseudo-science

Carl Edmonds

Key words
General interest, diving scholars, underwater medicine, meetings, medical society

Thank you for the opportunity to address the SPUMS Annual Scientific Meeting, probably for my last time. The acorn that a few of us planted in 1971 has grown, and you have every reason to be proud of this development. Nevertheless, I have chosen a somewhat negative topic: How diving medicine has changed from an Art to a Pseudo-science. This presentation is an opinion piece, and not a scientific review. For alternative views you will need to consult the literature on each of the points I make.

You may feel that, in the process, I am somewhat displeased with the development of diving medicine in Australia and New Zealand, but this is not so. I am proud of what SPUMS has achieved. I have affection and admiration for what you have done for my favourite subject. I see erudite university departments that will lead us into the age of science. I could never have achieved this. With my diplomatic skills, I would have ended up as road kill on the academic highway.

Hyperbaric units have flourished. I was 'it' for a few years, but I was delighted to relinquish this obligation, passing the baton from my diving unit to the hospitals in Sydney and elsewhere by the 1970s. Now they are everywhere with facilities I would give my eye teeth for, offering the sort of service that I could only dream of. The prolific educators, such as Simon Mitchell in New Zealand and John Lippmann in Australia, have done a magnificent job, taking that load off my shoulders. Thank you – you are attempting a daunting but vital task. Also, there is a reason why I shall refer often to the *SPUMS Journal* in my presentation. That is because it is the pre-eminent source of clinical material in diving medicine. Successive editors have each improved on their predecessor; I was the first, so I am entitled to make that claim.

Medicine follows fashion. When I graduated, traditional medicine was an art. Now it is a science, and I admire both, but I am concerned that in diving medicine we may have fallen between two stools. Most advances in traditional medicine were made by astute, observant clinicians. Think of Charcot, Jenner, Osler, Gower and Pasteur, and in diving medicine, Al Behnke, my friend and mentor. They applied measurements and experiments to their clinical observations and anecdotes; they practised the art of medicine. Nowadays, anecdote is not considered real evidence, and the term is often used in a derogatory manner. Now we have evidence-based medicine (EBM), the science of statistics. A science steeped in epidemiology and integral to the concept of good therapeutic trials.

In the UK, where I worked for three years in the early 1960s, these very different approaches were exemplified by two breakthroughs in endocrinology. One was an extensive, meticulous, survey of pre-diabetes in the UK. It was science as we now know it, using hundreds of thousands of subjects, producing three volumes of results, unquestionably valid. The leader of the survey team warned in a postscript against presuming that the value of the survey was in any way equated to the effort involved. Separately, Sir Charles Dent, by carefully observing a handful of clinical cases, and modifying calcium and phosphate intake, in a few pages provided a superb exposition of the whole complex subject of hyperparathyroidism. My point is that both approaches have validity, and neither is inferior.

A disclaimer – I shall not talk about hyperbaric medicine. This is a developing science, led by the activities of researchers such as Mike Bennett, Des Gorman and others. However, when you view the EBM database created by Dr Bennett and his colleagues, you will be less than impressed by the few diving medicine inclusions.[1] There are seven reports available as of this date for perusal. Possibly two of these have some clinical relevance, although I suspect only one would comply with strict EBM criteria. Diving medicine does not yet have the data necessary and available to the hyperbaric medical specialists, who essentially deal in therapeutic trials, eminently suitable to EBM.

Between the art of medicine and the science of EBM there is a pretence to science, in which its tools are misused. These are:

- Statistics, and how to lie with them
- References, and how to misuse them
- Conferences, and how to manipulate them.

I admit to being guilty of each of these sins, but it is easier to criticise others than admit one's own mistakes; I leave that to others. My problem is, how do I illustrate this pseudo-science? There are two possibilities: my preferred orientation is clinical, so I could choose a case report to illustrate the distortion of traditional medicine; or I could analyse some diving medical research reports critically, using these scientific tools.

No matter which method I use, I will offend someone, so let us do both. I will review a simple case report and critically review diving medical articles somewhat pertaining to it.

A medical colleague died from pulmonary decompression sickness (DCS) during 'technical diving' training. He was moderately obese, middle-aged, and doing repetitive dives with reverse dive profiles (RDPs). He was using a state-of-the-art decompression meter (DCM) with an algorithm not validated for this type of diving.

Let us first tackle the pseudo-science of statistics. Death statistics are important, because if diving is a safe activity, then it does not warrant more vigorous medical examinations, fitness assessment, improved training, or safer equipment. For decades, the instructor organisations have promoted diving as a safe sport, quoting a death rate of 2–4 deaths per 100,000 divers per year. This rate was achieved with what I regard as 'creative' statistics, mainly exaggerating the denominator, that is, the number of active divers.

Monaghan, a recreational diving instructor with a doctorate in population statistics, blew the whistle on these deceptions, but the propaganda has continued.[2] Unfortunately we diving doctors have promulgated this deceit in our lectures and journals. This Society's journal, in non-peer reviewed articles, has aided and abetted this process, publishing misleading articles, often sourced from the diving industry. Such comments as "*Diving is safer than swimming and lawn bowls*", represent a selective use of inappropriate non-comparable populations that defies common sense. No one has been killed by a low-flying lawn bowl!

Several surveys from various countries balance this view with reported death rates of somewhere in the range of 15–30 per 100,000 divers per year (1.5–3 deaths per 100,000 dives).[3–5] Although wondrous, diving is a potentially dangerous activity and warrants attention to the factors that make it so. For this reason and others, I conclude that the RTSC questionnaire, widely accepted and used internationally, is not an adequate alternative to a competent diving medical. I have no problem with excitement-orientated adventurers diving, and possibly dying, as long as they appreciate the risks, and do not mislead or entice others, often younger and less capable. It is others, such as the diver described above, that concern me. Are we informing them of the real hazards, or are we acting as spruikers for the diving industry, promoting it as a safe activity? The vulnerable potential victims that come to mind include people with asthma, diabetes and other disabilities, and also diving children. The figures can be manipulated to make diving with these conditions appear safer than it really is.

Years ago, based on our diving accident cases and deaths, we concluded that asthma substantially increased the risk from diving. An asthma attack was more dangerous underwater, in the ocean, trying to get back to shore, than on land. However, our scientific brethren euphemistically referred to these reports as anecdotes. By careful selection of diving statistics, the perceived risks can be minimised. This is pseudo-science at work.

How?

- Inflate the apparent numbers of active divers – inflating the denominator, reducing the apparent significance of all pre-existing diseases.
- Exaggerate the prevalence of the disease in the diving population. How? By presuming that the incidence of asthma in divers is the same as that in the normal population. This ignores the natural selection of healthy candidates for diver training, and the demographic surveys of active divers.
- Designate as 'asthmatics' all those divers who had a past history of asthma in childhood – ignoring the expected and normal 50% reduction in active asthma as children mature. Including them reduces the apparent risk from this disease.
- Do retrospective or 'survivor' surveys. If you survey all current divers you will find that there is a zero incidence of diving deaths by shark attack, drowning and asthma – the 'healthy worker' effect.
- Dismiss the significance of asthma in the death reports. In such surveys as Project Stickybeak, a most valuable concept, observer bias is probably inevitable if there is only one assessor and no critic.

These are some of the ways pseudo-science can confuse or defuse important issues. Scepticism with statistics is healthy. You may not be able to do a discriminate function analysis, but you can at least use common sense and judgment.

Des Gorman has described the BSAC study of divers with asthma as "*a role model of how not to do such studies*". I agree. Yet it retains pride of place in most diving medical reviews on asthma. Why would reputable physicians promote this misuse of statistics? Some, especially if they identify with the diving industry, have a need to promote both themselves and their sport. Most simply re-quote figures in common circulation, even if they come from unsubstantiated information from the diving industry.

Many decades ago, a number of divers with asthma gave excellent descriptions of asthma attacks induced by diving situations. I reported on these trigger factors, but did not explore them further, except for salt-water aspiration. Recently, in the *SPUMS Journal*, exercise physiologists in Colorado verified our observations and demonstrated the additive effects of triggering asthma in those who breathed against the resistance of normal scuba regulators.[6] However, I do not think they fully appreciated the value of their observations. An excellent article in the *SPUMS Journal* by Sandy Anderson described the limitations of our provocative tests for asthma in general medicine.[7] Chemical agents (histamine) have variable potency; inhalants (hypertonic saline, mannitol) depend on lung distribution, and vary in their effect with ventilation and respiratory tract anatomy. Exercise, which you would think could be standardised, has an effect that varies with the degree of fitness. Here in the Colorado study, using respiratory resistance, we have a totally standardised, safe, controllable and variable dose/

response provocative stimulus. It costs virtually nothing, and is a potential area for future research.

There are some statistics I find simply unbelievable. Consider children divers. In our journal, it was stated that 2,215 open water dives were undertaken by children without a single incident – not even ear equalisation problems.[8] Much better than the 10–30% incidence in adult trainees, especially when one considers that young age is an increased risk factor for upper respiratory tract barotrauma. Even this was usurped by the 3.5 million open water SNUBA experiences, mainly children, without a single incident – again quoted in our journal.

These miracles of statistics can be achieved only by failing to ask the right questions, or any questions, and then presuming negative responses. You should look for and document evidence before you say it is not there. That is pseudo-science, it ignores the statistical mantra: "absence of evidence is not evidence of absence". If evidence is not collected, this does not mean it does not exist.

Let us move back to the art of medicine, and the second tool of pseudo-scientists: the misuse of references. The cause of death in the diver described is not in dispute. Anyone who has seen divers die of the 'chokes' would easily recognise it, but why did he die? Chokes is a rarity in recreational divers who follow tables, do no-decompression diving and make allowance for predisposing factors, such as age and weight. The standard tables themselves include safety margins, in excess of the mathematical models on which they were originally based. It was not rare in professionals, who did prolonged dives with extended decompression – like abalone divers, divers who pushed the safety envelope. Chorinsky, Babbington and Hall come to mind. Nowadays they all would be called 'technical' divers.

Now we have DCMs that allow you to dive right to the limits of the various theoretical decompression algorithms. Many 'tech' divers, like the diver described, place complete faith in them. However, he had some predisposing factors for DCS, namely obesity and age. For long dives, we advise obese divers to reduce their allowable bottom time. This practice of adding safety factors to compensate for risk factors in air divers was supported both by the theoretical argument, and experimental observations – that adipose tissue absorbs five to six times more nitrogen than aqueous tissues. The nitrogen load is increased in fat divers.

Paul Bert first observed this when emaciated dogs endured extreme hyperbaric exposures, but succumbed to DCS from the same exposures after they had been well fed. Support for this belief has come from many subsequent animal and human studies, in diving and caisson work, in the field and during experiments. In the first edition of *Bennett & Elliott* it was stated that "*Obesity favours death after long exposures*".

However, a couple of selected references (abstracts only), discrediting the importance of fatness, are now widely quoted in dive magazines and this belief is becoming fashionable, even in some current diving medical texts. These references are used to refute numerous earlier observations. In the most recent US Navy study, it is impossible to determine the decompression stress to which the divers were subjected, and attempts to unearth the original data have been unsuccessful. I was, however, able to find some similar studies by the same authors, showing the positive relationship between weight and DCS. In a USAF report, describing altitude exposure after two hours of pre-oxygenation, the air usage during ascent was not stipulated. How these conditions influence nitrogen liberation from medium or slow lipid tissues, is totally beyond my ability to calculate, and apparently that of the researchers, as they did not clarify it.

The third and earlier report quoted as discrediting the weight/DCS association, actually supports it, suggesting that those who quote it may not necessarily have read it.

All three series employed armed forces populations, presumably homogeneous, with relatively narrow spreads of obesity, i.e., small dispersion of the weight parameter, compared with the normal population. Brian Hills had warned us of this error in his text on decompression sickness.[9] You need a wide range of fatness, or large sample numbers, to illustrate its likely importance.

The best example of uncritical use of references is that of Cot and the concept of dry drowning.[10] This paradox had serious treatment implications for immersion injuries. It implies that laryngospasm keeps the lungs dry as the diver dies from asphyxia. It was claimed that up to 20% of cases fell into this category. I have attended many autopsies in drowning victims, and treated dozens of near drownings. Never have I encountered a case of 'dry drowning'. Gordon Dougherty told me that in all his animal experiments using aqueous Indian ink the lungs were always stained by the dye.

But the clinical experts all agreed: dry drowning was a reality. They quoted each other, and themselves. With the help of a translator colleague, I sourced the original data, a paper by a Dr C Cot in 1931. A figure of 10% (not 20%) was of dry lungs at autopsy obtained from dead dogs, fished from the Seine. There was no reason to believe that the dogs actually drowned; dead dogs often ended up, via the sewers, in the Seine. Dead dogs with aerated lungs float head down and thus are less likely to sink, or take in more water, and the lungs can remain dry.

Extrapolating these findings to human immersion incidents is simply not warranted. Also, the Seine is fresh water. We all know that fresh water is absorbed rapidly from the lungs post-mortem, and during resuscitation of humans. The experts relied on autopsy reports in humans to make the retrospective diagnosis of dry drowning, and most of their cases were probably from fresh water. Dry drowning, it is now agreed, is a post-mortem artefact. It arose from a failure to read and critically review the original article that was then re-quoted for 70 years.

Let me summarise some of the problems with references and pseudo-science:

- References that have not been read should not be quoted.
- All references are not equal; use your judgment. If they are misleading or incomplete they should not be used, or their use should be qualified. Otherwise, you are misleading your audience.
- Abstracts and preliminary reports may support a belief, but they are not research evidence. They are opinions, no more and no less, and not usually peer reviewed or critically assessed as regards their validity.
- Data have to be transparent and available. Salesmen and pseudo-scientists in the diving industry often claim vast numbers of dives using a certain computer, or a certain table, or specific training, or a certain technique. This is usually a retrospective guestimate, with a presumption of safety. Chase references back to their source to see how robust and documented they are.
- Internet searches can be a trap. The interesting review paper by Mouret on obesity and DCS, a paper with whose conclusions I agree, illustrates this.[11] Almost half of her references were from the Internet – from sites that are not subject to peer review, and which may not even be available for perusal a few weeks later, or in which the data may be altered retrospectively. These are unsupported opinions, no matter how much one agrees with them.
- Many recent publications fall into the trap of using only Medline-type searches. The authors have ignored the wealth of material available in textbooks, monographs, conferences or theses and any research prior to 1961. The establishment of the UHMS collection at the Duke University library will be a great help in this, as will the Rubicon Foundation collection.
- A more difficult problem to overcome is that of genuine but unintentionally misleading references.

This last point is exemplified in the condition known as 'Taravana', DCS from breath-hold diving. The subject is very topical, but the reasons for believing in the story keep changing. The paper by Bob Wong on Taravana, in the *SPUMS Journal*, is a good, comprehensive review, faithfully representing the opinions of many workers.[12] However, the whole concept really rests on the validity of the case reports – and these are few and problematic. The opinions and the explanations are numerous, but, I believe, are largely based on misleading data.

Cross, the discoverer, was a master diver and a good one. He was not a physician or physiologist. He described in *Skin Diver Magazine* some incidents from the Tuamotos. Unfortunately some avant-garde decompression modellers convinced him that he was describing DCS. Beware of ultra-specialisation. To an enthusiast with a hammer, everything looks like a nail. Cross was good enough to let me peruse the case reports some years ago. Diseases such as hyperventilation hypoxia, salt-water aspiration syndrome, inner ear barotrauma, some marine animal injuries and the causes of vertigo in diving explained most. These conditions were not known when Taravana was first observed. Cross's cases include many obvious non-DCS cases. The reason for the wide range of clinical manifestations was probably the wide range of diseases lumped together under the Taravana cloak – because they occurred in the same area. You could similarly describe a Tutukaka Syndrome, grouping the problems noted during this week of diving at Tutukaka.

Another group of cases were described, ostensibly to clinch the Taravana concept, by Paulev – then by Wong himself – in submarine escape training 'breath-hold' divers. They developed DCS. True, they did, but they are not breath-hold divers in the same sense. Although these divers do conduct multiple breath-hold dives to escort their submariners to the surface, that is not all they do. They also breathe compressed air, just like scuba divers. The breath-hold divers often have to wait for the submariners, who sometimes take time to prepare themselves. Where do they wait? In small compressed air bubbles (blisters) built into the escape tank at various depths, or in submerged bells. So it is breath-hold diving, but it is combined with compressed air breathing. Unless you had experienced this type of diving, you would not be aware of this, or its importance, and it is not highlighted in the published reports.

The final truth about this possible disease may come from the recent Ama work, but I wonder why these divers, who have been exposed to 50 years of intense study without Taravana being reported, suddenly have cases of DCS being reported by the same authors who misled us regarding submarine escape divers. These cases need to be independently and critically reviewed. The message? Before you explain or model anything, you must first verify that it exists.

The next tool of pseudo-science is the consensus conference. The diver described above died after a series of repetitive dives with reverse profiles (RDPs), with decompression based on a contemporary computer algorithm (DCM), which had never been validated for this type of RDP diving exposure. He would never have got away with doing these dives decades earlier. He would have been protected by old-fashioned protocols advising no-deco dives, adding safety margins and avoiding RDPs. Conventional practice had been circumvented by a confidence in computers and a popular but incorrect interpretation of a consensus conference.[13]

I will not discuss DCMs here, but I will refer to the consensus conference about which I have previously expressed the strong view that it was held to influence behaviour, but in the absence of evidence. A sort of verbal meta-analysis, but without data. Ed Lanphier warned us "*Truth should not be determined by voting*".

How did we move from the art of medicine to a pseudo-science of consensus? The original workshops of the Undersea Medical Society were superb. Closed clinical meetings, attendance by invitation to a small group of experts from various disciplines and experienced clinicians who exchanged information, tried to understand and clarify problems, considered possible solutions and proposed avenues for productive research. There was no posturing and no lobbying. Indeed, there was no audience. There was no imposition or coercion in the workshops or in their publications. If there was disagreement, we agreed to disagree.

In the early 1990s, market forces intervened and the workshops mutated into commercially orchestrated meetings. Examples of these in diving medicine include the workshops on the terminology of decompression illness, asthma, DCMs, and RDPs. The main problem with these conferences is an implied obligation on delegates to reach consensus. Rarely do they agree to disagree, which for me is the basis of intellectual freedom. There is often a predetermined position, and although opposition may be recorded in the transcripts it is often overridden in the conclusions. A powerful chairman or the more eloquent delegates may impose their views. Whoever wields the pen that defines the recommendations, wields the power. These are what are quoted henceforth, not the voluminous transcripts, which are rarely read. There is an added bonus for the conveners, implying expert status, without their actually doing any original work in the field. There are exceptions: consensus conferences that actually contribute to medical knowledge.

In conclusion, please remember that I have been guilty of *all* these pseudo-science misdemeanours during my career.

I wish to acknowledge two groups of diving contributors. So many of our Australasian achievements have evolved from non-experts, part-timers and enthusiasts: Bob Thomas, Doug Walker, Noel Roydhouse, Alan Sutherland, Jack Barnes and many others. These are the unsung heroes of diving medicine. Most of all, I acknowledge the divers who have shared a spectacular world, given life-long friendships, and described their illnesses, which I translated into medical terminology, some agreeing to be clinical guinea pigs. They made my professional life much fuller, more productive and colourful.

Selected references

1 Bennett M. HBO evidence. The database of randomised controlled trials in hyperbaric medicine. <http://www.hboevidence.com> (last accessed 25 June 2007).
2 Monaghan R. Australian diving death rates: comparisons with USA and Japan. *SPUMS J*. 1989; 19: 24-5.
3 Monaghan R. The risks of sport diving. *SPUMS J*. 1998; 18: 53-60.
4 Hart AJ, White SA, Conboy PJ, Bodiwala J, Quintin D. Open water scuba diving at Leicester: five years' experience. *J Accid Emerg Med*. 1999; 16: 198-200.
5 Ladd G, Stepan V, Stevens L. The Abacus Project: establishing the risk of recreational scuba death and decompression illness. *SPUMS J*. 2002; 32: 124-8.
6 Gotshal RW, Fedorczak LJ, Rasmussen JJ. Severity of exercise-induced bronchoconstriction during compressed-air breathing via scuba. *SPUMS J*. 2004; 34: 178-82.
7 Anderson SD, Wong R, Bennett M, Beckert L. Summary of knowledge and thinking about asthma and diving since 1993: Discussion paper for the Thoracic Society of Australia and New Zealand, November 2004. *Thoracic Society News*. 2004; 14(4): 61-8.
8 Vandenhoven G, Collard F, Schamp E. Children and diving: medical aspects. Eight years' sports medical follow-up of the first scuba diving club for children in Belgium. *SPUMS J*. 2003; 33: 70-3.
9 Hills BA. *Decompression sickness Vol 1. The biophysical bases of prevention and treatment*. Chichester: John Wiley & Sons; 1977.
10 Cot C. *Les asphyxias accidentelles. Etude clinique, therapeutique et preventive*. Paris: Editions Medicales N. Maloine; 1931.
11 Mouret GNL. Obesity and diving. *Diving and Hyperbaric Medicine*. 2006; 36: 145-7.
12 Wong RN. Decompression sickness in breath-hold diving. *Diving and Hyperbaric Medicine*. 2006; 36: 139-45.
13 Lang MA, Lehmer CE, editors. *Proceedings of the reverse dive profile workshop*, 29-30 October 1999. Washington, DC: Smithsonian Institution; 2000.

Dr Carl Edmonds was the Foundation President and is a Life Member of SPUMS.
E-mail: *<puddle@bigpond.com.au>*

Dr Carl Edmonds (right) receiving a presentation at the SPUMS ASM 2007. Dr Mike Bennett, on behalf of the Society, presented him with a beautifully embossed leather-bound copy of the fourth edition of Edmonds et al, *Diving and Subaqautic Medicine.*

SPUMS notices and news

South Pacific Underwater Medicine Society Diploma of Diving and Hyperbaric Medicine

Requirements for candidates

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

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

Additional information

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

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

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

The Academic Board reserves the right to modify any of these requirements from time to time. The Academic Board consists of:
Dr Fiona Sharp, Education Officer, Professor Des Gorman and Dr Chris Acott.

All enquiries should be addressed to the Education Officer:
Dr Fiona Sharp,
249c Nicholson Road
Shenton Park, WA 6008
Australia
E-mail: *<sharpief@doctors.org.uk>*

Key words
Qualifications, underwater medicine, hyperbaric oxygen, research

---

Minutes of the SPUMS Executive Committee Meeting held in Melbourne on 24 February 2007

Opened: 1000 hr

Present: Drs C Acott (President and Chair), R Walker (Immediate Past-President), G Williams (Treasurer), F Sharp (Education Officer), G Hawkins (Acting Secretary), M Davis (Editor), C Lee (Committee Member), D Vote (Committee Member)

Apologies: Drs S Sharkey (Secretary) and D Smart (ANZHMG Representative)

1 Minutes of previous meeting
Dr Walker proposed that the minutes of the previous Executive Committee Meeting held on 4 June 2006 be accepted as a true record. Seconded by Dr Williams, passed unanimously.

2 Matters arising from previous minutes
Will be discussed as individual items in this meeting.

3 Annual Scientific Meeting
Dr Davis reported that preparation for the meeting was going well with 38 registrants and 8 'probables' signed up. It was stated that we needed at least 45 people for financial viability and this should be reached easily. Items regarding

the scientific programme were discussed with no major changes.

4 Journal report

4.1 Incorporation and amalgamation of EUBS into the SPUMS Journal.

4.1.1 It was felt that SPUMS was the far stronger organisation and that the EUBS contribution should be incorporated into the existing SPUMS Journal set-up.

4.1.2 The main concerns of committee members were the issues of logistics and the actual contribution of EUBS to the Journal.

4.1.3 There was also a concern that the SPUMS 'culture' would potentially be affected and that issues such as legal liability and GST would have to be sorted out.

4.1.4 Dr Acott suggested that there should be a trial period of 1–3 years and if there is poor contribution from EUBS then the incorporation could be dissolved.

4.1.5 Robust discussion ensued and it was decided that the Journal should remain under SPUMS' editorial control and be printed in Australia and bulk sent to Europe for distribution (at their cost).

4.1.6 It was also decided that the Journal should be a scientific journal only and organisational issues could be added as a separate 'newsletter' for each organisation but SPUMS would need a copy of the European newsletter prior to inclusion.

4.1.7 Dr Davis suggested that there should also be a set of criteria that EUBS has to fulfil to maintain the incorporation.

4.1.8 General consensus is that the incorporation should proceed after further investigation of the potential logistical issues and the setting up of editorial criteria for EUBS to fulfil by the Editorial Committee of the Journal.

[Dr V Haller (Public Officer) arrived 1050 hr]

4.1.9 Dr Davis thanked the Committee for their contributions and suggested that SPUMS should be represented at EUBS funded by SPUMS.

Motion: That SPUMS fund two members of the Executive Committee to go to EUBS ASM to discuss with the EUBS Executive Committee the proposed incorporation of the SPUMS Journal and EUBS newsletter. Proposed by Dr Acott, seconded by Dr Hawkins, passed unanimously.

It was suggested that the two members should be Dr Davis (as Editor of the Journal) and Dr Walker. Dr Davis is going to EUBS anyway and Dr Walker will check her schedule as to whether she can attend.

4.1.10 Dr Davis requested approval for the upgrade of Adobe Acrobat software for the Journal and this was approved by the Committee unanimously.

4.2 Journal budget

4.2.1 The budget for the Journal is approximately $48,000.00, which consists of the honorarium, printing and postage and the wages of the editorial assistant.

4.2.2 Dr Williams stated that the administrator's costs should be added to the journal cost as should the cost of the Editor attending the ASM.

4.2.3 This is an ongoing issue to accurately track the exact cost of the journal to the organisation and there needs to be a formalisation of the honorarium status. **Action:** Dr Acott and Dr Walker.

5 Treasurer's report

5.1 Currently there are 597 financial members and 210 who have yet to renew their memberships.

5.2 Dr G Williams proposed four changes to streamline the banking and finances of the organisation:

5.2.1 That the organisation formally changes its bank account from the ANZ to St George Bank to allow dual authority electronic funding approval and also to reduce credit card fees: passed unanimously.

5.2.2 That there should be four (4) signatories to the bank accounts of which any two can sign for funds. The four signatories should be the President, Treasurer, Secretary and Public Officer: passed unanimously.

5.2.3 That we accept only Visa, Mastercard and Cheque payments for the organisation to reduce credit card charges: passed unanimously.

5.2.4 That we need to change the constitution to exclude the term "honorary auditor" as the auditor is in fact paid for their services. This requires a constitutional change at the AGM and there was not enough time to include it in the current AGM agenda for voting. This is to be included in the 2008 AGM agenda.

Dr Williams also suggested that we should add the SPUMS ASM as a payment option to the website (along with annual fee payments). Approved and the website co-ordinator will look into this.

5.3 Postage costs for the Journal are as follows:

Australia	$6.00
NZ and South East Asia	$14.40
Rest of the World	$21.20

5.3.1 It was decided that the postage should be shown as part of the costs in the inside cover of the Journal.

5.3.2 The membership fees should therefore be:

Full membership	AUD $143.00 inc GST
Associate/Retired/Student	AUD $77.00 inc GST

Postage surcharge:

SPUMS Area:	Nil
South East Asia	AUD $10.00
Rest of World	AUD $20.00

Approved by the Committee. Membership fees will be discussed at a later date for presentation to the AGM in 2008 for approval by members.

6 Education Officer's report
This was tabled by Dr F Sharp.

7 Other Business

7.1 Code of conduct
Discussion ensued regarding the need for a code of conduct for members and it was felt that constitutional powers were adequate.

7.2 Website management

7.2.1 Dr Walker felt that because of work commitments she could not dedicate adequate time to the management of the SPUMS website. Dr Hawkins volunteered to take over website management.

7.2.2 Discussion also ensued regarding the uploading of past issues of the Journal to the website for download.

7.2.3 Dr Davis suggested that the first 30 volumes could be uploaded and he will also investigate the possibility of making the first 30 volumes uploadable to a US-based foundation for potential worldwide distribution. He will investigate this and present his results at the next meeting.

7.3 ASM Convenor's manual
It has been re-iterated that convenors should use the manual to plan the ASM and they should investigate options and present the options to the Executive Committee for approval prior to committing the Society to any outlaying of funds.

7.4 John Lippmann OAM
The SPUMS Executive on behalf of the Society would like to formally congratulate John Lippmann on receiving an OAM in the recent New Years Honours list.

7.5 Job descriptions for committee members
To be held over for discussion in New Zealand at the ASM.

7.6 Updating of the SPUMS Medical
There are formal sessions of the ASM dedicated to the development of medical guidelines for diving medicals and review of the SPUMS Medical will be undertaken after these.

7.7 Membership drive

7.7.1 Dr Davis requires formal acceptance of the new membership brochure.

7.7.2 This was formally accepted and Dr Davis will attempt to source representative photos for the brochure.

7.8 The Asian Hyperbaric and Diving Medical Association (AHDMA)
Dr Hawkins is attending the meeting in Bali in April and he will approach the AHDMA Executive Committee as to the development of closer links and the use of *Diving and Hyperbaric Medicine* as the journal of the AHDMA.

Closed: 1430 hr

Minutes of the Annual General Meeting of SPUMS held at Oceans Resort, Tutukaka, New Zealand, on Thursday 19 April 2007

Opened: 1857 hr

Present: Attendees of ASM

Apologies: Drs S Sharkey (Secretary), G Williams (Treasurer), C Lee (Committee Member), M Walker, R Walker (Immediate Past-President)

1 Minutes of the 2006 AGM
Motion that the minutes be accepted. Proposed, C Acott, seconded F Sharp, carried.

2 Matters arising from previous minutes
Nil

3 President's report: Dr C Acott

4 Secretary's report: Dr G Hawkins
(on behalf of Dr S Sharkey)

5 Education Officer's report: Dr F Sharp

6 Treasurer's report: Dr C Acott
(on behalf of Dr G Williams)

7 Other business
Nil

Closed: 1905 hr

Education Officer's report 2007

Several diplomas are in progress and two have been awarded:

1 Dr Andrew Fock, FANZCA
Alfred Hospital, Melbourne
"Health status and diving practices of a technical diving expedition"
Diving and Hyperbaric Medicine. 2006; 36: 179-85.

2 Dr Andrew Sean Hopson, FRCA
Prince of Wales Hospital, Sydney
"Intravenous infusions in hyperbaric chambers: effect of compression on syringe function"

Fiona Sharp

President's report 2007

Thank you for attending. I apologise for not being here for the whole conference but personal issues prevented this.

The past year has been a mixture:

- The Journal continues to flourish under the guidance of our Editor, Associate Professor Mike Davis. I thank him for his efforts and hope he will continue with the good work. The Journal is the flagship of the Society.
- Plans for incorporating the journal of the European Undersea Baromedical Society have been nearly finalised. To this end Mike Davis and the Immediate Past-President, Dr R Walker, will be going to the EUBS meeting in September of this year to finalise details. There will be a trial period of three years to ensure that the incorporation is not detrimental to our Society.
- The Society's membership numbers are stagnant. We need new members for the Society to survive so please promote the Society if you have the opportunity.

Over the next 12 months the SPUMS Diving Medical will be reviewed, particularly in regard to asthma and diabetes. I'm sure there will be hearty, if not heated, debate amongst the Committee.

Finally, I would like to thank the Committee for their efforts during the year, in particular, Glen Hawkins, who has been helping out as the temporary Secretary while Sarah tends to her family. Next year is election time so please think about nominations. I will not be seeking re-election.

Chris Acott

Treasurer's report 2007

Unfortunately I have been unable to attend this year's Annual General Meeting, and thank you to the President for delivering this report on my behalf.

It will be difficult for the President to answer any very specific queries that members may have re the SPUMS accounts, therefore if there are members with specific queries please e-mail me (details in front cover of Journal).

Currently SPUMS has three accounts with the ANZ Bank in Australia and a BNZ Account in New Zealand – at the time of writing this report the account balances are as follows:

SPUMS General ANZ - AUD$65,113
SPUMS V2 Reserve Account - AUD$92,063
SPUMS ANZ ASM Account - AUD$3,500
SPUMS BNZ Account - NZ$1,678 (balance at end of financial year).

I propose that membership fees remain unchanged in 2007, but there has been a variation in postage costs for SPUMS Members not residing in the South Pacific region; this is simply to reflect the actual cost of journal postage to other regions, full details are on the SPUMS website.

I anticipate that at the 2008 Annual General Meeting I will recommend a small increase in fees. I anticipate our costs will rise due to ongoing upgrades/modifications of the SPUMS website, ultimately leading to it becoming the main portal for membership renewals, new memberships and eventually registrations for the Annual Scientific Meeting. Also, presently the SPUMS Committee is at full strength, as the Committee is at maximum size (no committee member now holds more than one position) and this will lead to an increase in costs for the two teleconferences and one face-to-face meeting held most years.

I also plan in the next three months to move SPUMS' accounts to a new bank. This is to allow dual authority online banking, which will significantly streamline payments – unfortunately our current bankers are unable to provide this facility.

The audited SPUMS Accounts are available at the AGM, and I would propose that we continue to use our current Auditor, David Porter.

Guy Williams

Secretary's report 2007

Another year has flown by and since the 2006 AGM the SPUMS Committee has formally met once.

At the 2006 AGM, SPUMS membership was 867 members including 112 outstanding renewal payments. Current membership is 837 with 162 outstanding renewal payments. However, this year has shown some early signs that new memberships may be increasing with 21 new members so far. There were 44 new memberships in 2006.

Membership recruitment remains an agenda item being actively considered by the Committee. Some of the initiatives being considered and implemented include changes to membership categories, SPUMS' website development, and journal development.

Progress is never as speedy as most would like; however, the Committee are working at updating SPUMS' policy statements. The ASM and the Journal form an important part of this process and are an essential opportunity for the members of the Society to share knowledge and develop opinion on the relevant issues. An objective of the Committee for 2007 is to make some significant progress on policy statements.

Sarah Sharkey

Audit report to the members of the South Pacific Underwater Medicine Society, 2007

I have conducted various tests and checks as I believe are necessary considering the size and nature of the Society and having so examined the books and records of The South Pacific Underwater Medicine Society for the year ended 31 December 2006 report that the Society's Income and Expenditure and Balance Sheet have been properly drawn up from the records of the Society and gives a true and fair view of the financial activities for the year then ended.

Dated: 7 May 2007

David S Porter, Chartered Accountant
Mona Vale, New South Wales 2103

THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY
STATEMENT OF INCOME AND EXPENDITURE
FOR THE YEAR ENDED 31 DECEMBER 2006

	2006	**2005**
INCOME		
Subscriptions and registrations	88,188	97,835
Interest	3,504	4,648
Advertising and Journal sales	-	-
ASM 2004	-	2,532
ASM 2005	-	31,719
Sundry income	3,472	2,221
	95,094	138,955
EXPENSES		
Accounting fees	720	-
Administration, secretarial, etc	21,667	13,978
Amortization of website	10,741	10,307
ASM costs	8,911	41,128
ASM registrations previous year	-	-
Bad debt written off	-	-
Donations	250	-
Stationery, printing, postage	1,173	2,548
Journal and editorial expenses	47,771	41,748
Committee expenses	965	9,149
Computer equipment	4,558	491
Mail forwarding	-	600
Miscellaneous/Subscriptions	396	309
Bank charges and card charges	3,320	5,196
Audit	2,100	2,100
Insurance	5,665	5,727
Telephone	608	-
Treasurer	3,911	-
	112,756	133,281
SURPLUS/(DEFICIENCY) FOR YEAR	**$(17,662)**	**$5,674**

These are the accounts referred to in the report of D S PORTER, Chartered Accountant, Mona Vale, NSW 2103
Dated: 7 May 2007

THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY MOVEMENTS ON BANK BALANCES FOR THE YEAR ENDED 31 DECEMBER 2006

	2006	2005
OPENING BALANCES		
ANZ bank - ASM account		
- Access Cheque Account	7,162	46
- SPUMS Annual Scientific Meeting	3,853	6,949
- BNZ Achiever Savings	2,812	2,307
- VZ Plus	95,165	100,590
	109,470	109,892
add, **RECEIPTS**	95,094	142,967
	204,564	253,057
less, **PAYMENTS**	98,934	142,967
CLOSING BALANCES		
ANZ bank		
- Access Cheque Account	8,316	7,162
- VZ Plus	89,698	95,165
- SPUMS Annual Scientific Meeting	5,938	3,853
- BNZ Achiever Savings	1,678	2,812
	$105,630	**$109,470**

NOTE: Receipts and Payments may include Balance Sheet items which are not included in the Income and Expenditure statement.

THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY BALANCE SHEET AS AT 31 DECEMBER 2006

	2006	2005
MEMBERS' FUNDS		
Balance at 1 January 2006	130,161	124,487
Funds provided by NZ Chapter	-	-
Surplus/(Deficiency) for year	(17,662)	5,674
	$112,499	**$130,161**
represented by:		
NON-CURRENT ASSETS		
SPUMS website, at cost	32,285	30,620
Less, provision for amortization	27,715	(16,974)
	4,570	13,646
CURRENT ASSETS		
ANZ Access Cheque Account	8,316	7,162
ANZ VZ Plus	89,698	95,165
ANZ SPUMS Annual Scientific Meeting	5,938	3,853
BNZ Achiever Savings	1,678	2,812
2006 ASM income less expenses in advance	-	6,403
GST recoverable	929	1,120
	1,370	-
	107,929	116,515
NET ASSETS	**$112,499**	**$130,161**

These are the accounts referred to in the report of D S PORTER, Chartered Accountant, Mona Vale, NSW 2103
Dated: 7 May 2007

Report on Australian and New Zealand Standards Occupational Diving Committee Meeting, Tuesday 20 March 2007, Sydney

1 Australian Standard 2299.1

The final draft of Australian Standard 2299.1 was signed off. The significant differences from the 1999 edition are:

- i Revised text dealing with exposure to altitude after diving with guidance provided in an appendix.
- ii Revision of the requirements for availability of recompression chambers.
- iii Clarification of the time in which a stand-by diver should be able to enter the water and fitness-to-dive criteria.
- iv Changes to lifeline signals to be known by divers.
- v Reference to the AS2815 series for dive supervisor training and certification.
- vi Clarification of the diver's equipment requirements with particular focus on the need to ensure buoyancy management equipment suits any emergency function as well as providing the required operational control.

In the absence of experimental evidence on which to base guidelines for ascents to altitudes less than 2,400 metres post diving, expert opinion was sought. A consensus was reached between the operational requirements of diving followed by altitude exposure, and the known safety data. For ascents to greater than 2,400 metres, research data from Divers Alert Network USA have been incorporated into the Standard.

Local and overseas expert opinion regarding recompression chamber support requirements was sought. As a result, the table for chamber support has been updated and simplified based on current advice on risk of decompression illness. Requirements for on-site chamber support of dives involving certain types of work or factors that significantly increase risk of arterial gas embolism or high gas load/rapid decompression illness have been retained and clarified. The process published in the AS 2299 Standard for determining the level of recompression chamber support required for a diving operation is now considered suitable for application to the types of diving covered by both AS/NZS 2299.1 and AS/NZS 2299.2. The training and certification of occupational divers, and harnesses and lifelines were discussed in fine detail, and these details will be published in the Standard.

There are some modifications to the wording in the Standard in relation to the medical assessment. An annual medical assessment is required with no more than 12 months passing between the most recent assessment and any dive that is undertaken. In accordance with current practice in New Zealand, allowance has been made for a more comprehensive physical examination at the initial assessment and subsequently as clinically indicated but at intervals not exceeding five years. There is still a requirement for annual medical examination; however, this may be less detailed between the five-yearly checks at the discretion of the diving physician. This requires the data from the comprehensive assessment to be available to the practitioner, and may change practice if divers regularly see one medical practitioner for their assessments. Targeted physical examination, lung function tests, and audiometry would still be performed annually.

2 New business

Australian Standard/New Zealand Standard 2815.5 Dive Supervisor Training was signed off at the meeting.

A coroner's inquest into the death of a diver in New South Wales was also discussed. The coroner found difficulties with Australian Standard 2815.3 in defining the "workplace" for recreational diving. The background to this case was that a group of recreational divers chartered a fishing boat to undertake diving. The fishing boat operator was paid to provide transport to the dive site but did not participate in any of the dive planning or dive operation. An individual died during the diving operation due to running out of air. The coroner asked for clarification of the Australian Standard 2815.3 and the wording of this has been adjusted.

Two sub-committee working groups will look at the Australian Standards 2815.1 and 2815.2 and also a new Part-6 training standard for limited scuba diving.

A diving risk management supplement is being produced by a working group of the Australian Standards Committee.

3 Future directions for the Occupational Standards Group

3.1 Chamber operators and diver medical technicians have a working group producing new standards.

3.2 Committee SF17 recorded a negative vote towards the International Standards Organisation TC228 Standards for training of recreational dive masters, dive instructors and assistant instructors. The Australian Occupational Diving Committee submitted concerns about the medical standards for the International Training Standards. Despite a negative vote we were out-voted by the European block and the Training Standards will become regulation in Australia and New Zealand in the near future. In the future there may be some impact on Australian Standard 2299.3, which applies to occupational diving for recreational teaching.

3.3 Standards are likely to be written to cover nitrox for professional diving and safety requirements for technical and rebreather diving. As part of this review, the specific issue of the use of breathing gases other than air for occupational diving will be examined.

3.4 AS/NZS 2299.2 review will commence shortly.

3.5 AS 4005.1 will also need to be reviewed – and receive input from SPUMS.

Associate Professor David Smart, SPUMS Representative, Australian Standards Committee for Occupational Diving

Articles reprinted from other sources

Fatal respiratory failure during a 'technical' rebreather dive at extreme pressure [Abstract]

Mitchell SJ, Cronjé FJ, Meintjes WAJ, Britz HC

Abstract

A diving fatality at the extreme depth of 264 m fresh water is described. The diver was equipped with an underwater video camera which recorded events leading to his death. These events corroborated predictions about respiratory complications at extreme pressure made by early researchers. Review of the video and relevant literature resulted in the following physiological interpretation: an increase in respired gas density during descent caused a progressive increase in resistance to flow in both the airways and the breathing circuit. Initially, this was associated with a shift to ventilation at higher lung volumes, a relative degree of hypoventilation, and mild permissive hypercapnia. The promotion of turbulent airway flow by increasing gas density resulted in effort-independent expiratory flow at lower flow rates than usual. The consequent inability to match ventilation to the demands of physical work at the bottom precipitated a spiraling crisis of dyspnoea, increasing P_aCO_2, and wasted respiratory effort, thus producing more CO_2. Extreme hypercapnia eventually led to unconsciousness. This tragic case provides a timely and salient lesson to a growing population of deep 'technical' divers that there are physiological limitations that must be understood and considered when planning extreme dives.

Department of Anaesthesia, Auckland City Hospital, Auckland, New Zealand, Department of Interdisciplinary Health Sciences, University of Stellenbosch, Cape Town, and Muelmed Hospital Trauma Unit, Pretoria, South Africa

Reprinted with kind permission from Mitchell SJ, Cronjé FJ, Meintjes WAJ, Britz HC. Fatal respiratory failure during a 'technical' rebreather dive at extreme pressure. *Aviat Space Environ Med*. 2007; 78: 81-6.

Key words
Technical diving, diving physiology, carbon dioxide, hypercapnia ventilation, breathing, abstracts

---

Exhaled nitric oxide is decreased by exposure to the hyperbaric oxygen therapy environment [Abstract]

Puthucheary ZA, Liu J, Bennett M, Trytko B, Chow S, Thomas PS

Abstract

Exhaled nitric oxide (eNO) detects airway inflammation. Hyperbaric oxygen therapy (HBOT) is used for tissue hypoxia, but can cause lung damage. We measured eNO following inhalation of oxygen at different tensions and pressures.
Methods: Part 1, eNO was measured before and after HBOT. Part 2, normal subjects breathed 40% oxygen.
Results: Baseline eNO levels in patients prior to HBOT exposure were significantly higher than in normal subjects ($P < 0.05$). After HBOT, eNO significantly decreased in patients (15.4 +/- 2.0 versus 4.4 +/- 0.5 ppb, $P < 0.001$), but not in normal subjects, after either 100% O_2 at increased pressure or 40% oxygen, 1 ATA. In an *in vitro* study, nitrate/nitrite release decreased after 90 minutes HBOT in airway epithelial (A549) cells.
Conclusion: HBO exposure causes a fall in eNO. Inducible nitric oxide synthase (iNOS) may cause elevated eNO in patients secondary to inflammation, and inhibition of iNOS may be the mechanism of the reduction of eNO seen with HBOT.

UNSW and Department of Respiratory Medicine, Faculty of Medicine, and Hyperbaric Unit, Prince of Wales Hospital, Randwick, NSW, Australia

Reprinted with kind permission from Puthucheary ZA, Liu J, Bennett M, Trytko B, Chow S, Thomas PS. Exhaled nitric oxide is decreased by exposure to the hyperbaric oxygen therapy environment. *Mediators Inflamm*. 2006; 2006 (5): 72620.

Key words
Hyperbaric oxygen, research, nitric oxide, abstracts

Obituary
George Wookey

Born: London, October 1922
Died: Busselton, March 2007

On 12 October 1956, George Wookey secured his diving helmet and was lowered 183 m into a freezing Norwegian fjord. It is still the depth record for anyone in a flexible diving suit. "*A feat of courage that remains unequalled,*" said David Strike, celebrated Australian diver and author. "*I was so cold*," said the man himself last October at the unveiling of a plaque in Bergen, Norway, to commemorate his feat.

George was also a mine and bomb disposal expert, became a successful businessman in WA and, it is fair to say, did not waste a minute of his 84 years.

A former diver recalled how, in 1966, George showed the panache of James Bond when he was based in Malta and had retired, with several others, to the local bar to settle down with a few of its specialties – pints of cider topped with the local wine, Marsovin. Before he had a sip, George was sent for. An unexploded mine had been found in the harbour, directly where a mooring was being placed for a costly luxury yacht. "*B******," said George. "*I'll be back in a while*."

He then went to the harbour, put on his diving suit, went down in almost zero visibility, disarmed the mine and got himself back to the bar where he was upset that his drink had been removed. "*Needless to say, he didn't have to put his hand in his pocket for the entire night*," said a fellow diver and drinker.

George also found the wreck of the *SS Politician*, the ship which sank loaded with finest Scotch whisky and which was the basis for Sir Compton Mackenzie's famous book and film *Whisky Galore*.

His dive into the Norwegian fjord was part of a trial to discover the depth at which a diver could assist stranded submarine crews. While he went down with a heavy steel bench, representing the hull of a stricken submarine, a decompression chamber containing a diving assistant was suspended at 67 m to await his return.

Later he recalled how the light faded from bright, crystal-clear green to a beautiful blackness, illuminated only by bio-luminescent plankton surging upwards past him. Once on the floor of the fjord, he had to unshackle two wires from the bench with his fingers, which were so cold that they felt like sausages, then signal to the surface that he had completed the job. But after performing his task with relative ease, he found, as he prepared to be pulled up, that part of his air line had become trapped under the bench. For several minutes he had to clamber underneath to untangle it as those on the surface made matters worse by trying to take up the slack. Yet even that experience did not stop him from cleaning ships' hulls, taking underwater core samples and taking on salvage operations all those years later with his own company.

George Wookey being dressed in for his 600 ft dive (courtesy Historical Diving Society)

Despite coming up carefully, he suffered the bends and had to be rushed back into the decompression chamber for five hours. "*The relief I felt when the pain finally subsided and mobility returned to my arms and upper torso can only be imagined*," he said later.

In 1957, the MBE was awarded to George for his heroic effort that demonstrated it was possible to operate at depths which only a few years earlier had been thought impossible. The same year the Royal Navy also decided this form of diving was too hazardous to the diver.

George Alan Morley Wookey was born on 31 October 1922, the third child and only boy of George, a master grocer, and Jenny. He joined the Royal Navy at 15 and stayed for 22 years. In 1951 he was part of the team which searched for the wreck of the submarine *Affray*, the last British submarine lost at sea. After a search lasting 59 days and the investigation of more than 150 wrecks, George dived on *Affray* and during the next three months he helped to pioneer the use of an underwater camera with Commander "Buster" Crabbe, who was later to disappear near a Soviet warship in Portsmouth Harbour.

He learned mine and bomb disposal work and in 1959, when he found the *Politician*, with its 50,000 cases of whisky aboard, he brought up a dozen or so bottles on several occasions – though it was claimed (for the benefit of Customs and Excise) that they were heavily contaminated with sea water and oil. Years later George could still draw a map showing where the best whisky could be found buried in the sand.

George married Helen Jessup, with whom he had a daughter, Erica, then Judith Money, with whom he had three children, daughters Darryl and Andrea and son Martin. He married for a third time, in 2000, Patrice Fitzgerald, whom he thought he had married in Scotland in 1995 but discovered it was an illegal ceremony.

In 1961 George was lent to the New Zealand Navy and his family moved there. He next was loaned to the Jordanian army, travelling in plain clothes by car and camel to Akaba to train men in diving and mine clearance. Frustrated by the lack of promotion prospects, George then resigned and spent a few years on Malta restoring a motor fishing vessel.

In 1967 he set sail from Malta to New Zealand but at a stop in Fremantle he saw endless possibilities and instead sent for the family. George Wookey Underwater Services was set up and was a success. However, during a flat spell, he was briefly master of a livestock carrier. His son, Martin, remembers that he took it over as a favour for a friend for one trip, between Fremantle and Kuwait, but when he boarded he found the compass was unreliable. However, he set sail, sticking his hand out from the bridge to signal right. "*It was simple*," he later told Martin. "*out of the harbour, turn right and keep going generally until you bump into Asia*."

He retired in 1984, then moved south to Witchcliffe, where he took up farming and built his own house at Rosa Glen from mud bricks though he had no training as a builder – and was 70 years old. "*He hated to stand still*," said daughter Darryl. "*He then took up woodwork and many members of the family have tables he made*."

Martin recalls his room had a porthole that his dad had recovered from a wreck; his bunk was from a merchant ship, the *Ottway*; the lounge room light was made from the wheel of the *Ann Judith*, the boat he had sailed from Malta; and the fruit bowl was 2000 or 3000 years old, taken from the floor of the Mediterranean Sea.

George later settled at Quindalup, on Geographe Bay, and died on 21 March. He is survived by Patrice, his four children and Patrice's five, plus a grandson, a grand-daughter, two step-grand-daughters and Patrice's 13 grandchildren who considered George their grandfather.

"*He never lost his enthusiasm for the ocean*," said Martin. "*He took us diving, even though, for Dad, diving was like walking out into the backyard*."

Len Findlay

Reprinted with kind permission of the West Australian.

Key words
Obituary, deep diving, personality, general interest, reprinted from

The poetry doctor

The truth of being?

What is the truth of being?
A mystery severe
In a never ending journey
For meaning why we're here.

Are we all connected
In a universal pot
Of energy and karma
That guides us to our lot?

Are we in a hologram,
Each fragment is a whole
Where each of us has the universe
Imprinted on our soul?

Are we all in parallel,
Aligned but not in line,
Everything non-linear
And running not in time?

Are we all one spirit,
A God-being divine,
A labyrinth of loving
In which our souls combine?

Are we in a dreamtime,
A seed of Mother Earth
That nurtures and recycles
From death to a new birth?

Are we just plain mortals
Stained with original sin,
Begging the heavenly Father
To forgive and let us in?

My mind is all a-flurry
With these thoughts how I might be.
It's just all too difficult.
I think I'll just be me

…and go diving!

John Parker
<www.thepoetrydoctor.com>

Letters to the Editor

The future of our journal

Dear SPUMS Members,

The purpose of this letter is to update you on the current status of the Society's journal, *Diving and Hyperbaric Medicine*, and to encourage you to contribute material in order to ensure its ongoing viability and to achieve indexing with Medline and ISI in addition to our current indexing on EMBASE.

With over 800 current subscribers, there is clearly considerable interest in our journal. One of the continuing challenges with each edition is to ensure there is enough interesting and high-quality material in order to publish. Contributions of value are not just limited to original research with hard scientific data, but include a range of educational articles reporting on interesting and relevant issues. The Journal is highly dependent on its membership for contributions. In recent years the lack of contributions has resulted in delays to the publishing of several issues, including this one.

The fact that the Journal is not indexed on Medline is a disincentive to researchers who might otherwise submit their work for publication. Unfortunately it is the limited original research in our journal which is the main contributing factor in our difficulties in getting it fully indexed – a Catch-22 situation. The SPUMS Executive Committee is currently considering with the European Society the option of combining our journal with that of the EUBS in order to improve the viability of both. This would also improve our international readership.

Your contributions to *Diving and Hyperbaric Medicine* have the following benefits:

- supporting the development of knowledge in the fields of diving and hyperbaric medicine
- improving the viability of the Journal
- providing invaluable evidence in support of indexing the Journal
- providing an opportunity for you to gain CME points.

So, if you are in a position to submit work for consideration of publication, please consider *Diving and Hyperbaric Medicine* as the journal of choice, particularly for material relating to diving physiology and medicine.

Dr Chris Acott
President, SPUMS

Key words
Letters (to the Editor), medical society

The hundred-fathom link

Dear Editor,

I was interested to read Val Hempleman's obituary, which you published in the March 2007 edition of *Diving and Hyperbaric Medicine*. The reference to Lt George Wookey's 600 ft dive, from *HMS Reclaim* in a Norwegian fjord, on 12 October 1956, was particularly apposite for a number of reasons.

Firstly, George Wookey's death on 21 March 2007 was reported in an obituary, in the UK, in *The Daily Telegraph* on 6 April 2007. Members may be interested to know that in later life he spent many years living and working in Western Australia (see preceding obituary).

Secondly, Wookey's dive to a depth previously thought impossible was not without technical complications and could very easily have ended in disaster. The exercise involved his unshackling two wires from a heavy bench, which was meant to represent the hull of a stricken submarine. Having signalled the completion of his task, Wookey found that his gas supply line had become trapped under the bench and, whilst clambering to untangle it, his predicament was made worse by the topside crew 'taking up the slack'.

In the June 2004 edition of the *SPUMS Journal*, I reported that the world record No Limit (NLT) freedive for men was held by Loïc Leferme of France at 162 m, i.e., a little over 531 ft. The current record of 600 ft was set in August 2006 by Herbert Nitsch, an Austrian, at Zirje, Croatia.

The death of Loïc Leferme in April this year was reported, in the UK, in *The Sunday Times* on 15 April 2007. He died off the French Riviera, as a result of technical complications involving his inflatable lift bag, whilst returning to the surface following a training attempt at Nitsch's 600-ft NLT record. Similarly, the death of Audrey Mestre in the Dominican Republic, on 12 October 2002, was due to technical complications involving her inflatable lift bag, whilst returning to the surface following an attempt at the NLT record for women of 561 ft.

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

Key words
Letters (to the Editor), deep diving, breath-hold diving

Spirometry assessment of divers at the 2007 ASM

Dear Editor,

During the recent Annual Scientific Meeting in Tutukaka, New Zealand, 39 delegates participated in my ongoing research study investigating lung function in scuba divers. This was very constructive to the continuation of the study, which we are planning to continue over three years. In addition to investigating bronchial hyperresponsiveness we will be measuring the rate of decline in FEV_1 in a cohort of divers over three exposures.

Data collection was remarkably smooth, mainly due to compliance from the divers and the wonderful assistance of Drs Cathy Meehan and David Wilkinson. In time we will write up the results and publish them. In the near future, Cathy and I hope to present the findings at the European Underwater Baromedical Society meeting in September.

I am grateful to everyone who took part. All who provided an e-mail address will be forwarded the result of their "blows" in the coming month. If you do not hear from me please let me know. Furthermore, I hope to see everyone at the 2008 SPUMS Annual Scientific Meeting, where, once again, hopefully you will participate in this longitudinal study.

Anne Wilson
School of Population Health and Clinical Practice
University of Adelaide
Australia
E-mail: *<anne.wilson@adelaide.edu.au>*

Key words
Letters (to the Editor), pulmonary function, research, medical society

Maintenance of Professional Standards

Dear Editor,

Here are the details of the Maintenance of Professional Standards (MOPS) points that have been approved by the Australian and New Zealand College of Anaesthetists (ANZCA) for the SPUMS 36th ASM, Tutukaka, New Zealand, 15–20 April, 2007.

- Major CME Meeting: 3 CME points per hour (Code 111)
- Exceptions:
  - "Knowing me, knowing you! How divers and their dive computers interact: three case studies" and "Asthma, diabetes and the SPUMS Medical (Workshop)": Other Activities, 2 CME and 1 QA points per hour (Code 700)
  - "Hypothetical - evolving clinical problems": Major QA Meeting, 3 QA points per hour (Code 211)

The approval number for this conference is 07132.

Jan P Lehm
Department of Diving and Hyperbaric Medicine
Prince of Wales Hospital
Randwick, NSW 2031, Australia
E-mail: *<Jan.Lehm@SESIAHS.HEALTH.NSW.GOV.AU>*

Key words
Letters (to the Editor), meetings, MOPS

Book reviews

Oxygen first aid, third edition

John Lippmann

Soft cover, 160 pages
ISBN 0-646-23565-6
Ashburton, Australia: JL Publications; 2006
Price: AUD$20 plus postage
Copies can be ordered from Submariner Publications: <www.submarinerpublications.com>
Phone: +61-3-9886-0200
E-mail: <jlpubs@bigpond.net.au>

John Lippmann's monograph has become the standard text for the teaching of oxygen resuscitation. It was last reviewed in the Journal in 2002.[1,2] At that time, the reviewer considered the book "*essential reading for anyone who provides pre-hospital first aid*". So what has changed in the intervening four years both in terms of knowledge and techniques, and in the presentation of the material?

When comparing the second and third editions side by side they are almost identical. Only the third chapter, on the specifics of resuscitation, has been revamped, reflecting the changes in the recommended standards for resuscitation in the intervening years. This now includes a full section on automated defibrillation (ADF) rather than the brief appendix as in the previous edition. There are also a few minor changes to the chapter on oxygen delivery devices, with some new photographs. The simple 'Oxygen Provider Flow Chart' has been removed from the new edition for some reason. The ADF appendix has gone (see above) and is replaced by one on pulse check and continuous ventilation. The logic for putting the latter in an appendix rather than in the chapter on resuscitation escapes the reviewer. The extensive bibliography has been updated, though one wonders whether this would be more useful if it were more selective rather than trying to be all-embracing.

The presentation and layout is very similar to the previous edition, the typeface is clear and there are very few typographical errors. However, the removal of shading and some changes to formatting in the detailed procedural checklists make these less clear than in the previous edition. Almost all the illustrations and photographs are identical, but many have not reproduced in quite such good quality and are smaller than in the second edition; a particularly bad example being the photograph on page 84, of the DAN non-rebreather mask. There seems to be little point in showing black-and-white photographs of American colour-coded cylinders in the chapter on storage and handling; if you did not know they were green, the photo would certainly not tell you! An opportunity to enhance the illustrations in this new edition has been missed.

So who should buy this book? The previous reviewer's comment above remains true, so if you do not have a copy of the previous edition then you should buy this one. If you do have a copy of the second edition, and want the new resuscitation guidelines and the oxygen material in a single text then again this is for you. However, if you do not need the resuscitation guidelines because you already have these available elsewhere and you have the second edition, then stick with that.

Michael Davis
Editor, Diving and Hyperbaric Medicine

References

1 Lippmann J. Oxygen first aid (2nd edition). *SPUMS J*. 2002; 32: 172-3.
2 Errata. *SPUMS J*. 2002; 32: 234.

Key words
Book reviews, first aid, resuscitation, oxygen

Fathomeering: an amphibian's tale

Ivor Howitt

Soft cover, 155 pages
ISBN 0-9758347-0-3
Melbourne, Australia: Mountain Ocean and Travel; 2007
Copies can be ordered by e-mail from <books@motpub.com.au>
Price: AUD$29.95 plus p&p (GBP 12.00)

The story of this book coming to print is worth relating. HDS SEAP involvement goes back quite a long way. The terms "Amphibians", and "Fathomeering" first came to attention in an article published in the 50th edition of *Dive Pacific*, a NZ diving magazine. Fathomeering was, to me, a new term, but as the story explained it had been coined by a group of young adventurers based in Aberdeen, Scotland, at the end of World War Two. As I read the article I got quite excited for many reasons. The story was a great read, well written and had good diving history.

As President of the Diving Historical Society Australia, SE Asia (DHS ASEA), I wrote to the Editor, Dave Moran, to congratulate him for his foresight and to support this wonderful edition of his magazine, which had a large diving-history content. A short while later Ivor Howitt sent a more complete version of the article about fathomeering to the DHS ASEA, which included extra photos and other interesting bits of diving history. This delightful gift to the DHS ASEA immediately made me think of our members and how best to give them access to this cherished piece of diving history, and the diving memories of Ivor Howitt, pioneer fathomeer. Then along came the publishers: Mountain Ocean and Travel's Barry Andrewartha and Belinda Barnes certainly know the diving market from their many years of Sport Diving and Dive Log publications. Belinda agreed to publish and edit the work. She has transformed some wonderful text and photos into a great book.

The book of 155 pages is profusely illustrated with Ivor's and his cohorts' photographs, many in colour. The well-written text is enhanced with a treasure trove of reproductions of letters and receipts. These documents cover the purchase of diving equipment, including the receipts for that 1948 Self Contained Compressed Air Diving Apparatus from Siebe Gorman & Co Ltd. Among these letters is my favourite – a reply from Dunlop Rubber about the Frogman's Swim Fins, to say that they did not foresee any need to put these on the market again.

The backdrop for this book, the countries of Scotland and Australia, is very familiar to me, as my own life has led me through a similar landscape. Aberdeen, a beautiful city where Ivor grew up; the Cairngorm Mountains where Ivor hiked and climbed; and the West Coast of Scotland at Tobermory where he dived. Later, South Australia, Victoria, NSW and Queensland. Mentions of all these locations are well supported by great photographs.

This book is not only a fitting tribute to the diving career of Ivor Howitt, but extensively includes his mates. Importantly, it also gives a fair insight to the man, and the sense of adventure in the life led by a young group of lads as an escape from the 9–5 routine of work. How much of this real sense of adventure, present when Ivor grew up in Scotland in the 1940s, is found in young people now? By the 1960s, when I was trekking the hills and learning to dive, the sharp edge of adventure had already softened. Scuba cylinders were easily filled locally and there was one shop in Edinburgh at which I could buy dive gear. And I never, ever, even had a stray thought to ride a bicycle into the highlands to climb mountains.

The old adage that there is seldom anything new is highlighted in the section dealing with the very first formal sport diver course in Australia (February 1954). Today, in a hi-tech diving society, which has a subgroup of 'technical' divers, it is interesting to note the mention of rebreather and mixed-gas diving as an essential part of this first introductory course along with the new fangled scuba equipment.

HDS SEAP has willingly supported this project, as it achieves the very essence of what the Society is about, preserving the history of diving. This book gives a first-hand account of the exploits of some of the first recreational divers in the UK. Ivor was also among the early scuba divers in Australia. It is very probable that the Siebe Gorman Scuba set that Ivor brought to Australia in December 1951was the first to arrive; it was also one of the first to be purchased for recreational use in the UK. Finally, the fantastic photographs, taken with the ingenuity of a young engineer, underwater where few had ever gone before, are remarkable.

During the time that this book has been evolving, the project has received a great deal of support from diving historians hailing from Australia, Canada, NZ, the UK and the USA. I know that Ivor and his family appreciated this support over the time from manuscript to published book.

To Ivor and all his diving mates from the 1950s, I take my hat off. Many old diver stories are being published, but Ivor's book has the added advantage of being well written, with a robust sense of a quiet Scottish humour throughout. I highly commend this book to all – it is much more than a simple diving tale.

Bob Ramsay
Hyperbaric Health

Key words
Book review, diving, history, general interest

SPUMS Annual Scientific Meeting 2008

Dates: May 24 – 31
Venue: Liamo Resort, Kimbe WNB, Papua New Guinea

Guest speakers:

Professor Alf Brubakk
Associate Professor Richard Moon
Dr David Williams (Tropical/Envenomation Medicine)

Themes:

The Treatment Tables
Tropical/Envenomation Medicine Update
Resuscitation Update

Alf Brubakk and Richard Moon are both internationally known diving physiology and medicine experts who have been Guest Speakers at previous SPUMS conferences.

Professor Brubakk is from the Norwegian University of Science and Technology in Trondheim, Norway, and was one of the editors of the 5th Edition of Bennett and Elliott's *Physiology and Medicine of Diving*.

Dr Moon is Associate Professor of Anesthesiology at Duke University Medical Center, USA, and is the Medical Director of DAN International.

David Williams is a research scientist attached to the Australian Venom Research Unit at the University of Melbourne, Australia. His primary interest is in the management of the envenomed victim in tropical countries and he is a knowledgeable and entertaining speaker.

This will be an outstanding meeting in one of the best diving locations in the world.
Details of venue and conference may be found on the SPUMS website: <www.spums.org.au>
For early registration and booking click on 'Diving and U/W Medicine Conferences' and then download the registration and booking forms by clicking on 'Conference Registration'. For details of the venue click on 'Conference Information'.
Early registration/booking is recommended.

Full registration details and a call for papers will accompany the September issue of the Journal.

If you wish to present a paper please contact the Convenor.
Abstracts for presentation should be submitted before 30 April 2008 as a Word file of up to 250 words (excluding references – 4 only) and with only one figure.
Intending speakers are reminded that it is SPUMS policy that their presentation is published in *Diving and Hyperbaric Medicine*. The Editor will contact speakers prior to the meeting.

Conference attendees will be able to receive CME points from relevant medical bodies (RACGP, ANZCA, NZCGP, etc).

Convenor: Dr Chris Acott
30 Park Ave
Rosslyn Park, SA5072
AUSTRALIA
E-mail: <cacott@optusnet.com.au>
Telephone: +61-(0)8-8431-2295
Facsimile: +61-(0)8-8431-8219
Mobile: +61-(0)412-618417

The Australia and New Zealand Hyperbaric Medicine Group

Introductory Course in Diving and Hyperbaric Medicine
31 March to 11 April 2008
Prince of Wales Hospital
Sydney, Australia

Course content includes:

- History of hyperbaric oxygen
- Physics and physiology of compression
- Accepted indications of hyperbaric oxygen
- Management of decompression illness
- Wound assessment including transcutaneous oximetry
- Visit to HMAS Penguin
- Marine envenomation
- Practical sessions including assessment of fitness to dive

Contact for information:
Ms Gabrielle Janik, Course Administrator
Phone: +61-(02)-9382-3880
Fax: +61-(02)-9382-3882
E-mail: <Gabrielle.Janik@sesiahs.health.nsw.gov.au>

THE UNIVERSITY OF AUCKLAND
FACULTY OF MEDICAL AND HEALTH SCIENCES

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

Enquiries from registered medical practitioners are now being accepted for 2008.

Faculty: Des Gorman, Michael Davis (Course Director), Simon Mitchell, Chris Acott, William Baber and Drew Richardson

Overview: This is a distance-learning programme, available internationally without a resident component. However, attendance at a recognised short course in diving medicine (such as the ANZHMG, RAH or RAN courses) is required. Graduates will be able to practise effective clinical diving medicine in a primary care setting or to embark on clinical practice in hyperbaric medicine.

Recognised by the ANZCA towards the College Certificate in Diving and Hyperbaric Medicine.

For further information, including fees, please contact the Course Coordinator, Upendra Wickramarachchi
Phone: +64-(0)9-373-7599, extn 83058
Fax: +64-(0)9-373-7006
E-mail: <u.wicks@auckland.ac.nz>
or submit an online **Expression of Interest** in this subject at the website: **<www.health.auckland.ac.nz>**
by clicking on the Quicklink to Postgraduate Study.

Auckland University Post Graduate Diploma in Medical Science – Diving and Hyperbaric Medicine

The ANZCA Council has agreed that successful completion of the "Medicine 719" component of the University of Auckland Post Graduate Diploma in Medical Science – Diving and Hyperbaric Medicine, will be accepted as an alternative to the ANZCA DHM Formal Project.

Additionally, successful completion of the "Medicine 714 and 715" components of University of Auckland Post Graduate Diploma in Medical Science – Diving and Hyperbaric Medicine, will be accepted as an alternative to the formal course requirements of the ANZCA Certificate in Diving and Hyperbaric Medicine.

It was further agreed that up to six months of the training towards the University of Auckland Post Graduate Diploma in Medical Science – Diving and Hyperbaric Medicine, may be credited towards the six-month practical experience component of the ANZCA Certificate in Diving and Hyperbaric Medicine which is not required to be undertaken in an accredited unit.

L F Wilson
Chair, Hospital Accreditation Committee

2007 ROYAL AUSTRALIAN NAVY MEDICAL OFFICERS' UNDERWATER MEDICINE COURSE

Dates: 09 to 20 July 2007
Venue: HMAS Penguin, Sydney
Cost: $1833.00 (tbc)

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

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

EUROPEAN UNDERWATER AND BAROMEDICAL SOCIETY
33rd Annual Scientific Meeting

Dates: 08 to 15 September 2007
Venue: Sharm el-Sheikh, Sinai, Egypt

Sunny, warm Sharm el-Sheikh invites you to participate in the 2007 EUBS conference. Sharm el-Sheikh is the UNESCO designated city of peace and one of the fastest growing tourism communities on the face of the earth. Early registration is advised.

For further information, please visit our website <www.eubs2007.org> or contact:
Dr Adel Taher, Secretary General of 33rd EUBS Annual Scientific Meeting
E-mail: <info@eubs2007.org>
Mobile: +20 12 212 4292 (24 hours)

10TH INTERNATIONAL MEETING ON HIGH PRESSURE BIOLOGY

Date: 12 September 2007
Venue: Sharm el-Sheikh, Sinai, Egypt

This is a joint meeting with the 33rd Annual Scientific Meeting of EUBS.

Please see the International High Pressure Biology Group website at: <http://www.cf.ac.uk/phrmy/IHPBG/X_IHPBG_Home-page.html>

ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE COURSES 2007

Medical Officers Course

Basic		30/07/07	to	03/08/07
Advanced		06/08/07	to	10/08/07

DMT Full Course

November 2007	3 weeks,	12/11/07	to	30/11/07

DMT Refresher Course

August 2007		27/08/07	to	31/08/07

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

BRITISH HYPERBARIC ASSOCIATION ANNUAL MEETING 2007

Dates: 01 to 04 November 2007 (pre-meeting diving programme 29 October to 01 November)
Venue: Oban, Scotland

For information contact: BHA 2007, Dunstaffnage Hyperbaric Unit, Scottish Association for Marine Science, Oban, Argyll, Scotland PA37 1QA
E-mail: <info@bha2007.org>
Website: <www.bha2007.org>

UNDERSEA and HYPERBARIC MEDICAL SOCIETY
Annual Scientific Meeting 2008 - preliminary notice

Dates: June 2008
Venue: Salt Lake City

General information and online registration can be found at <http://www.uhms.org/Meetings/AMMeetingsMain.htm>
For additional information contact: Lisa Wasdin
E-mail: <lisa@uhms.org>

HYPERBARIC TECHNICIANS and NURSES ASSOCIATION
15th ANNUAL SCIENTIFIC MEETING
Dates: 09 to 11 August 2007
Venue: Stamford Plaza, Adelaide
For further information contact: Czes Mucha
E-mail: <cmucha@mail.rah.sa.gov.au>
Phone: +61-(0)8-8222-5121
Fax: +61-(0)8-8232-4207

Instructions to authors

(revised December 2006)

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

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

Requirements for manuscripts

Documents should be submitted electronically on disk or as attachments to e-mail. The preferred format is Microsoft Office Word 2003 . Paper submissions will also be accepted. All articles should include a **title page**, giving the title of the paper and the full names and qualifications of the authors, and the positions they held when doing the work being reported. Identify one author as correspondent, with their full postal address, telephone and fax numbers, and e-mail address supplied. The text should generally be subdivided into the following sections: an **Abstract** of no more than 250 words, **Introduction**, **Methods**, **Results**, **Discussion, Conclusion(s), Acknowledgements and References**. Acknowledgements should be brief. Legends for tables and figures should appear at the end of the text file after the references.

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

The preferred length for original articles is 3,000 words or fewer. 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 15 references. Abstracts are also required for all case reports and review papers. Letters to the Editor should not exceed 500 words with a maximum of five references. Legends for figures and tables should generally be less than 40 words in length.

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

Table columns should be as tab-separated text rather than using the columns/tables options or other software and each submitted double-spaced as a separate file. No vertical or horizontal borders are to be used.

Illustrations and figures should be submitted as separate electronic files in TIFF, high resolution JPG or BMP format. Our firewall has a maximum size of 5 Mb for incoming files or messages with attachments. Large files should be submitted on disc.

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

References

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

Freeman P, Edmonds C. Inner ear barotrauma. *Arch Otolaryngol.* 1972; 95: 556-63.

Hunter SE, Farmer JC. Ear and sinus problems in diving. In: Bove AA, editor. *Bove and Davis' diving medicine*, 4th ed. Philadelphia: Saunders; 2003. p. 431-59.

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

Any manuscript not complying with these requirements will be returned to the author before it will be considered for publication in *Diving and Hyperbaric Medicine*.

Consent

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

Copyright

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

DIVER EMERGENCY SERVICES PHONE NUMBERS

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

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

SOUTH-EAST ASIA
+65-750-5546 (Singapore Navy)
+63-2-815-9911 (Philippines)
+60-5-930-4114 (Malaysia)

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.
Enquiries to: <diverhealth@hotmail.com>

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.

DIVING-RELATED FATALITIES RESOURCE

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

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

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

CONTENTS

Diving and Hyperbaric Medicine Volume 37 No. 2 June 2007

Diving and Hyperbaric Medicine is indexed on EMBASE

Printed by Snap Printing, 166 Burwood Road, Hawthorn, Victoria 3122