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

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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

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Membership is open to all medical practitioners.
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SPUMS Membership,
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630 St Kilda Road, Melbourne, Victoria 3004, Australia
or e-mail <stevegoble@bigpond.com>
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The Society's financial year is January to December, the same as the Journal year.
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There will be an additional surcharge of $8.00 for journal postage for all members living outside Australia.

The Editor's offering

In the last few years the occurrence of isolated inner ear decompression illness (IEDCI) in recreational divers breathing air has been clearly established as nothing like as rare as previously thought. Several articles and reprints on this subject have appeared in past issues of this journal, including modelling of the pathophysiological processes that may be involved and the possible link with patent foramen ovale. All these pertinent references are listed in Richard Smerz's article and are not reproduced here. The Hawaiian series of 28 presentations of isolated IEDCI is well documented and provides only the second series of any size in the literature.[1]

Smerz has gone to considerable lengths to develop a database incorporating one of the largest reported series (1,422 patient records) of decompression illness in recreational divers. The total series is summarised in a recent paper, in which he argues for the effectiveness, compared with other reports, of the 'deep spike' Hawaiian treatment tables.[2] However, all case series differ and similar results have been achieved by some other centres with shallow oxygen tables, though many hyperbaric units using tables such as the US Navy Table 6 alone have reported substantially poorer outcomes than those of the Hawaiian unit. Many chambers treating divers do not have the pressure capability to emulate these deep tables, which include pulls to as deep as nearly 70 metres at the start of treatment.

It will remain difficult to show that such treatments, heavy on manpower and potentially carrying additional long-term occupational risk for attendants, are indeed more efficacious than shallow oxygen tables, unless units with similar depth capabilities combine their resources to conduct a prospective randomised study. Since chambers with such capabilities tend to opt for going deeper, e.g., Comex 30 treatment table, in severe cases anyway, the ethics of such a randomised trial of deep mixed-gas versus shallow oxygen treatment tables would be problematic.

Intuitively it may come as little surprise that navy divers tend to have personality traits indicative of more thrill and adventure seeking than other groups as reported by van Wijk. Does this have potential to help in the selection process for military diving training or in predicting those candidates who are likely to successfully complete such training? This would then be a potentially useful tool. One wonders what this might have to do with completing the 'mud run' in Auckland Harbour as an RNZN diver, but one could certainly put this down to 'experience', though not one to be actively sought after.

Chris Acott completes his review of extraglottic airway devices (EADs) in the acute resuscitation of swimmers and divers with a look at one of the most challenging, if not near impossible, situations with which a commercial diver is ever likely to be faced – dealing with an unconscious diver in a bell diving situation. Not all EADs function well in a hyperbaric environment and Acott provides considered advice on which gear to carry and a protocol for management. May it never happen!

The new *in vitro* models for studying skin growth and its components, reviewed by Malda and his colleagues, have great potential for enhancing our understanding of the role of hyperbaric oxygen in wound healing. Submission of this review article arose from a chance discussion following a presentation given by Malda at the 2006 meeting of the Hyperbaric Technicians and Nurses Association; an example of the importance of interaction between the various professional groups involved in hyperbaric medicine.

Those of us who treat divers with the 'bends' are very aware of the potential for post-injury stress reactions in these patients. Unfortunately most go their own way after discharge and are lost to follow up; a few go on to have long-term problems. This was highlighted many years ago in a paper from the Auckland chamber.[3] The impact of a diving accident on those involved, other than the victim, has been given little consideration in the diving medical literature. The case report by Ladd is thus important in highlighting this issue and describing how one such incident was successfully treated.

This journal issue should reach readers about a week before the Annual Scientific Meeting in Tutukaka, New Zealand; just enough time to down tools at short notice and head across the Tasman or into the Southern Ocean from the North and participate in what will be an excellent week in all respects. An exciting conference programme has been put together and the surroundings and diving are outstanding. See you there! If not, then plan now to attend the 2008 ASM in Papua New Guinea, for which Chris Acott is the Convenor.

Michael Davis

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Up close and personal. Front cover photo taken by Dr Martin Sayer in Benga Lagoon at the Fiji ASM 2006.

Original articles

A descriptive epidemiological analysis of isolated inner ear decompression illness in recreational divers in Hawaii

Richard W Smerz

Key words
Decompression illness,decompression sickness. inner ear decompression illness, inner ear decompression sickness, treatment, epidemiology

Abstract

(Smerz RW. A descriptive epidemiological analysis of isolated inner ear decompression illness in recreational divers in Hawaii. *Diving and Hyperbaric Medicine*. 2007; 37: 2-9.)
Inner ear decompression illness (IEDCI) was once thought to be relatively rare and seen predominantly in deep, mixed-gas divers. The incidence of this type of injury is unknown, but IEDCI may be more common than previously thought and can be seen in recreational scuba divers using compressed air as their breathing medium. This study was conducted at the Hyperbaric Treatment Center (HTC) in Honolulu, Hawaii, to determine the frequency of occurrence of IEDCI and to evaluate some of the epidemiological parameters associated with these cases. Between 1983 and 2006, 28 presentations (2.8% of all cases of decompression illness treated) with a diagnosis of isolated IEDCI were identified in 26 divers. Presenting symptoms and physical findings included vertigo, nausea, postural imbalance, vomiting, nystagmus, hearing loss, and tinnitus. Most cases developed after multiple deep dives or after dives in which adequate decompression did not occur. All but two divers were breathing air. Symptoms developed on average 70 minutes after diving. The average delay to treatment was nine hours post injury. All but three cases were treated using the HTC deep treatment tables. Nineteen cases made a full recovery, with all cases achieving substantial improvement. Most cases required four to five treatments to obtain that level of recovery. Those with incomplete resolution of symptoms at the time of discharge were left with mild degrees of motion sickness and gait disturbance, and some were left with hearing loss. IEDCI warrants early and aggressive intervention to reduce the risk of permanent disability.

Introduction

Isolated inner ear decompression illness (IEDCI) is an acute peripheral cochleo-vestibular disturbance arising as a consequence of breathing compressed gas at increased atmospheric pressures. It is characterised by symptoms and physical findings of acute vertigo, nausea and postural imbalance, and perhaps vomiting, hearing loss, and tinnitus. It has historically been reported rarely. AH Smith may have been the first to describe the symptoms of what is now referred to as inner ear decompression sickness (IEDCS) in caisson workers when he noted both deafness and vestibular problems in compressed air workers in 1873.[1] Later, in 1929, Vail demonstrated that inner ear damage could occur during decompression from embolisation of nitrogen bubbles and result in necrosis of those tissues.[2] For a period of time thereafter, IEDCI was infrequently noted. The frequency of cases may have been lessened through the implementation of improved safety procedures, but this is also because IEDCI was often seen only in cases of more extensive neurological injury and thought to be part of a larger syndrome. Thus, IEDCI was relegated to a finding of lesser import and not regarded as a separate entity.[3]

The incidence of IEDCI in any diving population, be it commercial, scientific, military or recreational, is unknown. It had been thought to occur largely in deep, mixed-gas divers or saturation divers in commercial diving. The symptoms of IEDCI may accompany inner ear barotrauma or be part of a more global presentation of decompression sickness (DCS) affecting the brain itself, which can make the diagnosis of IEDCI rather challenging for the diving physician.[4] In the 1970s, several reports again focused attention on the possibility that IEDCI might also be a discrete finding.[5–8] It was not reported in recreational divers using compressed air until the 1990s.[9–11] More recently, several studies appear to associate isolated IEDCI with the existence of a patent foramen ovale (PFO).[12–14]

This study reports on the experiences at the Hyperbaric Treatment Center (HTC) of the University of Hawaii John A Burns School of Medicine in evaluating and treating isolated IEDCI, that is ‘stand-alone’ cases of IEDCI, in recreational divers.

Methods

Characterisation of this clinical syndrome with the more general term IEDCI vis-à-vis IEDCS is used except where IEDCS is specifically meant. A review of 1,422 patient records was undertaken by the author to determine the number of isolated IEDCI cases treated at the HTC between the years 1983 and 2006. The study was reviewed by the Committee on Human Studies of the University of Hawaii and determined to be exempt from the Department of Health and Human Services regulations, 45CFR Part 46. All possible cases were considered for inclusion in this study. A possible case was defined as one who had been diagnosed with IEDCI in the HTC database at the time of treatment, as well as any diver who had presented with symptoms of at least vertigo, nausea, and/or vomiting, and might also have had ataxia, tinnitus and/or hearing loss. Confirmed and/or probable cases were defined as those who evinced only a peripheral cochleo-vestibular abnormality resulting from decompression stress or arterial embolism.

Confirmed and probable cases were determined after a complete review of the clinical records of each identified possible case based upon the recorded past medical history, history of presentation, diving history of the incident event(s), physical examinations conducted, and any neurological and/or otological assessments performed at the time of treatment. Divers who presented with histories and physical findings consistent with a more extensive expression of DCS, inner ear barotrauma, viral labyrinthitis, vestibular neuronitis, Ménière's disease, vertebral and basilar artery disease or cerebellar disease were excluded.[15,16]

Epidemiological data focusing on gender, age, dive profile, breathing gas employed, time to onset of symptoms, time delay to treatment, presenting symptoms, physical findings, and HTC treatment regimen undertaken for confirmed or probable cases were extracted and analysed. Outcome of treatment was assessed by comparing pre- and post-treatment severity scores devised by the HTC and used to determine efficacy and outcomes of the HTC treatment tables in a previous study.[17] Since the goal of treatment is to restore the patient to as near a state of normal functionality as possible, the ability to conduct routine, normal activities of daily living (ADL) was chosen as the outcome measure. ADL were defined as the routine, unencumbered physical and mental functions normally undertaken by the patient prior to the diving injury. During the chart review, each patient was assigned a pre-treatment initial functional impairment score (iFIS) of one to four based upon physical findings at the time of presentation and impact on ability to conduct routine ADL (Table 1).

For iFIS scoring in general, minor subjective symptoms included dizziness, motion sickness, heaviness, malaise, lightheadedness, headache and fatigue. Mild to moderate symptoms/signs included minor balance problems, minor weakness or loss of sensation, aches, tingling and numbness. Substantive symptoms/signs included incapacitating vertigo, major disturbance of balance, hearing loss, paresis, paralysis, paraplegia, bowel/bladder dysfunction, altered mental status, altered vision and incapacitating pain. Life-threatening symptoms/signs included cardiopulmonary arrest and severe central neurological injury.

Table 1
Honolulu Hyperbaric Treatment Center functional impairment scoring system
(ADL – activities of daily living)

Score	Definition of level of impairment
0*	No physical signs/symptoms, no impairment/limitations to ADL
1	Minor subjective symptoms, no physical signs, no impact/limitations to ADL
2	Moderate objective signs/symptoms, mild to moderate impact/limitations to ADL
3	Major objective signs/symptoms, substantial impact/limitations to ADL
4	Life-threatening signs/symptoms, severe immediate impact/limitations to ADL

*Used for post-treatment scoring only

Patients were assigned a residual functional impairment score (rFIS) of zero to four at the time of discharge from care at the HTC using the same scoring system as for the iFIS (Table 1). Pre- and post-treatment scores (iFIS and rFIS) were compared to determine improvement.[17]

The treatment tables employed to treat these cases were those routinely used at the HTC and are briefly summarised here.

TT60

This begins with recompression to 60 feet sea water (fsw, 18 metres' sea water (msw); 283 kPa) where the patient is placed on 100% oxygen (O_2). Three O_2 periods are undertaken at 18 msw, then three at 13.6 msw, two at 9 msw, and two at 4.5 msw, then ascent to the surface. All O_2 periods are 20 minutes in length interspersed with 5-minute air breaks. Up to three O_2 period extensions may be used at 18 msw and/or 13.6 msw; peak ppO_2 at 18 msw = 284 kPa.

TT160

This begins with a deep compression to 160 fsw (48.4 msw; 588 kPa) on air. Upon reaching 48.4 msw, the patient is placed on a 50/50 N_2/O_2 gas mix for 30 minutes, followed by a slow staged decompression to 18 msw where the gas is changed to 100% O_2. The schedule thereafter is as for TT60; peak ppO_2 at 48.4 msw = 294 kPa; at 18 msw = 284 kPa.

TT220

This begins with deep compression to 220 fsw (66.6 msw; 774 kPa) on air. Upon reaching 66.6 msw, the patient is placed on a 65/35 N_2/O_2 gas mix for 15 minutes, followed by a slow staged decompression to 45.4 msw where the gas mix is changed to 50/50 with a still slower staged ascent to

Table 2. Dive, symptom and treatment characteristics of 28 cases (all divers but 11 and 13 were diving on air; numbers in parentheses after dives represent

Diver	Dive profiles	Symptoms	Onset* (min)	Delay† (min)	Physical findings	iFIS	Treatment regimen	rFIS
1	26 msw x 50 min 1:30 hr SI 9 msw x 50 min	Vt, N	300	1,320	Nystagmus (h,L) PI (R)	3	774 kPa x 3 284 kPa x 1 ENT eval [A,E]	1
2	50 msw x 8 min 3:00 hr SI 38 msw x 40 min	Vt, N	30	360	Nystagmus (h,L) PI (R) Hearing loss (s/n,R)	3	774 kPa x 2 284 kPa x 4 ENT/Neuro eval [A,Tp,E]	0
3	26 msw x 60 min	Vt, N, V	20	420	Nystagmus (h,L) PI (R)	3	774 kPa x 2 588 kPa x 1 284 kPa x 4	0
4	27 msw x 30 min (2) 0:45 hr SI 27 msw x 30 min	Vt, N, V, HL	30	240	Nystagmus (h,R) PI (L) Hearing loss (s/n,L)	3	774 kPa x 6 ENT eval [A,Tp,E]	0
5	23 msw x 56 min 1:10 hr SI 18 msw x 62 min	Vt, N, V	60	500	Nystagmus (h,L) PI (R)	2	774 kPa x 2	0
6	27 msw x 30 min (4)	Vt, N, V	10	165	Nystagmus (h,R) PI (L)	3	774 kPa x 1 588 kPa x 2 284 kPa x 3 ENT eval [A,Tp,E]	0
7	27 msw x 30 min (2) 18 msw x 40 min (2) SIs < 10 min	Vt, N, V	30	180	Nystagmus (h,R) PI (L)	3	774 kPa x 4 284 kPa x 3 ENT eval [A,Tp,E]	0
8	30 msw x 25 min (2) 26 msw x 25 min (2) 15 msw x 25 min (2) SIs < 10 min	Vt, N, V	25	180	Nystagmus (h,R) PI (L)	3	774 kPa x 2 284 kPa x 5	1
9	35 msw x 15 min 1:15 hr SI 27 msw x 25 min	Vt, N, V, HL	20	360	Nystagmus (h,L) PI (R) Hearing loss (s/n,R)	3	774 kPa x 2 284 kPa x 5 ENT/Neuro eval [A,Tp,E]	1
10	20 msw x 60 min 1:00 hr SI 18 msw x 50 min	Vt, N, V	960	480	Nystagmus (h,L) PI (R)	2	774 kPa x 1 284 kPa x 3 ENT eval [A,E]	0
11	54 msw x 180 min Deco time 105 min	Vt, N, V	100	430	Nystagmus (h,R) PI (L)	3	774 kPa x 2	0
12	27 msw x 44 min	Vt	15	420	Nystagmus (h,L) PI (R)	3	774 kPa x 3 284 kPa x 1	1
13	60 msw x 74 min Deco time 28 min	Vt, N, V	120	450	Nystagmus (h,L)	2	284 kPa x 1	0
14	56 msw x 26 min Deco stops: ad hoc Rapid ascent IWR@ 6 msw x 20 min (37% nitrox)	Vt, N, V	10	720	PI (R)	2	774 kPa x 1	0

*time to onset of symptoms post dive; †delay from onset of symptoms to treatment
iFIS – initial functional impairment score; rFIS – residual functional impairment score
Dive profiles: SI – surface interval; IWR – in-water recompression
Symptoms: Vt – vertigo; N – nausea; V – vomiting; HL – hearing loss; T – tinnitus
Physical findings: h – horizontal; t – torsional; R – right; L – left; U – upper; s/n – sensorineural; PI – postural imbalance
Investigations: A – audiogram, Tp – tympanogram, E – electronystagmogram

of confirmed or probable isolated inner ear decompression illness
the number of dives; if decompression stops were done, the total stop times are shown)

Diver	Dive profiles	Symptoms	Onset* (min)	Delay† (min)	Physical findings	iFIS	Treatment regimen	rFIS
15	15 msw x 40 min	Vt, N, V	10	360	Nystagmus (h,R) PI (L)	3	774 kPa x 1 588 kPa x 1 284 kPa x 4 ENT/Neuro eval [A,E]	0
16	60 msw x 30 min	Vt, N, V, HL, T	10	360	Nystagmus (h,L) PI (R) Hearing loss (s/n,R)	3	774 kPa x 1 588 kPa x 1 284 kPa x 4 ENT eval [A,Tp,E]	1
17	27 msw x 40 min	Vt, N, V, HL	30	140	Nystagmus (h,R) PI (L) Hearing loss (s/n,L)	3	774 kPa x 1 243 kPa x 25 ENT eval [A,E]	1
18	33 msw x 30 min (2) 24 msw x 30 min (2) 18 msw x 40 min 21 msw x 30 min SIs < 10 min	Vt, N, V, HL	60	720	Nystagmus (t,U) PI (L) Hearing loss (s/n,L)	3	284 kPa x 2 243 kPa x 3 ENT/Neuro eval [A,Tp,E]	1
19	33 msw x 15 min (2) 39 msw x 10 min 23 msw x 40 min (4) SIs < 10 min Deco time (last dive) 12 min	Vt, N, V	30	360	Nystagmus (h,L) PI (R)	3	588 kPa x 2 ENT eval [A,E]	0
20	27 msw x 50 min 1:00 hr SI 18 msw x 50 min	Vt, N, V	60	550	Nystagmus (h,L) PI (R)	3	774 kPa x 1 284 kPa x 1 Echocardiogram	0
21	48 msw x 48 min Deco time 20 min 1:27 hr SI 43 msw x 56 min Deco time 24 min	Vt, N, V	30	360	Nystagmus (h,L) PI (R)	3	774 kPa x 2 284 kPa x 1 ENT eval [A,E]	0
22	33.5 msw x 24 min 0:35 hr SI 13.5 msw x 34 min	Vt, N, V	10	480	Nystagmus (h,R) PI (L)	2	774 kPa x 1 ENT eval [A,E]	0
23	16.5 msw x 35 min 0:15 hr SI 15 msw x 45 min 23 msw x 35 min	Vt, N, V, HL, T	20	2,110	Nystagmus (h,L) PI (R) Hearing loss (s/n,R)	2	284 kPa x 4 ENT eval [A,Tp,E]	1
24	24 msw x 40 min Deco time 4 min	Vt, N, V, HL	15	180	Nystagmus (h,R) PI (L) Hearing loss (s/n,L)	3	774 kPa x 1 284 kPa x 1	0
25	27 msw x 30 min Loss of buoyancy Rapid ascent	Vt, N, HL	10	1,440	PI (L) Hearing loss (s/n,L)	2	774 kPa x 1	0
26	27 msw x 30 min	Vt, N, V	30	140	Nystagmus (h,R) PI (L)	3	588 kPa x 1 243 kPa x 16 ENT eval [A,Tp,E]	1
27	21 msw x 30 min	Vt, N, V	20	120	Nystagmus (h,L) PI (R)	3	774 kPa x 1 242 kPa x 7 ENT eval [A,E]	0
28	18 msw x 41 min 1:41 hr SI 12 msw x 52 min	Vt, HL	10	1,440	Nystagmus (h,L) PI (R) Hearing loss (s/n,R)	3	774 kPa x 7 ENT/Neuro eval [A,E]	0

18 msw where the gas is changed to 100% O_2. The schedule thereafter is as for TT60; peak ppO_2 at 66.6 msw = 271 kPa; at 45.4 msw = 281 kPa; at 18 msw = 284 kPa.

TT47

A few cases received follow-up treatments at 47 fsw (14 msw, 243 kPa), 100% O_2, four O_2 periods of 20 minutes each.

Results

A total of 61 possible cases presented with at least vertigo, nausea and/or vomiting or had been previously classified as IEDCI. Of these, 28 presentations in 26 divers were ultimately determined to be confirmed or probable cases of isolated IEDCI. Five cases originally classified as having isolated IEDCI were reclassified as having a more global DCS problem as a result of this review. The 28 cases of isolated IEDCI constituted 2.8% of all cases treated for decompression illness (DCI) at the HTC, an average case rate of 1.2 per year. All were male divers with an average age of 46 years (range 20–77 years).

The breathing gas was compressed air in 26 of the 28 cases, and trimix (helium, nitrogen, oxygen) in the other two cases. The average dive depth was 32.7 msw (108 fsw) with a range of 15–60.6 msw (50–200 fsw). Twenty-two cases made multiple deep dives in rapid succession (with surface intervals of less than 10 minutes) for extended periods of time, or single decompression dives without making decompression stops at all, or not achieving adequate decompression or exceeding no-decompression limits. Six cases developed symptoms after 'routine' dives to depths ranging from 15–27 msw (50–90 fsw) that were either at the edge of the no-decompression limits or within them. Three of these 'routine' dive cases appear to have embolised, which may explain their particular circumstances. The average time to onset of symptoms was about 70 minutes post dive (range 10–960 minutes, median 25–30 minutes).

The specific dive profiles for each case, as well as initial symptoms and their time to onset after diving are shown in Table 2. The dive profiles are listed in the sequence in which they occurred, with surface intervals, when undertaken, shown where they actually were effected. Only six divers (Divers 11, 13, 14, 19, 21 and 24), including the two mixed-gas divers, undertook decompression stops on any of their dives.

Divers 15, 25, and 28 were thought to have had arterial gas emboli from pulmonary barotrauma as the mechanism of injury leading to their specific symptoms and physical findings. Significant histories supporting this contention were, respectively, a breath-hold ascent, loss of buoyancy control with rapid ascent, and asthma with demonstrated air trapping on lung scan.

Initial reported symptoms in decreasing order of frequency were vertigo (28/28), nausea (26/28), vomiting (23/28), hearing loss (9/28), and tinnitus (2/28). The two cases who experienced tinnitus also suffered hearing loss. There were no cases in which hearing loss alone was a presenting problem.

Table 2 also depicts the delay to treatment time from onset of symptoms, the relevant physical findings, the iFIS, the treatment regimen to include any additional expert evaluations and the rFIS at the time of discharge. The average time delay to treatment was 9 hours (range 2–35 hours, median 6 hours).

On physical examination, 27 cases were found to have postural imbalance, 26 had nystagmus, 10 had hearing loss, and two complained of tinnitus. None of the 28 cases had a history of difficulty with equalisation during descent or ascent, ear blockage, or ear fullness, nor did they evince physical findings of middle ear barotrauma or tympanic immobility on physical exam. All were able to autoinflate their middle ears without difficulty.

The finding of nystagmus was accomplished using a combination of physical exam to include use of Frenzel lenses, and in some cases only after electronystagmography (ENG) was performed by an otologist. All except divers 14, 18, and 25 demonstrated horizontal nystagmus with the fast component in the direction as listed in Table 2. The finding of an upward, torsional nystagmus in diver 18 was confirmed by both an evaluating otologist and neurologist, both of whom believed the lesion was peripheral. Likewise in those cases where ENG was performed, peripheral vestibulopathy was confirmed. In divers 14 and 25, nystagmus was not clinically detected nor studied by ENG.

Postural imbalance was assessed based upon the inability of the patient to stand or ambulate without falling, and, if capable, on performance of Romberg's test, one-leg standing, Fukuda's test, Unterberger's test and heel-toe walking. More than half of these patients initially presented with prostrating vertigo and were able to be more fully tested only after the initial recompression treatment. Direction of leaning or falling on exam is recorded in Table 2. In all cases except divers 14 and 25, the direction of fall or leaning with postural imbalance was in the opposite direction to the fast phase of nystagmus as determined on examination or ENG.[16]

Hearing was routinely tested using standard tuning forks (Weber, Rinne, Schwabach tests), and in the 10 cases with hearing loss, sensorineural loss was suggested based upon findings of absent bone conduction in one ear (N = 8) and loss of both air and bone conduction in one ear (N = 2, with Rinne and lateralisation to the normal ear with Weber).[18] Interestingly diver 2 was found to have hearing loss even though he had not noted it as a complaint.

Eighteen (64%) cases, including eight of the 10 cases with hearing loss, were evaluated by an otologist at some point in their treatment regimen with testing via audiogram, ENG, and tympanography as deemed appropriate (Table 2). For those cases in which an audiogram was performed, a sensorineural hearing loss of 20 decibels or greater was observed (specifically reported in six of the eight cases as being in the mid- to high-frequency range).

Twenty-one cases had an iFIS of 3 on admission, indicating substantial limitations. The remaining seven cases had a moderate degree of impairment (iFIS = 2). Nineteen cases were discharged with an rFIS of 0, indicating full functional recovery, while nine were discharged with an rFIS of 1, indicating some mild residual symptoms principally manifest by a sense of motion sickness with rapid movement, a wide-based gait or some residual hearing loss. Five of the 10 cases who presented with hearing loss still had some hearing deficit at the time of discharge, though all had improved clinically. No post-discharge audiological evaluations were available for review.

The sequence of recompression treatments is shown in Table 2 in the order in which they occurred as well as the number of treatments. The average number of treatments required was 5 (range 1–26, median 4–5). All but three cases were initially treated on one of the HTC deep tables.[17] No specific rationale for why two of these three cases were not treated on a deep table could be ascertained from review of the records. Diver 13 was treated on the TT60 (284 kPa) because his symptoms had appreciably resolved prior to his arrival at the HTC. He was the only one of the three treated at 284 kPa to be discharged with an rFIS of 0.

Two patients actually suffered this injury twice each, one with a four-year interval between episodes and the other with a five-year interval (Divers 4, 17 and 9, 16 respectively). In both cases, the divers related that, prior to their latest injury, they had had some degree of residual hearing loss from their initial accident which had worsened acutely when they presented with their second episode of IEDCS. Only one patient in this study population had been evaluated for the possibility of having a PFO and that finding was positive.

Discussion

The history of the initial observations and the evolution of the establishment of IEDCS as a discrete clinical entity were very nicely summarised by Edmonds in a previous edition of this journal.[19] Prior to the early 1990s, this malady was thought to be mostly seen in those who undertook deep, mixed-gas diving and was rarely seen in compressed air divers. Doolette and Mitchell recently described the possible biophysical basis for the development of inner ear DCS in deep, mixed-gas divers.[20] In the past two decades, however, reports have emerged suggesting that isolated IEDCI may also be seen in recreational divers using compressed air at shallower depths than had been noted previously.[9,10] In a later series of 29 sport divers using compressed air, 28 evinced isolated inner ear DCS.[11]

Thus, it is reasonable to conclude that while isolated IEDCI was predominantly seen in deep, mixed-gas divers, it was not exclusively confined to those divers and may have been more common than previously thought and simply not reported. Indeed, this case series includes 12 cases who were treated in the 1980s. It could also have been that actual cases of IEDCI occurring in air-breathing divers were dismissed as improbable and assigned to another diagnosis because the then published literature implied that it could not happen in air divers or, if it did, only in very rare circumstances, even though some of the earliest accounts of this problem had actually been observed in air divers.[1,5,6] Since that time, there has been a substantial increase in the numbers of recreational divers, most of whom continue to use air as their breathing medium, and so it stands to reason that there might be an increase in the numbers and frequency of this entity as a result.

One of the major challenges to unmasking this condition is the ability to clarify the diagnosis of IEDCI and differentiate it from inner ear barotrauma, which can present with similar symptoms.[21] Oftentimes this requires comprehensive audiological and vestibular testing (audiogram, tympanometry, electronystagmography) to more precisely and objectively evaluate and diagnose cases accurately. As was pointed out by Wong and Walker, it can be quite difficult to organise and execute precise and timely neuro-physiological testing when confronted with a patient who is acutely symptomatic and may need to be expeditiously recompressed.[8] This places the burden of making that initial assessment on the diving medical physician, who needs to ferret out the diagnosis based upon a careful and detailed history of the incident event(s) and a thorough and accurate physical exam.[22]

This study is hampered to some degree by the fact that only eighteen (64%) cases had additional audiological and neuro-physiological studies and/or evaluation. Such studies would have been particularly useful in diver 14, in whom nystagmus was not discernable, diver 24, with isolated hearing loss, and diver 25, who had neither discernable nystagmus nor hearing loss, as they may have provided additional objective findings upon which to predicate the diagnosis. However, the physical findings alone in most cases supported the diagnosis of an acute peripheral cochleo-vestibulopathy,[16] with IEDCI being the most likely underlying aetiology.

With the more recent reports, yet another perplexing and potentially significant association between the existence of a PFO and IEDCI has been suggested.[12–14] This implies that an isolated inner ear peripheral cochleo-vestibulopathy could result from direct embolisation of the anterior vestibular artery or its branches. This theory, if true, would support the mechanism of injury in cases 15, 25 and 28, suspected of having arterial gas emboli resulting in IEDCI. Since those initial PFO reports, only one case in which the diving history did not seem to support the development of IEDCI has been seen at the HTC. That patient was sent subsequently for contrast echocardiogram to evaluate the existence of a PFO, and the results were positive. In retrospect, it is possible that some of the divers with IEDCI following less than provocative dive profiles may also have had a PFO which may have contributed to their specific episodes. That question will necessarily go unanswered.

This case series reaffirms most of the findings of previous studies. The presenting symptoms and physical findings were not uniform.[4] The most common symptom was vertigo, followed by nausea and vomiting. With respect to physical findings, nystagmus and postural imbalance were the most common findings. Hearing loss was seen in only about one third of the cases, while both tinnitus and hearing loss were observed in just two cases.

The average depth of the incident dive might be considered to be shallow in comparison with previous reports.[9,10] However, the majority of cases emanated from multiple deep dives without surface intervals, thereby resulting in a considerable accumulation of inert gas, or from seriously violated dive tables with inadequate decompression. The average time to onset of symptoms in this study group was similar to that reported by Nachum et al.[11] Symptoms developed after the incident dive as opposed to during it, and none had experienced an event or had physical findings suggestive of otic barotraumas. This is a presentation more consistent with IEDCI than inner ear barotrauma.[22]

A rather stark relationship between delay to treatment and eventual outcome has been reported, with a delay in excess of 42 minutes resulting in residual inner ear dysfunction in that series.[6] This may explain those cases with residual impairment in this study but, conversely, the proportion of cases who obtained clinically observable recovery was slightly better than that of the findings of Nachum.[11] This suggests that the window of opportunity to effect meaningful treatment may be considerably longer than originally thought. Delay to treatment was most often a consequence of the logistics involved in transporting cases to Oahu from the neighboring islands.

Another recommendation in the study by Farmer was the use of deeper treatment schedules to treat IEDCS.[6] In all but three of the cases in this study, the deep treatment schedules routinely employed at the HTC were used. The use of the HTC deep tables in the majority of cases may explain the higher rates of clinical recovery in this study compared with the other series in which shallower treatment tables were employed.[6,11,23]

In this case series, there were no patients who failed to show some clinical improvement. Insofar as there is natural compensation for such injuries mediated via the cerebellum that occurs over time, it may be difficult to ascribe clinical recovery to treatment alone. Typically, it is believed that most vestibular end-organ injuries result in permanent damage and that full compensation may take two to four weeks to occur.[24] That most cases clinically improved within a week's time of recompression therapy may indicate only that it accelerated the normal compensatory mechanisms. However, given the significance of this injury, it is doubtful that any diving medical officer would rely solely on spontaneous recovery and not treat these cases with recompression. Recovery from a hearing deficit is best followed by serial audiological testing.

Finally, in the present series, the role of PFO cannot be elucidated since it was investigated in only one diver. Three cases were thought to result from direct embolisation.

Conclusions

IEDCI can and does occur in recreational scuba divers using compressed air. It accounted for nearly 3% of all DCI cases treated at the HTC, which was a lower frequency than that reported by others.[25] While IEDCI is more likely to occur after more extreme exposures to depth and dive times, it may occur from shallower exposures and from embolisation. Significant impairment with a high potential for permanent incapacitation exists for those cases not treated early and aggressively to include complete initial and follow-up oto-neurological evaluation and testing. Our view is that, in line with Farmer et al,[6] deeper treatment schedules should be employed to treat IEDCI whenever possible. In the light of recent evidence, divers with IEDCI should probably undergo contrast echocardiography to exclude PFO, especially those for whom there is not a more compelling explanation to account for their symptoms.[12–14]

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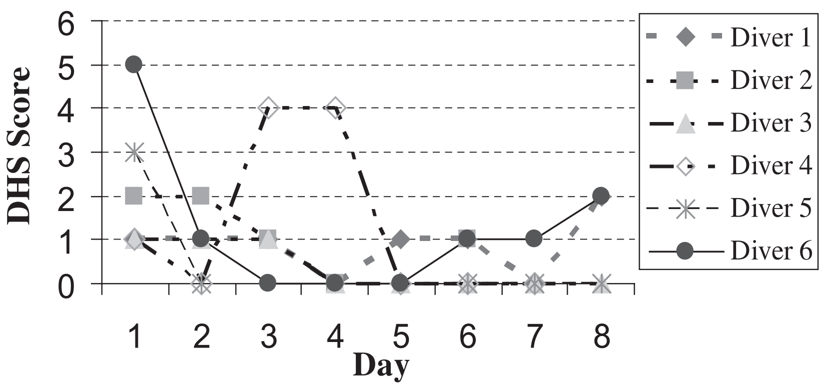
Richard W Smerz, DO, MTMH
Clinical Professor, Undersea and Hyperbaric Medicine
Medical Director, Hyperbaric Treatment Center
University of Hawaii John A Burns School of Medicine
347 North Kuakini Street
Honolulu, Hawaii 96817
Phone: *+1- (0)808-587-3425*
Fax: *+1- (0)808-587-3430*
E-mail: *<rsmerz@htchawaii.com>*

Figure 2
Diver health scores (DHS – Diver Health Status)



Erratum

Fock A. Health status and diving practices of a technical diving expedition. *Diving and Hyperbaric Medicine*. 2006; 36: 179-85.

Figure 2 did not reproduce correctly, and is republished here.

Sensation-seeking personality traits of navy divers

Charles H van Wijk

Key words
Psychology, personality, occupational diving, survey

Abstract
(Van Wijk CH. Sensation-seeking personality traits of navy divers. *Diving and Hyperbaric Medicine*. 2007; 37: 10-15.)
Objectives: This study investigated whether the sensation-seeking traits of naval divers differ from those of the general population, naval personnel in general, and sport divers.
Methods: A total of 66 South African naval divers, 716 general naval personnel, and 22 sport divers completed the Sensation Seeking Scale, version V. Their scores were further compared with those of other published studies.
Results: Naval divers scored the same as the general norm population (US students), higher than the general naval sample on total scores and on the Thrill and Adventure Seeking (TAS) and Experience Seeking subscales, and the same on the Disinhibition (DI) and Boredom Susceptibility (BS) subscales. Naval divers further scored higher than sport divers on the TAS subscale, but lower on the DI and BS subscales.
Discussion: Naval divers do not pursue sensation seeking indiscriminately, but are nonetheless characterised as more thrill and adventure seeking than other general navy and civilian diving groups. The study also highlighted the role of national culture when using normative scores for comparisons.

Introduction

BACKGROUND

Do divers dare to live dangerously? Anecdotally, divers are seen as having unique characteristics, and previous studies into the sensation-seeking or risk-taking personality traits of divers have investigated military divers, occupational divers, and recreational divers.[1–3] The trait of sensation seeking has been defined as "*the need for varied, novel and complex sensations and experiences and the willingness to take physical and social risks for the sake of such experience*".[4] These studies used the Sensation Seeking Scale (SSS), which, apart from the total score, also provides for four subscale scores, namely Thrill and Adventure Seeking (TAS), Experience Seeking (ES), Disinhibition (DI), and Boredom Susceptibility (BS).[5]

Military divers were significantly more thrill and adventure seeking, and significantly less experience seeking and disinhibitory than the published male norm groups at the time.[1] Civilian sport divers, similarly, were significantly more thrill and adventure seeking, and experience seeking, and significantly less susceptible to boredom (with a trend to less disinhibition) when compared with norm groups.[3] Other surveys into the characteristics of divers concluded that "divers tend to gamble, take risk, and seek adventure".[6] While these studies all indicate that divers may have stronger risk-taking tendencies (which is not necessarily synonymous with sensation seeking), they are problematic in that the comparison groups are often the 'general population' (e.g., younger student samples in the above cases).

This suggests that the question as to what extent divers per se are sensation seekers or risk takers, may be relative simply to the extent that they may reflect the environment in which they live or work. In effect, it could be asked how much divers as a group differ from other normative groups they relate to, such as other high-risk sports or other military groupings.

It has also been reported that different groups of high-risk sportsmen (including alpinists, mountain skiers, scuba divers, white-water canoeists, parachutists, hang-glider pilots, and motorcycle racers) all tend to exhibit the same sensation-seeking profile; in other words, they did not differ amongst themselves, but they differed significantly from the general population.[7] While that sample included divers, there were no exclusive diver groups. To achieve a more definitive indication of the sensation-seeking traits of recreational divers, they would need to be compared with other amateur sportsmen who also engage in high-risk sports. The same would apply to comparing commercial divers with other high-risk occupational groups (e.g., pilots).

In the case of navy divers, it could be argued that young people are attracted to the navy in pursuit of adventure, or because they wish to experience new people and places (in line with the old adage of 'join the navy and see the world'). If navy divers then display elevated sensation-seeking tendencies, these may simply be an extension of a navy profile in general, and may not necessarily imply that navy divers are more sensation seeking than other naval groups. Therefore, to understand the sensation-seeking traits of navy divers better, they need to be compared with other groups within the navy.

Further, it is possible that national cultural differences may exist between groups of different countries. Sensation-seeking measures of navy divers from any particular country could thus reflect cultural influences, and would, therefore, need to be compared with scores obtained from their countrymen (e.g., sport divers from the same cultural background).

PURPOSE OF THIS STUDY

This study uses the SSS to compare a sample of South African Navy (SAN) divers with other related groups. The analysis of the data focuses on four questions:

1 Are SAN divers different from the general population? In other words, is it possible to talk of the sensation-seeking nature of navy divers?
2 Are navy divers different from the general navy? In other words, do their scores reflect something of the diving environment, or simply their military background?
3 Are navy divers different from sport divers? In other words, is sensation seeking common in the diving fraternity?
4 What is the role of national culture in the scores of particular groups across countries?

Methods

PARTICIPANTS

As mentioned, there were three groups of participants. SAN divers were invited to complete the SSS-V, and they did so anonymously after giving written informed consent. The SSS-V was completed in small groups, and the divers also provided demographic data referring to age, years of service, years qualified as military divers, and gender. Only divers on active diving duty, with at least one year of operational experience post qualification, were included. All the divers invited agreed to participate.

The rest of the navy participants were recruited through visits to their units. All participation was voluntary and occurred after informed consent was given. The general navy sample is representative of the fleet (in the age group 18–35 years) in terms of age, gender, years of naval service, and occupational class, although it excluded any submariners. The groups are described in Table 1.

The SA sport divers were recruited through local diving clubs, and they completed the SSS-V during visits to the clubs. They also provided information regarding their age, academic qualification, years qualified as divers, frequency of diving, and gender.

INSTRUMENT

Zuckerman's Sensation Seeking Scale – V was used.[5] It is a self-report questionnaire consisting of 40 forced-choice items. Respondents are asked to choose which of two statements best describes their interests or preferences. It provides a total, and four subscale scores. The scale has good psychometric properties, and is described in detail elsewhere.[5,8] The four subscales were described as follows:[9]

Thrill and Adventure Seeking (TAS) items indicate a desire to engage in risky and adventurous activities and sports that provide unusual sensations. The basic theme is summarised in the item "I sometimes like to do things that are a little frightening".

Experience Seeking (ES) items represent the seeking of stimulation through the mind and the senses, through music, art, travel and even psychedelic drugs.

Disinhibition (DI) items describe the seeking of sensation through drinking, partying, gambling, and sexual variety. It represents a kind of impulsive extraversion empirically associated with psychopathy and hypomania.

Boredom Susceptibility (BS) items do not represent a style of sensation seeking as much as an aversion to repetitive experience, whether in work or with other persons, and manifest in restlessness and boredom when such constancy is unavoidable.

Table 1
Description of composition of the South African Navy sample

Branch	Description	N	Sex (%) Male	Sex (%) Female
Divers	Qualified naval divers*	66	95	5
General navy sample	Sailors representative of fleet†	716	70	30
Technical	Mechanical, electrical, radio/radar technicians	100	92	8
Protection force	Harbour and naval installation security	89	81	19
Catering	Chefs and stewards	81	59	41
Communication	Communicators, signalmen	60	47	53
Administrative	Personnel and logistical clerks	96	49	51
Mine counter-measure	Mine counter-measure sailors	27	93	7
Combat officers	Line officers on sea-going vessels	57	86	14

*does not include any officers
†comprises all the participants from the listed occupational groups, as well as participants in other occupational groups that were not large enough to analyse individually

Table 2
T-score comparisons for South African Navy divers and the general South African Navy sample with a reference norm group[5] (see text for explanation, *p < 0.01)
(TAS – thrill and adventure seeking; ES – experience seeking; DI – disinhibition; BS – boredom susceptibility)

	Total		TAS		ES		DI		BS	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Navy divers	49.83	8.64	48.98	16.31	49.52	8.03	49.88	7.60	50.48	8.30
General navy	42.26*	9.09	30.35*	14.04	44.51*	8.53	47.80*	9.49	49.42	9.46

DATA ANALYSIS

To answer the first question, the navy divers were compared with the published norm group, using t-test for single samples.[5] The original norm group were presented using T-scores, and the scores of the present sample were converted to T-scores to allow comparison. T-scores are standardised scores, with a set mean of 50, and a set SD of 10.

To answer the second question, the navy divers were compared with eight other branches of naval occupations, as well as with a "general SAN" sample. To place this within the national cultural context (in answer to the fourth question), the navy sample was further compared with the scores of other military recruits.[2] Differences between the navy diver group and the other naval occupation groupings were analysed using ANOVA, with Tukey's post hoc test.[10] Comparisons with the scores of other previously published groups were analysed using t-test for single samples.

To answer the third question, the navy divers were compared with a group of SA sport divers, using t-test for independent samples. To place this again within the national cultural context, the navy sample was also compared with the scores of USA sport divers.[3] To further explore whether there were differences between professional and amateur divers, the navy divers were also compared with commercial divers.[2] Finally, the scores of the navy divers were compared with published reports of sport and commercial divers using single sample t-tests.

The data analysis comprises of a number of statistical analyses, creating the potential of Type I errors. To counter this, it was decided to use the $p < 0.01$ level to indicate significance.

Results

GENERAL POPULATION REFERENCE GROUP

Table 2 presents the single sample t-test analysis using T-scores. The referent group norms are published in Zuckerman (1994).[5] There were no significant differences between the scores of the SAN divers and the published norm group. This was unexpected, and led to a comparison of the general navy group's scores with those of the norm group (using the same technique). This revealed that the SA navy had lower scores on all the markers than the norm group (only BS was not significant at $p > 0.01$).

SA NAVY

The navy divers had a mean age of 25.4 (± 5.2) and the mean age of the general navy group was 25.1 (± 4.0). There were

Table 3
Zuckerman's Sensation Seeking Scale – V: means and standard deviations of the South African Navy sample (see text for statistical results)
(TAS – thrill and adventure seeking; ES – experience seeking; DI – disinhibition; BS – boredom susceptibility)

Branch	N	Total score		TAS		ES		DI		BS	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Divers	66	19.08	5.67	8.91	1.25	5.02	1.89	3.29	2.63	1.91	1.77
General navy sample	716	14.35	5.39	6.00	2.70	3.92	1.75	2.71	2.11	1.71	1.55
Technical	100	15.07	5.69	6.19	2.64	4.17	1.71	2.86	2.28	1.86	1.70
Protection force	89	12.85	4.46	5.34	2.51	3.44	1.57	2.81	1.77	1.28	1.26
Catering	81	13.60	4.73	5.93	2.64	3.83	1.76	2.26	2.02	1.57	1.15
Communication	60	12.83	5.19	5.45	2.95	4.10	1.80	1.97	2.02	1.32	1.35
Administrative	96	13.19	5.31	5.50	2.77	3.82	1.77	2.41	2.13	1.47	1.32
Mine counter-measure	27	14.41	5.52	5.26	2.49	3.59	1.55	3.67	2.11	1.89	1.67
Combat officers	57	17.21	5.01	7.37	2.33	4.26	1.49	2.82	2.17	2.75	1.97

also no significant age differences across the subgroups. Gender composition differed across all the groups though, and there were fewer women among the divers than in most of the other groups. The scores of the subgroups are presented in Table 3.

There were significant differences in the total SSS scores of the different occupational groups ($F(8,629) = 11.77$; $p < 0.01$). The navy divers' total SSS scores were significantly higher than those of the technical, protection, catering, communications, administrative, and the mine counter-measures branches ($p < 0.01$ for each). In terms of the total score, there was no significant difference between navy divers and combat officers ($p = 0.6$), mostly due to the combat officers' elevated scores on the BS subscale. However, in total, navy divers scored significantly higher on the SSS than the general navy ($t = 6.83$; $p < 0.01$).

The TAS subscale showed significant differences between the different naval branches ($F(8,629) = 16.95$; $p < 0.01$). Navy divers scored significantly higher than sailors from the technical, protection, catering, communications, administrative, and mine counter-measures branches ($p < 0.01$ for each), and tend to score higher than the combat officers branch. The divers also scored significantly higher than the general navy sample ($t = 8.77$; $p < 0.01$).

There were significant differences between the different naval branches on the ES subscale ($F(8,629) = 5.09$; $p < 0.01$). Navy divers scored higher than sailors from the protection, catering, administrative, and mine counter-measures branches ($p < 0.01$ for each), and tended to score higher than the technical branch ($p < 0.05$). They further scored significantly higher than the general navy sample ($t = 4.86$; $p < 0.01$).

With regard to DI scores ($F(8,629) = 3.38$; $p < 001$), navy divers tended to score higher than the communications branch ($p < 0.05$) and the general navy ($t = 2.08$; $p < 0.05$).

On the BS subscale ($F(8,629) = 6.07$; $p < 0.01$), navy divers tended to score lower than the combat officer sample ($p < 0.05$).

OTHER MILITARY REFERENCE GROUPS

The means and standard deviations of the SAN divers and Norwegian military recruits can be found in Table 4.[2] The SAN divers scored higher on TAS ($p < 0.01$), but lower on DI and BS ($p < 0.01$). The Norwegian group may not be such a useful comparison, though, as they differed (by obtaining higher scores) from all the South African navy groups on all the markers ($p < 0.01$).

The study of Biersner and LaRocco (30 military divers, mean age 29.6) used a previous version of the scale (the 72-item SSS-IV), ruling out direct comparisons with US Navy divers.[1] They do, however, present the same trend as the current group of SAN divers (higher in TAS, lower in ES, DI and BS than norm groups).

SPORT DIVERS

The means and standard deviations of the SAN divers and USA sport divers are presented in Table 4. The SAN divers scored higher on TAS ($p < 0.01$), but lower on ES, DI, BS, and total scores ($p < 0.01$ for each).

SAN divers and SA sport divers were also compared (Table 4). While their totals (and ES scores) were comparable, the SAN divers scored significantly higher on TAS ($p < 0.01$), but significantly lower on BS ($p < 0.01$) and had a tendency toward lower scores on DI ($p = 0.051$) than the SA sport divers.

SA sport divers scored significantly lower than USA sport divers for the total score, TAS and ES ($p < 0.01$ for each) of one study, and tend to score lower than USA sport divers on the total score ($p < 0.05$) of another study.[3,11] There were no significant differences for BS and DI (Table 4).

Table 4
Zuckerman's Sensation Seeking Scale – V: means and standard deviations of the South African Navy divers and six comparison groups
(TAS – thrill and adventure seeking; ES – experience seeking; DI – disinhibition; BS – boredom susceptibility)

	N	Total score	TAS	ES	DI	BS
SAN divers	66	19.08	8.91	5.02	3.29	1.91
General navy	716	14.35	5.94	3.98	2.69	1.71
Norwegian military recruits	28	20.89	6.61	4.75	5.82	3.71
USA sport divers[3]	30	22.5	8.5	6.1	5.1	2.7
USA sport divers[11]	29	22				
SA sport divers	22	18.73	6.05	4.95	4.50	3.23
European 'risky sportsmen'[12]	332	23.79	7.86	6.21	5.27	4.44

SA sport divers scored significantly lower than the sample of European 'risky sportsmen' (N = 332, which included mountaineers, skiers, scuba divers, white-water canoeists, parachutists, hang-glider pilots, and motorcycle racers) on the total score ($p < 0.01$), TAS ($p < 0.01$), and ES ($p < 0.01$), and tended to score lower on BS ($p < 0.05$) (Table 4).[12]

COMMERCIAL DIVERS

When compared with a small sample (N = 5) of Norwegian North Sea divers, the SAN divers tended to be more thrill- and adventure-seeking orientated, have the same inclination in terms of experience seeking, and have lower tendencies towards disinhibition and boredom susceptibility, and total sensation-seeking behaviour.[2]

Discussion

ARE SOUTH AFRICAN NAVY DIVERS DIFFERENT?

When compared with the general population, the SAN diver sample did not have a markedly different profile. However, as the SA naval group scored lower than the general norm population (USA students), and Norwegian military recruits, the lack of a 'navy diver profile' could be due to cultural differences. Their scores may need to be compared with a general (non-navy) SA population to establish whether they do indeed ascribe to a separate profile.

Elevated scores in respect of thrill- and adventure-seeking indicators seem typical of military diving. Within the SA context, the elevated thrill and adventure seeking is indicative of the diving context, and not merely a reflection of the military environment. The increased thrill- and adventure-seeking tendencies of SAN divers follow the military diving samples of other countries (who show higher thrill and adventure seeking, but lower experience seeking, disinhibition, and boredom susceptibility). The same trends appear when they are compared with US and SA sport divers, and with commercial divers. The military diving profile (in contrast to that of civilian sport and commercial diving) may thus have a tendency to look as follows: typically higher thrill- and adventure-seeking traits, with lower tendencies of experience seeking, disinhibition and boredom susceptibility.

IS SENSATION SEEKING A PARTICULAR TRAIT OF THE MILITARY CONTEXT?

Sensation seeking per se does not appear to be a strong indicator of SA servicemen and women. The SA Navy produced low disinhibition and susceptibility-to-boredom scores, which decreased their total sensation-seeking scores. This may be a function of the military itself. It is an organisation with strict environmental controls, in the form of the rules and regulations of the military, which discourage less socially acceptable forms of sensation seeking. Alternatively, the military norms of this culture may deem certain activities (like the use of alcohol) as totally acceptable, thereby reducing the need to engage in less socially acceptable activities when seeking new sensations. The significantly lower scores as compared with those of the Norwegian recruits may be a function of cultural differences.

IS SENSATION SEEKING A PARTICULAR TRAIT OF THE DIVING FRATERNITY?

All published samples of divers report elevated TAS scores compared with their controls, and sometimes report elevated total scores as well.[3,10,13] However, ES, DI, and BS scores are seldom significantly raised, and even decreased at times. This suggests that divers enjoy the thrill- and adventure-seeking aspects of sensation seeking, but seem less interested in the other forms of sensation seeking. The dangerous nature of diving may account for some of the lower disinhibition and boredom susceptibility scores: the careful planning required for high-risk activities (like diving) might attract individuals who are less inclined to disinhibitory activities, while the painstaking preparation that is necessary would lead to the natural attrition of individuals who are high in boredom susceptibility.

In conclusion, divers per se are not automatically high sensation seekers. Rather, navy divers are more thrill and adventure seeking than other navy groups and other diving groups, and high thrill and adventure seeking could therefore be seen as inherent to naval diving.

DOES NATIONAL CULTURE PLAY ANY ROLE?

This study highlighted the role of culture in comparing scores. The general navy sample scored lower than the general population (USA students) and Norwegian military recruits. SA sport divers further scored lower than US sport divers, and also lower than a sample of Europeans engaged in risky sports.

It could be argued that the SA naval sample was older, and had more responsibilities than the student sample (e.g., family commitments, work responsibilities). However, it is proposed that cultural background would also have played a significant role in the different scores. For example, in SA society, many young people join the military for its career prospects, and not in search of adventure. Many SA servicemen and women are further the primary caretakers of large, extended families, and may be averse to taking risks that may jeopardise their income or ability to fulfil their social responsibilities.

Differences between other international samples were previously demonstrated, and were attributed to differences in national culture.[14] Others ascribed cross-cultural differences between, for example, American and Arabic subjects, to their respective socialisation experiences, and suggested that the activities in the SSS may not be suitable for all cultural or national groups.[15] It was further reported that non-Western cultures scored lower on the total and subscale scores than Western countries.[16] This emphasises the need for national samples for norm groups, in order to compare results in a meaningful way.

Do divers dare to live dangerously? They do prefer to engage in thrill- and adventure-seeking activities, which is particularly true for navy divers. However, due to the risky nature of their profession or sport (and possibly their training to recognise it), they tend to prefer less disinhibitory activities, and those who persevere in diving furthermore seem less susceptible to boredom.

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

Address for correspondence:
17 Twelfth Avenue
Fish Hoek 7975, South Africa
Phone: *+27 21 787 4541*
E-mail: *<cvw@netactive.co.za>*

Review articles

The use of extraglottic airway devices in diving medicine – a review of the literature. Part 2: Airway management in a diving bell and deck decompression chamber

Christopher J Acott

Key words
Extraglottic airway devices, resuscitation, first aid, bell diving, disabled diver, medical kits, review article

Abstract

(Acott CJ. The use of extraglottic airway devices in diving medicine – a review of the literature. Part 2: Airway management in a diving bell and deck decompression chamber. *Diving and Hyperbaric Medicine*. 2007; 37: 16-24.)
Airway management and resuscitation in a diving bell (DB) or deck decompression chamber (DDC) are difficult due to the confined space, limited lighting and limited equipment. A review of currently available extraglottic airway devices was undertaken to determine which ones would be suitable for acute airway management in a DB or DDC. The review concentrated on ease of insertion and use, training required, protection against aspiration and gastric inflation, suitability for rescue breathing (RB) and spontaneous ventilation. The ones deemed suitable were then tested in a hyperbaric environment. Naspharyngeal or oropharyngeal airways, the classic laryngeal mask airway and the streamlined liner of the pharyngeal airway (SLIPA™) were found to be suitable for use in the DB or DDC. However, more data for the efficacy of the SLIPA™ in resuscitation or airway management of trauma is required.

Introduction

Airway management and resuscitation in a diving bell (DB, Figure 1) or deck decompression chamber (DDC) are difficult due to the confined space, limited lighting and rudimentary equipment.[1] A Medline search revealed that there are no recent case histories or data about emergency airway management or management of an unconscious diver in a DB or DDC, the only previous study being from 1981.[2] This issue is also not addressed in recent editions of the US Navy or National Oceanographic and Atmospheric Administration diving manuals.

Retrieval of the unconscious diver into the DB requires the use of a pulley system (Figures 2a and b). Once inside, the bell space limitations dictate that any resuscitative efforts are confined to the patient (diver) suspended in the upright position by the pulley system or lying upright against the side of the bell (Figures 3a to d).[1,3] Cardiopulmonary resuscitation (CPR) inside a DB is, therefore, extremely hard if not impossible to do. The procedure manual for the Comex Company recommends the insertion of an oropharyngeal airway (OPA) and the use of a cervical collar to stabilize the head. Rescue breathing (RB) with the patient upright suspended by a pulley or against the side of the bell would be difficult because the resuscitator is facing the patient. External cardiac compression (ECC) with the patient upright lying against the side of the bell could be performed with the resuscitator's hands but when the patient is suspended by the pulley the resuscitator is required to use his knee or head.[3] ECC in these positions would be ineffective considering that only between 5 and 20% of normal cardiac output can be achieved with the patient supine on a flat, hard surface.[4] Effective CPR can be performed inside a DDC because the patient is flat on a hard surface; however, the position of the resuscitator(s) relative to the patient is dependent on the size and shape of the chamber. Prevention of gastric aspiration in a DDC or DB is difficult. The risk, however, may be diminished in a DB because the patient is in the upright position.

Current airway management recommendations include the use of a Guedel or Brook airway, cervical collar, Laerdal pocket mask (LPM), a wooden screw (to be placed between the teeth if trismus is present) and a hand- or foot-operated suction.[3,5] The clinical circumstances (presence of trismus, available space, retrieval position of the patient) dictate the appropriate extraglottic airway device (EAD) to be used.

The Diving Medical Advisory Committee (DMAC, United Kingdom) suggested that the classic laryngeal mask airway (cLMA), size not specified, should be available if the diving medical technician is trained to use one.[5] The use of all cuffed EADs requires specialised care in a pressurised environment. Pressurisation will decrease the volume of the cuff, making it difficult to reinflate (Boyles' and Laplace's Laws), while during decompression it will expand necessitating the measurement of the intra-cuff pressure. The cuff volume/pressure will also change with gas diffusion as the gas mixtures breathed and chamber atmosphere change. The majority of these problems are overcome if water is added to the cuff prior to pressurisation. However, even if

Figure 1
Schematic of diving bell; note the hoist dangling through the bottom entry hatch

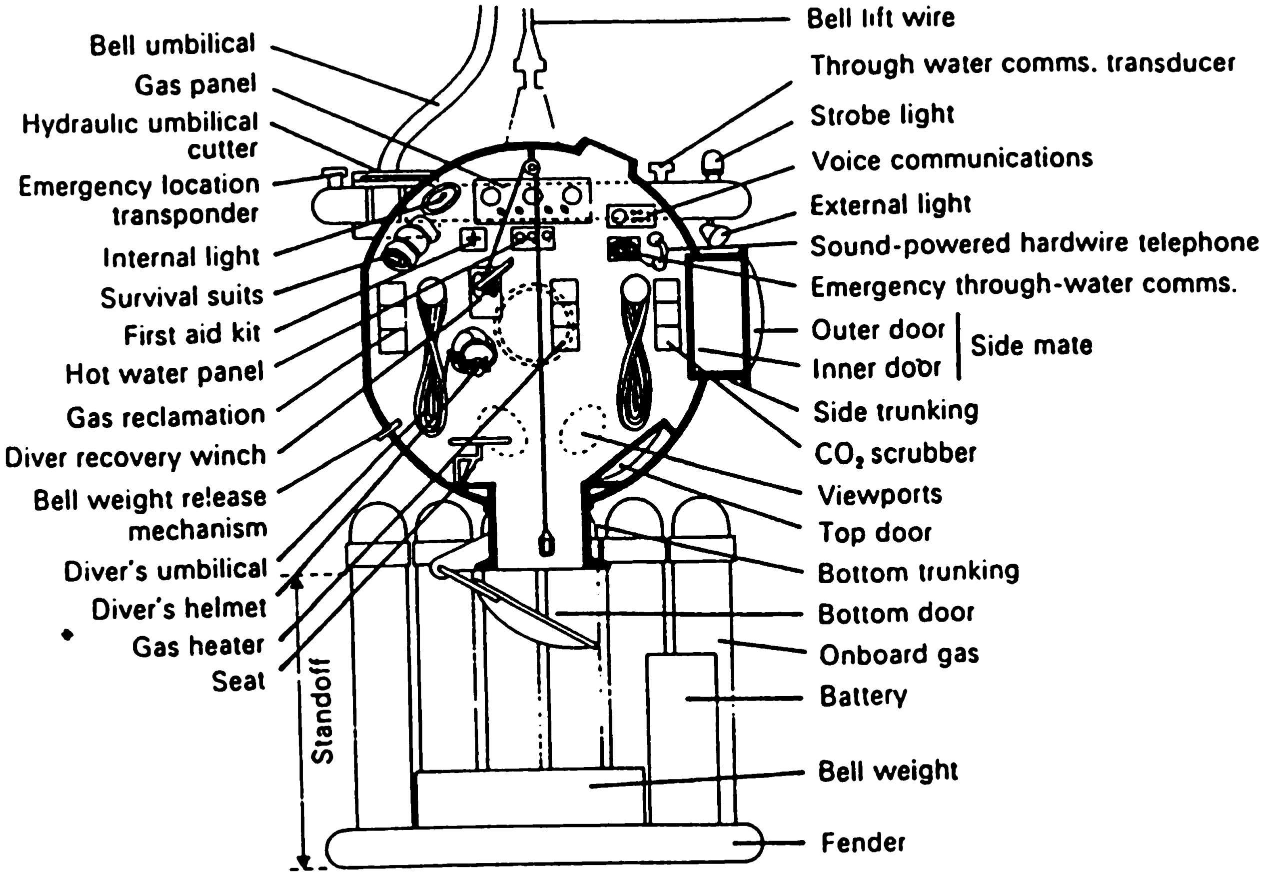
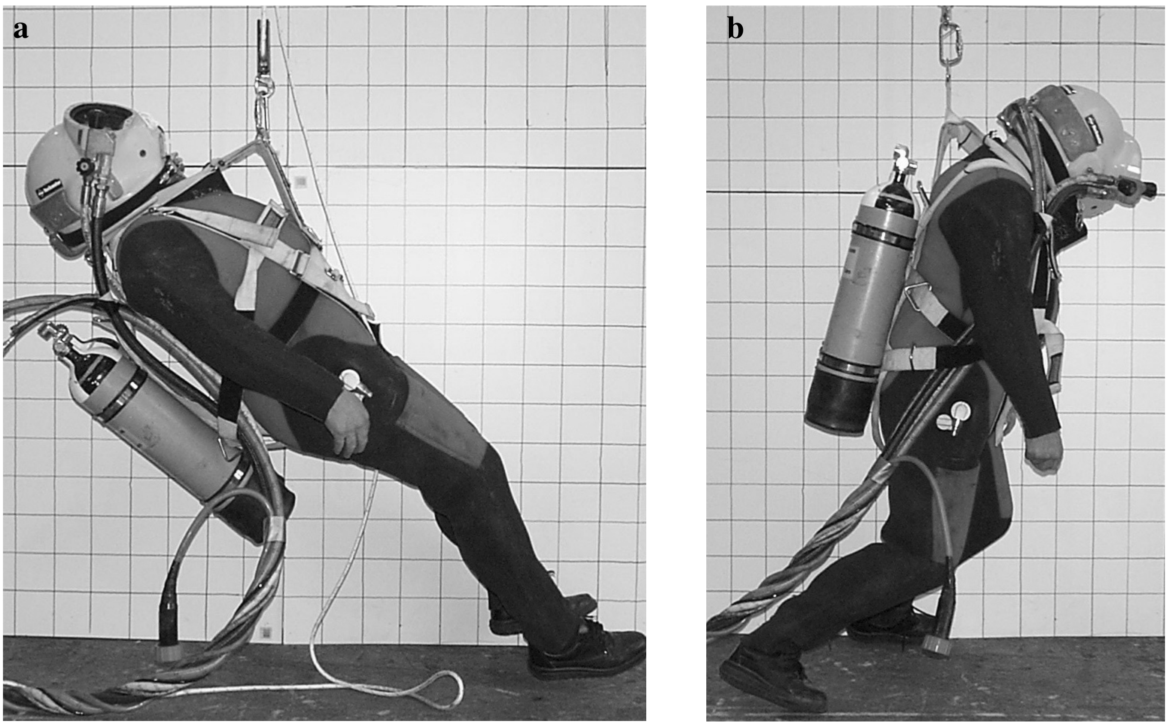


Figure 2
The diver may be lifted into the bell with the hoist attached either anteriorly (a) or posteriorly (b). This is often assisted by partial flooding of the bell to help float the diver through the hatch.



the cuff is filled with water the intra-cuff pressure will need to be monitored during decompression because not all air pockets will be completely eliminated. The DMAC made no recommendation concerning the management of the cLMA's cuff during compression or decompression.[5]

A study published in 2000 concerning simulated airway management during spaceflight has some implications for the management of the airway and unconscious diver in a DB or DDC because the space capsule has similar space and lighting limitations.[6] This study showed that intubation was difficult, while the cuffed oropharyngeal airway (COPA), cLMA or intubating LMA (iLMA) can be used successfully.[7] The COPA is no longer available. Limitations of the iLMA were discussed in the first part of this review article.[7]

DMAC specified that intubation equipment is to be at the dive site but not in the chamber.[5] Intubation is an acquired skill and retraining is necessary for skill retention. Therefore, it may be inappropriate for on-site personnel (including medical practitioners) to attempt if they rarely practise it. The aim of this paper was to decide which of the currently available EADs (listed in Table 1 of Part 1 of this review[7]) are suitable for emergency airway control in a DB or DDC using the criteria outlined in the left-hand column of Table 1 overleaf. The airway devices thought to be suitable were then tested in a hyperbaric environment. The majority of the available EADs are reviewed in Part 1 of this paper except oropharyngeal (OPA) and nasopharyngeal (NPA) airways and the Laerdal pocket mask, which are reviewed here.[7]

Literature review

OROPHARYNGEAL AIRWAYS (OPAs)

Guedel oropharyngeal airway (Figure 4)

The Guedel airway has a flange at the oral external end, a reinforced straight bite area (which fits between the victim's teeth) and a curved intraoral air channel, which follows the

Figure 3
The recovered diver partially (a and b) inside the bell with the bell-man maintaining the airway with the anterior and posterior hoist positions. In (c) the bell-man is barely visible behind the diver as he is hoisted into the bell.

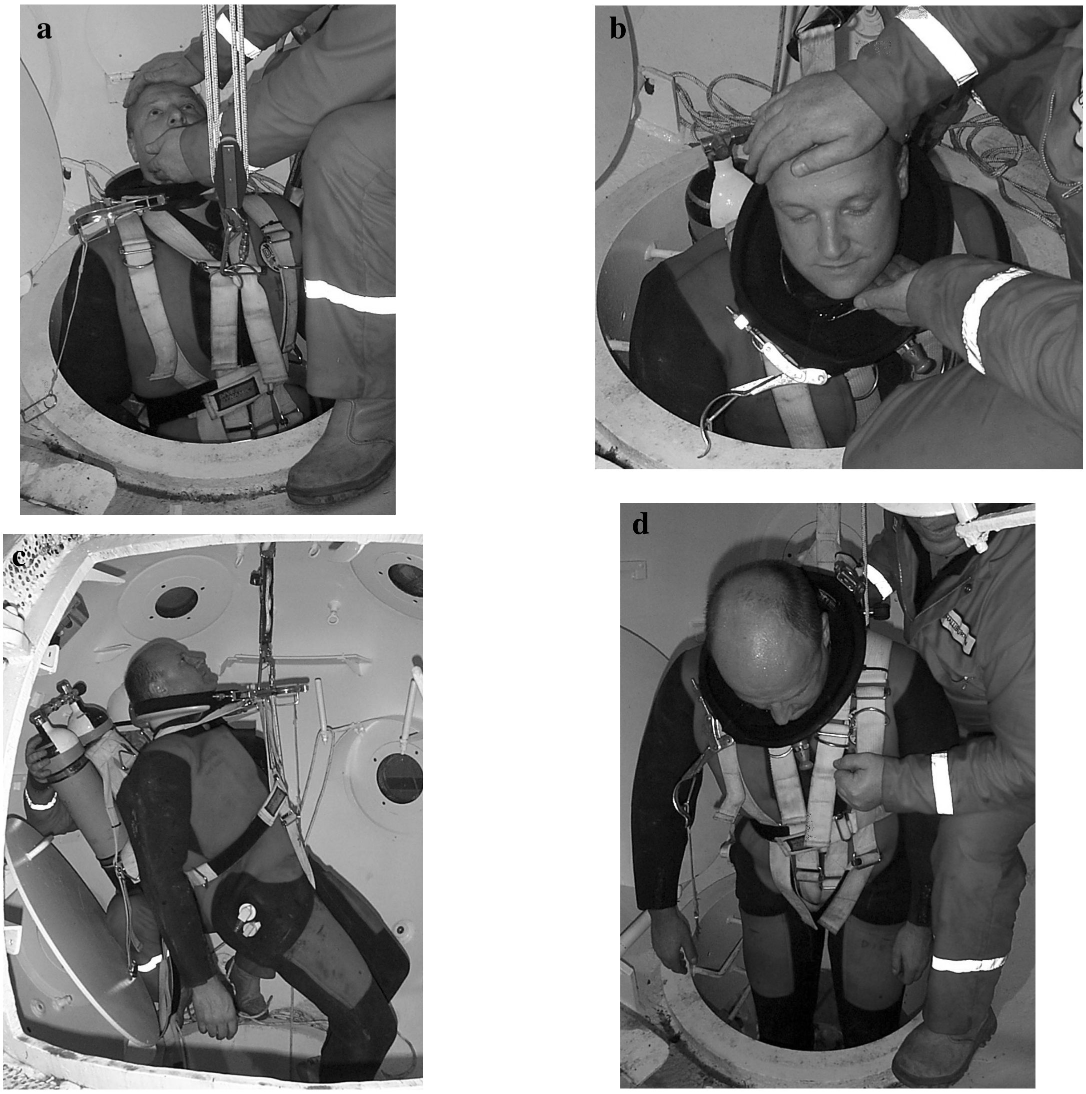


Figure 4
The Guedel oropharyngeal airway consists of three portions: the flange, the bite portion and the oral air channel; designed by Arthur Guedel in 1933, it is still the most used airway aid

contour of the tongue. It is manufactured in plastic in various sizes for paediatric and adult use. It is inserted easily and can be used in either spontaneously breathing patients or those requiring RB or bag mask ventilation (BMV).[8]

Brook airway (not shown)

The Brook airway was designed in 1962 to make RB "less unpleasant to perform".[9] It consists of a Guedel-shaped intraoral section, which is connected to a flange designed to maintain an airtight fit on the victim's mouth. There is an extraoral ventilating tube, which contains a one-way valve allowing the victim's expired air to exit through a short side arm. It is made of plastic and is easily inserted with the operator facing or behind the patient. The victim's jaw needs to be supported as with a Guedel airway. There are two sizes available – one for use in children aged less than 9 years with an intraoral section 4 cm in length, and the other for adult use 9 cm in length. Supplemental oxygen cannot be given.

Glossopalatine tube (Lifeway) airway (Figure 5)

The glossopalatine tube (Lifeway) airway is a variant of the Brook airway but has a side port for supplemental oxygen. It consists of a mouthpiece or 15 mm connector for the rescuer, a tube containing a non-rebreathing valve, a mouth sealing cap and an intraoral glossopalatine tube that can be tilted to displace the tongue from the posterior pharyngeal wall. The intraoral tube now has additional side holes to aid ventilation.[10] Complications associated with the use of an OPA are listed in Table 2.[8,11–13]

NASOPHARYNGEAL AIRWAY (Figure 6)

A nasopharyngeal airway (NPA) is the only EAD that can be used if the victim's mouth cannot be opened. It is a plastic tube designed to fit the curvature of the nasopharynx with a flange at the nasal end and a bevelled distal pharyngeal end. A safety pin is often used in the nasal end to prevent the disappearance of the NPA into the nose. It avoids dental damage and is better tolerated by a semi-conscious patient than are oral airways. Several sizes are available.[8]

Table 1
The desired characteristics of extraglottic airway devices (EADs) for use in a diving bell or deck decompression chamber and a comparison of nasopharyngeal and oropharyngeal airways, and the cLMA, SLIPA and COBRA EADs (LRT – lower respiratory tract; Nd – no data; Ld – limited data)

Characteristic	NPA	Guedel	Brook	Lifeway	cLMA	SLIPA™	COBRA
Simple to use	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Easily inserted	Yes	Yes	Yes	Yes	Yes	Ld	+/-
Easily stored	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Low resistance	+/-	+/-	+/-	+/-	Ld	Nd	Nd
Protects LRT	No	No	No	No	+/-	Ld	No
Stable once inserted	Yes	+/-	Yes	Yes	+/-	Yes	+/-
Cuffless	Yes	Yes	Yes	Yes	No	Yes	No
CPR friendly	Yes	Yes	Yes	Yes	Yes	Nd	Ld
Ease of training	Yes	Yes	Yes	Yes	Yes	Ld	Ld
Prevents aspiration	No	No	No	No	No	+/-	No
Prevents gastric inflation	No	No	No	No	No	Yes	No
Atraumatic insertion	+/-	Yes	Yes	Yes	Yes	+/-	Yes
Useful in trismus	Yes	No	No	No	No	No	No
Various sizes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Few complications	Yes	Yes	Yes	Yes	Yes	Nd	Nd

When correctly positioned, the NPA extends from the nares to end just above the epiglottis. In a study of 120 patients, there was no correlation between length of NPA needed and the victim's height and weight.[14] Interestingly, the majority of commercially available NPAs were too short. Other authors recommend that the length of NPA required approximates to the distance from the tip of the nose to the tragus of the ear plus 2.5 cm.[8] The complications noted with the use of NPAs are listed in Table 2.[8,15,16] The majority of these can be avoided by correct insertion technique:

1 Lubricate the airway
2 Select the patient's most patent nostril
3 Insert gently perpendicular to the face so that it will pass along the floor of the nostril
4 Force must not be applied if resistance is felt
5 To reduce trauma, rotation of the NPA 90˚ so that the bevel is in a posterior position has been recommended; this position is maintained until resistance is lost as it enters the nasopharynx
6 Rotate the NPA back 90˚.

Contra-indications to the use of an NPA include nasal and base-of-skull fractures and, in the clinical setting, choanal atresia, anticoagulation medication and previous cleft-lip surgery.[8,16]

Figure 5
The glossopalatine (Lifeway) airway is similar to the Brook airway but has the advantage of allowing supplementary oxygen through the side port

LAERDAL POCKET MASK (Figure 7)

The Laerdal pocket mask (LPM) can be used for RB if the rescuer is situated near the victim's head. It requires jaw support and/or the use of an NPA or Guedel airway. One-rescuer use in a DB or DDC would require it to be repositioned each time RB is attempted. Therefore, it is not recommended for use in a DB but can be used in a DDC if there are two rescuers. The cuff needs to be filled with water prior to compression to maintain its integrity in a pressurised environment.

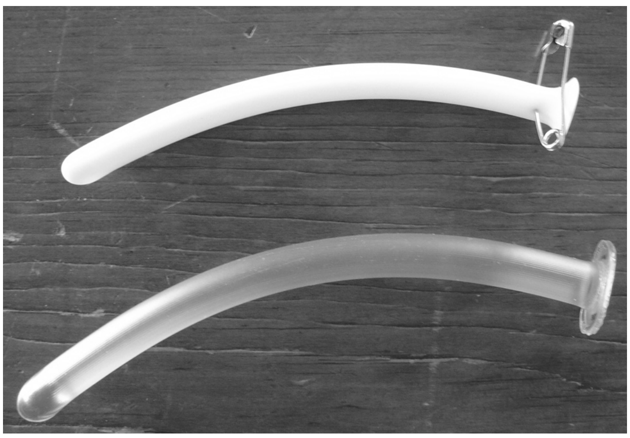
OTHER EADs

The cLMA has been extensively described.[1,17] The main advantages and disadvantages of the cLMA for use in a DDC or DB are listed in Table 3. The physical characteristics of commercial divers (working in the North Sea) indicate that sizes 4 and 5 are adequate.[2] The cuff needs to be filled with water prior to compression to overcome compression/decompression problems.

Aspiration risks are decreased if the ProSeal laryngeal mask airway (pLMA) or the streamlined liner of the pharyngeal airway (SLIPA™, Figure 8) is used.[18,19] The SLIPA™ is designed to seal the airway without the use of an inflatable cuff and its design may prevent aspiration. A study showed that it compares favourably with the cLMA in ease of insertion.[18] At present it is not readily available and more studies are needed. The pLMA will also allow stomach decompression but studies have shown it to be more difficult to insert when compared with the cLMA, and so it is not suitable for use in this situation.[19]

The oesophageal tracheal combitube (OTC) is a double-lumen, double-cuffed, polyvinyl extraglottic airway device.[1,20] It is easily inserted but not easily stored because of its large size,

Figure 6
Two types of nasopharngeal airway (NPA) are shown. The NPA passes through the nose and extends to just above the epiglottis; the flange rests outside the nostril and in some cases has a safety pin passed through it



and its two cuffs make its use in a DDC or DB limited. It may be used as a substitute for intubation at the dive site.

Results of literature search

The suitability of, or the reasons for rejecting, a particular EAD are listed in Table 4. No EAD satisfied all the criteria stipulated in the left-hand column of Table 1. The cLMA (Figure 1, Acott 2006[7]), SLIPA™ (Figure 8), COBRA (Figure 9), Brook (not shown) and Lifeway (Figure 5) airways were thought to be suitable for use because of

- ease of insertion
- ease of training
- the exterior airway tube would make RB possible from any position.

The cLMA and COBRA rely on inflated cuffs to seal the airway and therefore would need water added to the cuff to avoid the problems of a pressurised environment. A lack of space and manoeuvrability would make the Guedel and NPA unsuitable for RB and useful only if the victim was unconscious but breathing. The NPA is the only airway suitable in cases of trismus (Table 1 compares these devices).

Further testing was needed to confirm the suitability of the cLMA, SLIPA™ and COBRA in a pressurised environment.

Methods

The cLMA, COBRA and SLIPA™ were pressurised to 405 kPa (4 ATA) and the following tests performed:

1. 20 ml of water was placed in the cuff of a cLMA and COBRA after full deflation and then both were compressed and decompressed.
2. A cLMA and COBRA were compressed without any additional air placed in their cuffs and then the cuffs were inflated at depth.

Figure 7
The Laerdal pocket mask is collapsible and can be used either in rescue breathing or attached to a ventilating bag

Table 2
Complications of nasopharyngeal and oropharyngeal airways

Oropharyngeal

- Uvula damage (by entrapment of the uvula between the oral airway and the hard palate)
- Lip and tooth damage
- Tongue ulceration and necrosis from prolonged use
- Gastric inflation
- Worsening of or causing an obstruction (if it is too large the tip can displace the epiglottis posteriorly or if too small it will push the tongue into the posterior pharynx obstructing the airway)
- Fracturing of the airway with subsequent dislocation into either the oesophagus or the lungs
- Attempted use in a semi-conscious patient with intact airway reflexes causing gagging and/or vomiting leading to airway obstruction and/or aspiration

Nasopharyngeal

- A reported rate of epistaxis of 3–20% (with or without aspiration of blood)
- Sub-mucosal passage
- Turbinate damage
- Disappearance into the nose
- Induced vomiting with or without aspiration
- Induced laryngospasm (if too long)
- Naso-oesophageal intubation (if too long)
- Gastric inflation with rescue breathing
- Perforation of the cribriform plate (although cranial vault penetration has been reported only with nasotracheal intubation and nasogastric tube insertion)
- Obstruction from dried secretions, blood or compression within the nasal cavity

Table 3
Advantages and disadvantages of the cLMA for use in a diving bell or deck decompression chamber

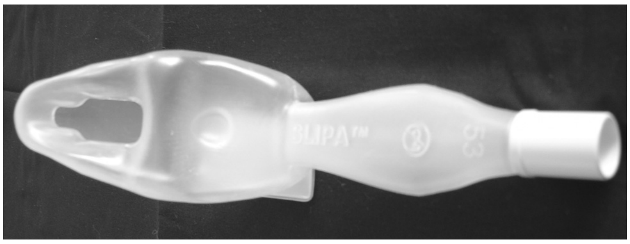
Advantages

- Small and easily stored
- Can be inserted blindly
- Insertion is anatomically independent
- Insertion may not be impeded by manual inline immobilisation or the presence of a hard collar
- Rescue breathing is easier

Disadvantages

- Does not protect the airway from aspiration even though it offers better protection than OPAs or NPAs
- Risk of gastric inflation with rescue breathing
- Difficulty with insertion if the patient's head is in the neutral position or if the patient is in the upright position facing the operator
- Inflatable cuff
- An over-inflated cuff will interfere with the airway seal causing a gas leak with rescue breathing and subsequent gastric inflation

Figure 8
The SLIPA™ airway

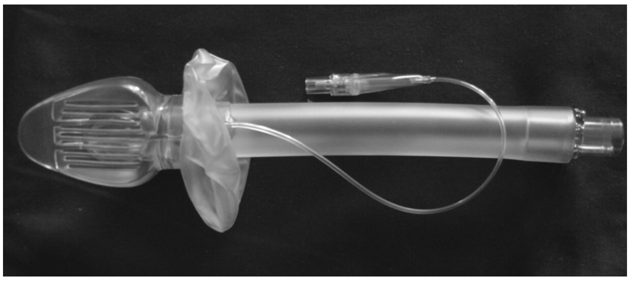


3 The SLIPA™ was used with a manikin to see if ease of insertion changed at pressure.
4 The ease of insertion of the cLMA and COBRA with 20 ml of water in their cuffs was tested on a manikin.
5 At atmospheric pressure, 20 ml of water was again placed in the cuffs of a cLMA and COBRA after full deflation and then both were tested for ease of insertion in a manikin to eliminate any deterioration in performance by the operator due to nitrogen narcosis at depth.

Results

Insertion of the COBRA with the cuff inflated with 20 ml of water was not possible in either attempt (at atmospheric or increased pressure) and during insertion the cuff ruptured. Difficulty with insertion was found even with decreasing volumes of water (15 and 10 ml). In addition, if the cuff was inflated at depth it distorted and ruptured during ascent if the pressure/volume was not monitored. These tests indicated that the COBRA functioned poorly and therefore it was eliminated.

Figure 9
The COBRA airway; the grilled section that fits over the laryngeal inlet is clearly shown. It is impossible to insert the COBRA with the cuff inflated with 20 ml of air or water.



Insertion of the cLMA was possible at either atmospheric or increased pressure with 20 ml of water in the cuff. If the cuff of the cLMA was inflated at pressure the cuff overinflated and distorted the anatomy of the mask during the ascent. There was no distortion of the cuff during ascent if it was filled with 20 ml of water prior to pressurisation.

Pressurisation did not alter the stiffness or insertion characteristics of the SLIPA™.

Table 4
Results of a literature review of the suitability of extraglottic airway devices for use in a diving bell or deck decompression chamber (Y – yes; N – no)

Extraglottic airway device	Suitable?	Comments
Oropharyngeal airways	Y	
Nasopharyngeal airway	Y	
Laerdal pocket mask	Y	
Classic laryngeal mask airway	Y	
Streamlined liner of the pharyngeal airway	Y	More data needed
ProSeal laryngeal mask airway	Y	Suitable for use at a diving platform
Oesophageal tracheal combitube	Y	Suitable for use at a diving platform
Easy tube	Y	Suitable for use at a diving platform; not readily available
COBRA perilaryngeal airway	N	Found unsuitable following testing
Intubating laryngeal mask airway	N	Cannot be left in for long period of time
Pharyngeo-tracheal lumen airway	N	Not readily available
Cuffed oral pharyngeal airway	N	No longer available
Glottic aperture seal airway	N	Not readily available, introducer required, not easily inserted
Laryngeal tube airway	N	Two cuffs, limited data
Airway management device	N	Two cuffs, limited data
Soft seal laryngeal mask	N	Not easily inserted
Laryngeal tube suction airway	N	Two cuffs, limited data
PAxpress oropharyngeal airway	N	Traumatic, limited data

Discussion

All of the recommended EADs (OPA, NPA or cLMA) can be readily used in a DB or a DDC because they are easily inserted. Insertion of an OPA or an NPA requires minimal training but the period of time before retraining is required is unknown compared with 6 and 12 months for the cLMA.[21]

The Guedel airway and an NPA are useful only if the victim is unconscious but breathing in a DB, while the LPM and all the OPAs and NPAs can be used by two rescuers performing CPR in a DDC.

Although not ideal, the cLMA could be used in nearly all situations in a DB or DDC except where the victim is semi-conscious and intolerant of an OPA or has trismus; in these situations an NPA is the EAD of choice. Additional training is required for the use of a cLMA and a simple protocol relating to the management of the cuff during compression and decompression needs to be adhered to:

1 Aspirate all air from cuff prior to compression
2 Fill cuff with 20 ml of water
3 Following insertion, check airway seal by applying gentle positive pressure and then add additional water if necessary (10–20 ml will be required for sizes 4 and 5 respectively)
4 During decompression, repeatedly aspirate for air every 405 kPa (4 ATA) decrease in pressure.

Several EADs can be used on the dive platform at atmospheric pressure. The OTC and pLMA are alternatives to intubation if the resuscitator has limited training in endotracheal intubation but studies suggest the OTC is the easier to insert of the two.[7]

Table 5
Suggested airway devices suitable for use in a diving bell (DB), deck decompression chamber (DDC) or on a diving platform

Diving bell
- Nasopharyngeal airways sizes 7, 7.5, 8
- Brook airway or glossopalatine tube airway
- Classic laryngeal mask with 20 ml syringe (sizes 4, 5)
- Cervical collar
- Hand-operated suction

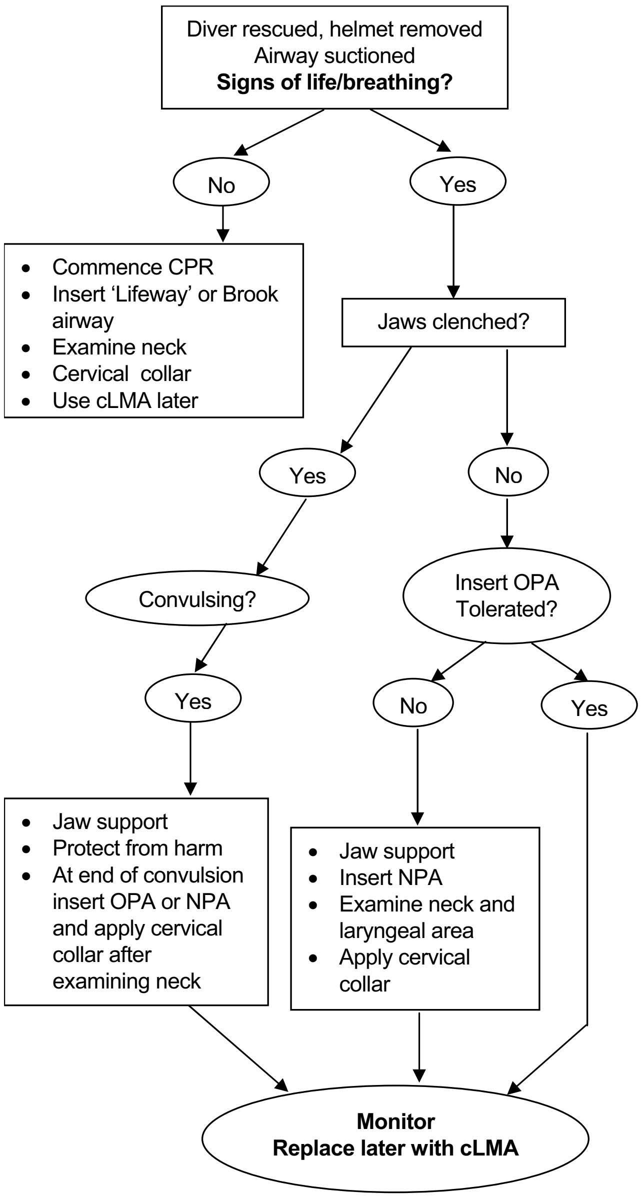
Deck decompression chamber
- As for DB
- Guedel airway
- Laerdal pocket mask

Diving platform
- As for DDC but better suction
- Oesophageal tracheal combitube
- ProSeal laryngeal mask airway (digital insertion plus introducer)

Summary

None of the EADs reviewed is ideal. Circumstances may dictate the choice of EAD to be used. The cLMA could be used in nearly all situations but additional training/retraining is required. The currently recommended interval for retraining of diving medical technicians (every three years) is not adequate for skill retention in the use of the cLMA. An annual refresher (manikin training) on the use of the cLMA is required. An airway/resuscitation management protocol for use in a DB is outlined in Figure 10, while Table 5 lists a range of suggested airway equipment that should be available in a DB, in a DDC, or at a diving platform.

Figure 10
Flow chart for airway management in a diving bell



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Christopher J Acott, MBBS, Dip DHM, FANZCA, is Physician in Charge Diving Medicine, Hyperbaric Medicine Unit, Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital, South Australia, and Coordinator of the Diving Incident Monitoring Study

Address for correspondence:
30 Park Ave
Rosslyn Park
South Australia 5072, Australia
Phone: *+61-(0)8-8222-5116*
Fax: *+61-(0)8-8232-4207*
E-mail: *<cacott@optusnet.com.au>*

In vitro models for evaluation of hyperbaric oxygen therapy in wound healing: a review

Jos Malda, Rebecca A Dawson, Evette Kairuz, Gemma Topping, Robert Long and Zee Upton

Key words
Human skin equivalent, models, hyperbaric oxygen, chronic wounds, research, review article

Abstract

(Malda J, Dawson RA, Kairuz E, Topping G, Long R, Upton Z. *In vitro* models for evaluation of hyperbaric oxygen therapy in wound healing: a review. *Diving and Hyperbaric Medicine*. 2007; 37: 25-30.)
Chronic ulcers are a major problem affecting a significant number of people around the world. The condition is difficult to heal and often leads to amputation. Hyperbaric oxygen (HBO) has been used clinically for the treatment of chronic ulcers and positive outcomes have been reported. However, owing to the lack of large randomised controlled trials and some conflicting data, controversy regarding the effectiveness of HBO in chronic wound healing persists. Besides randomised controlled clinical trials, *in vitro* studies hold promise in providing further insight into the role of HBO in wound healing and in aiding the establishment of a scientific foundation upon which more rational and efficacious HBO therapeutic regimes may be developed. The present article provides an overview of the available *in vitro* data on HBO with regards to wound healing. In particular, it focuses on experimental design issues and future opportunities using human skin equivalent models to study HBO-mediated wound healing.

Introduction

Chronic leg and foot ulcers are a significant cause of pain and impaired quality of life. Even small lesions may become a long-term problem, resulting in partial lower-limb amputation, and creating a sustained demand on healthcare systems.[1] The associated loss of productivity and the requirement to provide support infrastructure places additional financial burden on the wider community.[1]

Hyperbaric oxygen treatment (HBO) has been suggested as a potential wound healing therapy due to the hypoxic nature of the chronic wound and the requirement for oxygen during the wound healing process.[2,3] Indeed, increased wound closure in response to HBO has been demonstrated using animal models and, importantly, clinical studies have demonstrated faster healing of chronic ulcers and a decreased risk of major amputation.[4–9]

These outcomes have been used as the justification of Medicare coverage for the treatment of these conditions with HBO (item numbers 13015 and 13020) in Australia.[10] However, due to the conflicting data and the lack of a large randomised controlled trial, controversy regarding the effectiveness and validation of treatment regimes of HBO for enhancing healing of chronic wounds still exists.[11] Thus, its clinical application is the subject of great debate. In view of this, elucidation of the pathophysiological mechanisms underlying the demonstrated success of HBO will aid the further validation and hence full exploitation of the therapeutic potential of HBO therapy in wound healing.

Evaluation of HBO *in vitro* using human cell monolayers

Two-dimensional (2D) *in vitro* monolayer cultures of keratinocytes, fibroblasts, melanocytes and endothelial cells have been used to evaluate the effects of HBO.[12–16] HBO has not been shown to affect keratinocyte proliferation, either positively or negatively, in two studies reported to date.[15,16] We have recently confirmed this in our laboratory using monolayer cultures of the human keratinocyte cell line, HaCaT (unpublished results). In addition, differentiation appeared not to be significantly affected by HBO, as evaluated by means of the expression of late differentiation markers cytokeratin 10 and involukrin.[16]

Data reported on the effects of HBO on human fibroblast proliferation is conflicting. For example, Hehenberger et al and Tompach et al observed a dose-dependent effect on proliferation after 24 hours following a single hyperbaric treatment.[12,13] In contrast, Piepmeier et al did not observe any effects with a single treatment and Dimitrijevich et al observed a mitogenic effect only after prolonged HBO exposure.[14,15] Interestingly, these authors also demonstrated that collagen production by fibroblasts is inhibited by HBO treatment, contrary to the widely accepted belief that HBO aids wound healing by up-regulating collagen synthesis.[15,17] Clearly, it is difficult to draw any hard conclusions based on the limited and contrasting data available, illustrating the need for more extensive *in vitro* studies.

Figure 1
See caption on next page for explanation

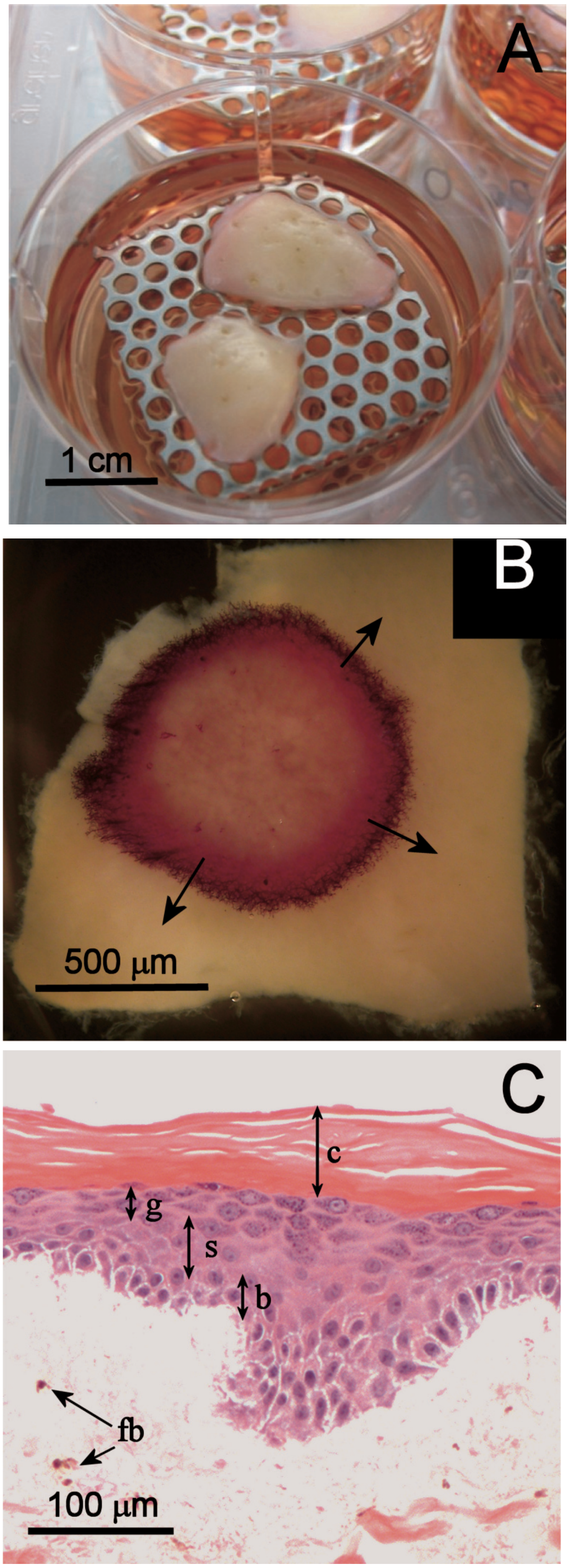


Figure 4
See caption on next page for explanation

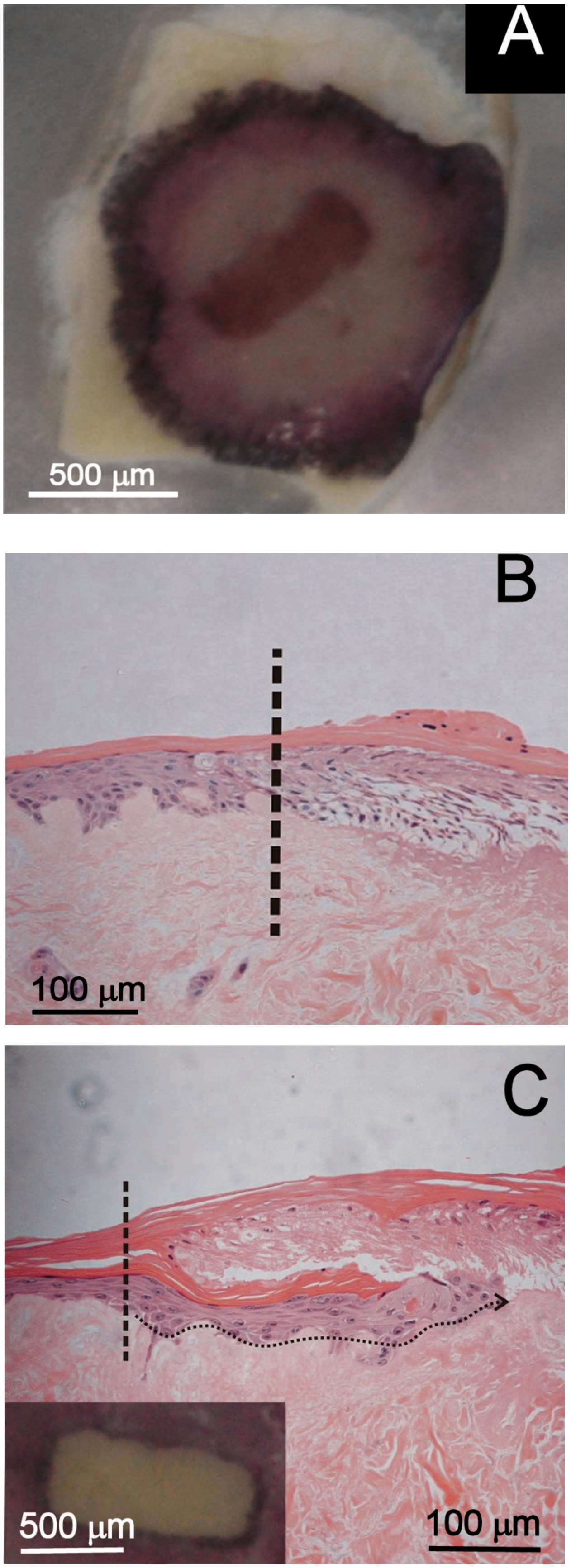


Figure 1
(A) The human skin equivalent (HSE) model; appearance at Day 10 of culture at the air-liquid interface
(B) A MTT-stained HSE after 5 days of culture; arrows indicate lateral migration of the newly-formed epidermis
(C) Histological cross section of the HSE at Day 10 demonstrating the stratum basale (b), stratum spinosum (s), stratum granulosum (g) and stratum corneum (c) and fibroblasts (fb) in the dermal component

Figure 4
(A) MTT and (B) histological analyses of the wounded HSE model immediately after burning. The model was burnt using a heated metal rod after 8 days' culture. The dashed line shows the margin of the burn
(C) Histology 6 days after wounding; the dotted arrow running beneath the basement membrane shows the migration of keratinocytes from the wound margin. The inset shows MTT analysis of the burn area (reproduced from Topping et al[22] with permission)

Two-dimensional cell culture has proven to be a valuable research tool, but its limitations have become increasingly recognised. Because of the highly unnatural geometric and mechanical constraints imposed on cells, these cultures only approximate properties of normal tissues.[18] Moreover, this approximation is almost always limited to single cell types and does not take into account the impact of the other cells and the supporting environment that surrounds tissues.[18] Thus, the results obtained on the effects of HBO using 2D cell culture may be misleading and non-predictive for *in vivo* responses.

Evaluation of HBO using three-dimensional *in vitro* models

To study the complex process of wound healing *in vitro*, more physiological three-dimensional (3D) models have been developed.[19] These have become known as human skin equivalent (HSE) models, reflecting the intent to more closely mimic the *in vivo* situation. HSEs are reproducible *in vitro* models of skin that allow the culture to occur at the air/liquid interface and provide a valuable tool when investigating factors and treatments, including HBO therapy, that can improve or impair wound healing.

HSEs, consisting of a fibroblast-containing collagen gel with a layer of seeded keratinocytes on top, were first employed by Dimitrijevich et al for the study of HBO-mediated epithelialisation.[15] Their preliminary study provided histological indications that HBO enhances epidermal differentiation after 10 successive 90-minute treatments at 202.6 kPa.[15] For our studies, we adopted an HSE based on a de-epidermised dermal scaffold.[20] After seeding a layer of human keratinocytes (4.9 x 10^4 cells.cm^{-2}) on the top of this scaffold, the models were submerged in standard keratinocyte culture medium for one to three days to allow cell expansion prior to subsequent culture at the air/liquid interface (Figures 1a and b).[21,22]

This model possesses significant advantages over other skin equivalents with scaffolds. Specifically, it is composed of a dermal matrix (with or without incorporated fibroblasts) and has an intact basement membrane, elements that have been shown to be important for the adherence of the epidermis to the dermis and for the differentiation of keratinocytes.[23] Hence, the epidermis formed on these scaffolds has a high degree of similarity to the epidermis *in vivo*, with the main regions clearly visible: a rapidly proliferating basal layer, a differentiating supra-basal layer and an uppermost, stratified cornified layer (Figure 1c).[20,22]

HSE models have been used as a testing and research platform for the cosmetic, pharmaceutical and chemical industries, as well as for the study of skin wound healing.[19,24] For example, the HSE model based on the de-epidermised dermis has been used as a model for contraction, cell invasion and angiogenesis.[25–27] In addition, it was used clinically as a skin replacement following release of contractures in previously burnt patients.[27]

Using this particular HSE model, we have recently demonstrated that daily hyperbaric treatments (90 min, 100% oxygen at 243 kPa) accelerate the reconstruction of an epidermis compared with air treatments at 101.3 kPa (1 ATA) (Figure 2).[21] Immunohistological characterization of the HSEs using various epidermal markers, including cytokeratins 1/10/11 (primary proteins of skin), revealed the earlier onset of epidermal differentiation within the HBO-treated constructs compared with air (Figures 2c and d). Moreover, the reconstructed epidermal layers in HBO-treated samples were significantly thicker at both Day 3 and Day 5 compared with the non-treated controls (Figure 3).

Additionally, after three days of culture at the air/liquid interface, the populated surface area of the dermal scaffolds, as visualized using 3-[4,5-dimethylthiazol-2-yl]-2,5-diphenyltetrazolium bromide (MTT; stains living cells purple) staining (Figure 1b), was significantly greater ($p < 0.05$) for the HBO-treated samples than for the controls (mean ± SD, 0.46 ± 0.03 cm^2 and 0.58 ± 0.06 cm^2 for control and HBO, respectively) due to an increase in cell migration and proliferation.[21] Although a difference was observed after five days, this was not significant. Thus, using the HSE model and employing a protocol similar to that used to treat chronic wounds clinically, we demonstrated that HBO stimulates the reconstruction of the epidermis. Moreover, we showed, for the first time, that these changes in epidermal formation are supported by differences in markers of proliferation, differentiation and basement membrane components.

Experimental design issues for *in vitro* HBO treatment

Although the HSE model offers numerous opportunities to further dissect the role of HBO in the healing of chronic wounds, there are differences between the model and the *in vivo* situation that should be considered and will impact on the experimental design. The HSE is a simplified model and lacks both innervation and vascularisation. However, oxygen will directly diffuse into the culture medium and has been shown to result in a significant rise in the partial pressure of oxygen (pO_2) over a 90-minute treatment; these values correlate with the values observed in normal tissue at 100% O_2 inspired within the range of 101.3–253 kPa.[15] The fall in tissue pO_2, observed after clinical HBO exposure, will be faster *in vitro* than *in vivo* and therefore the HSE model is a somewhat conservative indicator of the potential *in vivo* benefits of HBO therapy.

Rapid gas exchange can also influence the pH in the culture medium. Optimal growth of cells *in vitro* is dependent on maintaining a physiologic pH. Although the changes in the pH of the medium during a 90-minute HBO treatment were shown to be less than 0.10 pH units, depending on the conditions, pH changes can be significant and should thus be considered.[15] The most commonly used culture systems employ incubation in a high carbon dioxide (CO_2) environment, typically 5%. Hence, bicarbonate has to be present in the medium at a concentration of about 25 mM to reach the physiologic pH of about 7.4. When handling cells for extended periods of time in the absence of high CO_2 concentrations, e.g., in hyperbaric oxygen conditions, bicarbonate is not an adequate buffer and the pH of the media can rise to non-physiological levels. Therefore, other buffers with appropriate pKa levels, such as HEPES (N-[2-Hydroxyethyl] piperazine-N'-[2- ethanesulfonic acid]) for example, could be used.

The control of temperature is an additional challenge, since changes in the temperature will affect the cellular responses, including proliferation.[28] Thus, it is important to carefully control the temperature in order to obtain reliable outcomes. Hence, a monoplace or multiplace chamber is less suitable than a research or custom-designed hyperbaric chamber that allows the control of temperature via a water jacket.[13,21]

Figure 2
(A, B) Hematoxylin and eosin staining and (C, D) expression of the differentiation marker cytokeratin 1/10/11 (K1/10/11) of cross-sections of reconstructed epidermis after 5 days of daily 90-minute treatments with air at 101.3 kPa (A, C) or 100% oxygen at 243 kPa (B, D)

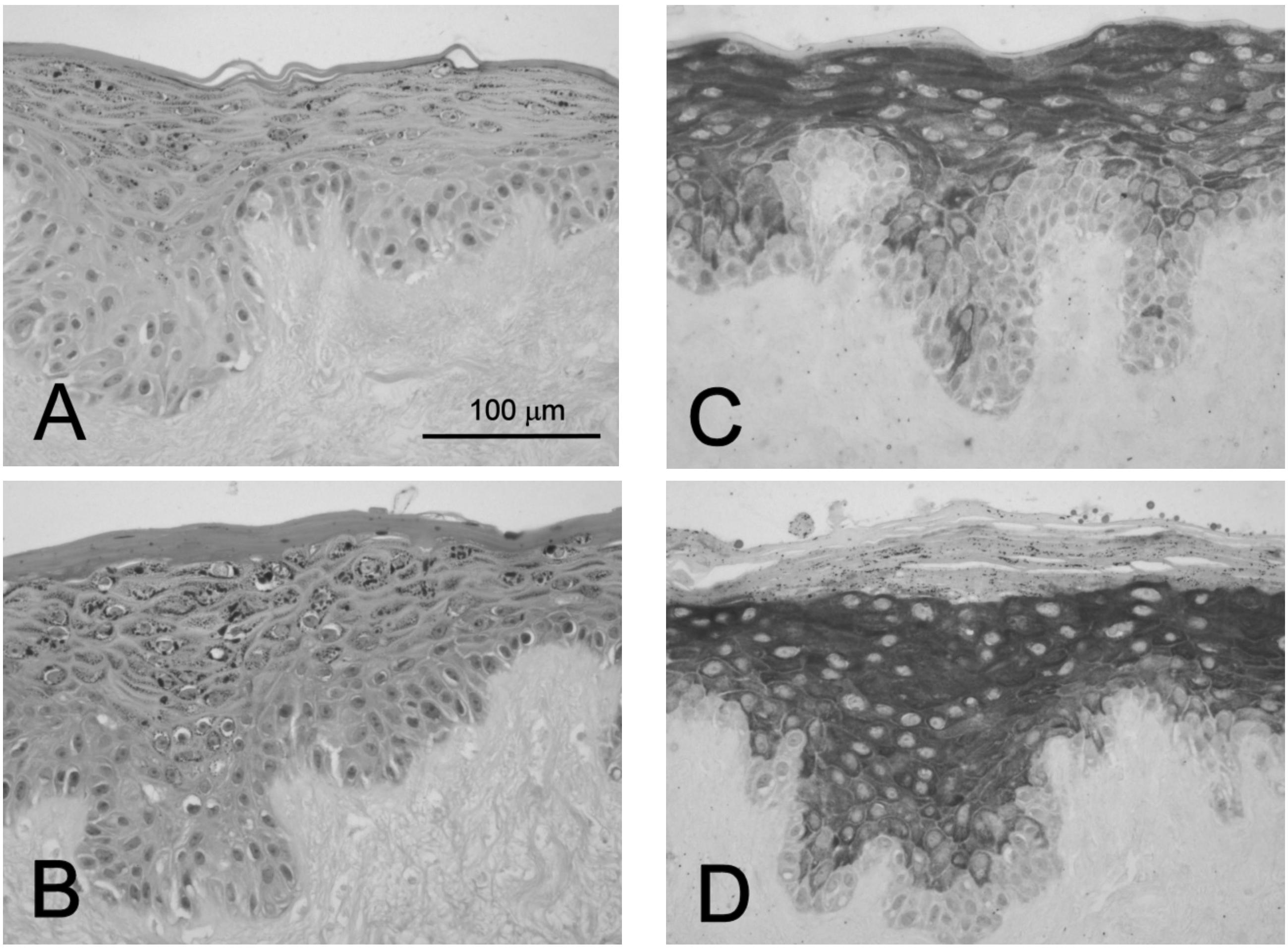
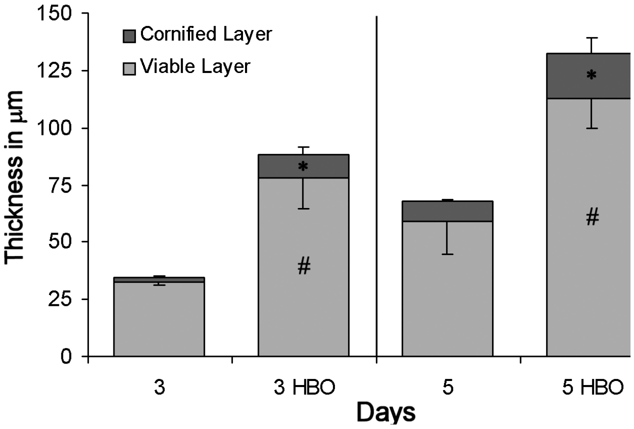


Figure 3
Thicknesses of the cellular and cornified layers after 3 and 5 days as determined by image analysis (n = 3 in 3 independent experiments, # and * indicate significant differences from control, p < 0.05). Adapted from Kairuz et al[21] with permission.



Future opportunities using skin equivalent models in wound healing research

HSE models provide an exciting means to improve and extend our knowledge regarding the effects of HBO on biological processes during the healing of chronic ulcers. Clearly, to further resemble native skin, various additional types of cells can be incorporated into the HSE, including melanocytes and Langerhans cells in the epidermal compartment, and fibroblasts and endothelial cells in the dermal compartment.[19] In addition, wounds can be created in the model and the healing response can be monitored.[22,29] Figures 4a and b show the wounded HSE model immediately after burning with a heated metal rod after eight days' culture, and Figure 4c the subsequent migration of keratinocytes facilitating wound re-epithelialisation.[22]

The model could be further improved to specifically mimic the *in vivo* chronic wound environment. Generally, this environment is of a hypoxic and highly proteolytic nature and diabetes is often an underlying cause of the condition.[2] The hypoxic nature of chronic wounds *in vivo* can be reconstructed by culturing the HSEs in a low-oxygen environment using a low-oxygen cell culture incubator or chamber. Similarly, the proteolytic environment of the chronic wound could be simulated by bathing the wounds created in the HSE model in chronic wound exudate obtained from consenting patients suffering from non-healing wounds. In addition, hyperglycaemia, as seen in diabetes, can be reproduced in the *in vitro* models by the application of abnormally high levels of glucose (up to 100 mM). Subsequently, intermittent HBO treatments can be administered and changes in the healing response can be evaluated histologically, as well as genetically. In this respect, the current advances in proteomics and genomics are of particular interest and can be incorporated into the research approach.

Conclusions

HSE models have advanced our understanding of wound healing, as well as of basic skin biology. Such models provide a more physiological 3D *in vitro* model of human skin that allows the incorporation of various cell types and circumvents the disadvantages associated with 2D *in vitro* models. Moreover, HSEs can be wounded and the healing can be studied. In addition, cultures can be maintained in the presence of chronic wound fluid, high glucose or hypoxia, thus simulating to some extent the inhibiting chronic wound environment. HSEs are therefore a valuable tool in furthering our understanding of the effects of HBO and can aid the further establishment of a scientific foundation upon which more rational and efficacious HBO therapeutic regimes may be developed.

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Jos Malda PhD, Rebecca A Dawson, Evette Kairuz, Gemma Topping and Zee Upton,
Tissue Repair and Regeneration Program, Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane
Robert Long, Medical Director, Wesley Centre for Hyperbaric Medicine, Brisbane, Australia

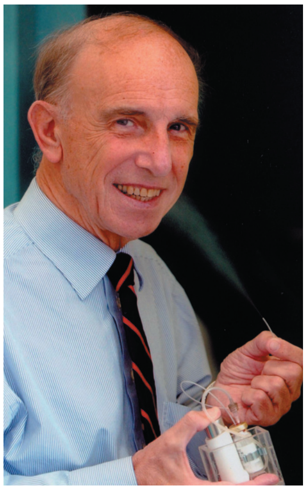
Address for correspondence:
Dr Jos Malda
Tissue Repair and Regeneration Program
Institute of Health and Biomedical Innovation
Queensland University of Technology
60 Musk Avenue, Kelvin Grove, Brisbane
Queensland 4059, Australia
Phone: *+61-(0)7-3138-6213*
Fax: *+61-(0)7-3138-6030*
E-mail: *<jos@malda.nl>*

Services to diving recognised by Australian government

John Maxwell Lippmann
Medal of the Order of Australia

For services to scuba diving safety, resuscitation and first aid and in particular the establishment of the Divers Alert Network Asia-Pacific

Brian Andrew Hills
Member of the Order of Australia (posthumous)



For service to medical research, particularly in the fields of respiratory physiology and decompression sickness as an educator and author

Dr David Smart, the Medical Co-Director of the Department of Diving and Hyperbaric Medicine at Royal Hobart Hospital, has been appointed Clinical Associate Professor in Diving, Hyperbaric and Emergency Medicine, Faculty of Health Sciences, University of Tasmania. He has been Clinical Senior Lecturer with the Faculty since 1994.

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

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Minutes of the SPUMS Executive Committee Meeting held on 4 June 2006 at the Pearl South Pacific Hotel, Fiji

Opened: 1700 hr

Present: Drs C Acott (President, Education Officer), R Walker (Past-President), G Williams (Acting Treasurer), D Smart (ANZHMG Representative), M Davis (Editor), C Lee (Committee Member)

Apologies: Drs S Sharkey (Secretary), D Vote (Committee Member)

1 Minutes of the previous meeting
Dr Acott proposed that the minutes of the previous telephone conference of 12 March 2006 be accepted as a true record. Seconded by Dr R Walker.

2 Matters arising from the minutes
2.1 SPUMS Administrator
No further comment.
2.2 SPUMS Committee overseas representatives
No response from either. It was decided to remove their names from the Journal but still have them on the SPUMS website.

2.3 ANZCA SIG member on the SPUMS Educational Board
No response had been received from Dr Walker.
2.4 Constitutional amendments
2.4.1 Consumer Affairs were drafted by Dr Williams for presentation at the 2006 AGM.
2.4.2 Motion regarding the application of 'model rules' to the publishing of the SPUMS Committee meeting minutes has been drafted by Dr R Walker for presentation at the 2006 AGM.
2.4.3 Increase in subscription fees was drafted by Dr Williams for presentation at the 2006 AGM.
2.4.4 Motion regarding additional membership categories has been drafted by Dr R Walker for presentation at the 2006 AGM.
2.4.5 Nominations for the Education Officer and Public Officer have been received and are to be presented at the 2006 AGM.
2.5 Strategies for increasing the SPUMS Membership
No new ideas were discussed.
2.6 Welcome letter for new members
No further action discussed.

3 Annual Scientific Meetings
3.1 Concerned the Fiji meeting; no further action.
3.2 Concerned the Fiji meeting; no further action.
3.3 No difficulties were noted for the 2006 conference regarding payment of registration and travel fees.
3.4 Concerned the Fiji meeting; no further action.
3.5 Concerned the Fiji meeting; no further action.
3.6 Concerned the Fiji meeting; no further action.
3.7 Dr Davis reported that arrangements for the 2007 conference were progressing.
3.8 Dr Acott proposed that the 2008 meeting be held at either Kimbe or Alatou in PNG. The theme of the meeting will be "Treatment tables: physiology and why do they work".

4 Journal report
Amalgamation of *Diving and Hyperbaric Medicine* and the EUBS newsletter was briefly discussed. No further conclusions were made.

5 Treasurer's report
To be presented at the AGM.

6 Education Officer's report
Dr Fiona Sharp has volunteered to be the new Education Officer. This will be announced at the AGM.

7 Other business
7.1 Complaint regarding the misconduct of a SPUMS member conducting diving medicals ongoing.
7.2 SPUMS underwriting of personal business equipment carried for purposes of the SPUMS meetings. The Committee agreed that this should be covered by SPUMS if insurance can't be obtained.
7.3 Delegates wishing to attend the Cocktail Party and/or Gala Dinner and not the Scientific Meeting. This was discussed by the Committee and it was agreed that the full registration fee needs to be paid for any person attending these functions. It was also agreed that:

- no discount is to be given if a delegate is unable to attend either the Cocktail Party or the Gala Dinner;
- attending only the Gala Dinner purely in a social setting despite paying the registration fee for the rest of the conference is to be discouraged, but should be at the discretion of the conference convenor.

Closed: Not recorded

Further report on Australian and New Zealand Standards Occupational Diving Committee
Held on Monday 29 May 2006 at Standards Australia House, Sydney

Australian And New Zealand Standard 2299.1 Occupational Diving Operations Part 1: Standard Operational Practice

Some further modifications include:

Breathing-air quality/hydrocarbon contamination
The draft revision of AS/NZS 2299.1 has been modified to indicate that control of the pressure, moisture and temperature of the compressor and filter system was critical to filter operation.
Clauses 3.13 and 5.6.4 of the draft have been modified to address moisture level and hydrocarbon contamination issues, along with addition of a new clause 5.6.5.

Table 4.2 Limits for repetitive dives
These now maintain consistency with published DCIEM tables.

Medical examination requirements
The New Zealand diving medical certification system is different to that used in Australia. All divers (including recreational) undertake a comprehensive medical examination every five years and health screening (using a system of nurses or other trained personnel) is undertaken annually. If any problems are detected during the intermediate screening, the diver is referred back to their physician. This system works well if divers are under the continuous supervision of a single physician or group of physicians using a centralised database, but becomes problematic if divers are geographically mobile. Clause 8.2 has now been modified in a manner that suits both countries. The separate page containing the medical fitness certificate at the end of Appendix N has also been improved so it has a specific title and identifies the Standard. There is still a requirement for annual medical assessments for professional divers.

Dive supervisor qualifications

Minor wording changes have occurred to ensure that the dive supervisor has training that is specific to the type of diving being conducted.

Proposed date for next SF-017 meeting

It is proposed to hold the next SF-017 meeting on Tuesday 20 March 2007 following a meeting of the Training Working Group on Monday 19 March. The venue proposed is Sydney.

Dr David Smart
SPUMS Representative, Australian Standards for Occupational Diving

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The SPUMS website

www.spums.org.au

The SPUMS Committee recognises the need to stay in touch with our members. As we move yet further into the age of 'instant communication' the value of having an up-to-date and informative website becomes critical. It is now some 18 months since we upgraded our website and improvements and refinements will continue to be added to meet your needs.

Amongst the services now available, it is possible to join the Society and *pay your annual membership* subscription on-line. The *Diving Doctor List* is available to any casual site visitor and is used by many diving organisations to direct their prospective divers to their nearest diving doctor. Under the *Information and Research* section review articles and diving-related resources can be found. The *SPUMS Medical* can be downloaded from the web and used in your practice. Upcoming Australian and international diving and hyperbaric medicine *conferences and courses* are promulgated, and links to other diving organisations can be found.

The *SPUMS Constitution* and policy statements are published on the site, as are the *requirements for the SPUMS Diploma of Diving and Hyperbaric Medicine* and the *Instructions to Authors* for submission of articles to the journal.

The Committee is currently evaluating options to place a full set of journals (from 1971 onwards) onto the site. Electronic access to all past journals will provide a fabulous resource to prospective researchers or practitioners interested in updating their clinical knowledge. A number of further refinements are planned over the next year.

Please take the opportunity to regularly review the site. Any suggestions for improvements or additions are welcome and can be forwarded to the SPUMS Secretary.

Robyn Walker

Australian and New Zealand College of Anaesthetists Annual Scientific Meeting

Diving and Hyperbaric Medicine Special Interest Group – Concurrent session

Date: 28 May 2007
Time: 1530–1700 hr
Venue: Melbourne Exhibition and Convention Centre

Speakers:
Professor Bruce Spiess, Virginia, USA
Simon Mitchell, Auckland. New Zealand
Associate Professor David Smart, Hobart, Australia
Glen Hawkins, Sydney, Australia

Contact: <margaret.walker@dhhs.tas.gov.au>
Conference registration: <www.anzca2007asm.com>

SPUMS diplomates 2006

Congratulations go to Dr Andrew Fock, The Alfred Hospital, Melbourne, who was awarded his diploma in 2006. His thesis was entitled "Deep decompression stops".

SPUMS Annual General Meeting 2007

The SPUMS AGM 2007 is to be held in the Marina Room, Oceans Resort, Tutukaka, Northland, New Zealand, at 1830 hr, Thursday 19 April 2007.

PLEASE NOTE THE CHANGED TIME AND DATE

Agenda

Apologies:
Minutes of the previous meeting:
Minutes of the previous meeting will be posted on the meeting notice board and appeared in *Diving and Hyperbaric Medicine*. 2006; 36(3): 162-6.
Matters arising from the minutes:
Annual reports:
President's report
Secretary's report
Education Officer's report
Annual financial statement and Treasurer's report
Subscription fees for 2007:
Treasurer to propose a motion
Election of office bearers:
Nil
Appointment of the Auditor:
Business of which notice has been given:
Nil

Australia and New Zealand Hyperbaric Medicine Group

Accepted Indications for Hyperbaric Oxygen Therapy

Revised and approved December 2006

Broad indication	Specific indication
Bubble injury	Decompression illness Arterial gas embolism (diving/iatrogenic/misadventure)
Acute ischaemic conditions	Compromised flaps/grafts Crush injury/compartment syndrome Reperfusion injuries Sudden sensorineural hearing loss Avascular bone necrosis
Infective conditions	Clostridial myonecrosis Necrotizing fasciitis Non-clostridial myonecrosis Necrotizing cellulitis Malignant otitis externa Refractory mycoses Refractory osteomyelitis Intracranial abscess
Radiation tissue injury	Osteoradionecrosis established prophylactic Soft tissue radiation injury established prophylactic
Problem wounds	Chronic ischaemic problem wounds Diabetic ulcers/gangrene/post-surgical Non-diabetic pyoderma gangrenosum refractory venous ulcers post-surgical problem wounds
Toxic gas poisoning	Carbon monoxide poisoning (mod/severe) Carbon monoxide poisoning delayed sequelae
Ocular ischaemic pathology	Cystoid macular oedema Retinal artery/vein occlusion
Miscellaneous	Thermal burns Bells palsy Frostbite
Adjuvant to radiotherapy	As adjunct to radiotherapy in treatment of solid tumours

Notes

1. The purpose of this list is to document the conditions for which it is considered hyperbaric oxygen (HBO) therapy has sufficient evidence of treatment benefit. These recommendations are based on review of the literature and clinical experience. These conditions are limited to those where the evidence for the efficacy of HBO is at least as strong as currently accepted therapeutic alternatives.
2. This list is made available for the use of individual hyperbaric medicine facilities in formulating admission and discharge policies. The list constitutes recommendations only and does not mandate clinical practice.
3. It is proposed that this list be reviewed by a joint committee of members of the ANZHMG and ANZCA SIG on a two-yearly basis. Submissions will be possible through these organisations and all available evidence at the disposal of this joint committee will be considered.
4. The ANZHMG and ANZCA SIG support clinical research into the efficacy of HBO in these and other conditions. Patients with conditions other than those above should be regarded as experimental and treatment undertaken in that context. These organisations hold that such treatment should be administered with the approval of a local ethics committee and involve no charge for professional or facility services.

The diving doctor's diary

Treatment of psychological injury after a scuba-diving fatality

Gary Ladd

Key words

Diving deaths, scuba diving, psychology, instruction – diving, occupational health, trauma and stress, case reports

Abstract

(Ladd G. Treatment of psychological injury after a scuba-diving fatality. *Diving and Hyperbaric Medicine*. 2007; 37: 36-9.)

After the death of a student during an ocean scuba-training dive, the student's diving instructor was suffering from acute stress disorder, a post-traumatic stress reaction. The treatment of the instructor's distress using a combination of two recognised trauma therapies – eye movement desensitization and reprocessing, and cognitive-behaviour therapy – is described. Improvement was noted after four treatment sessions. The instructor reported further improvement at a two-month follow up and the positive effects were maintained nineteen months later.

Introduction

Death and injury are a risk for recreational scuba divers. For instance, in British Columbia, Canada, the estimated incidence is 2.05 per 100,000 dives for fatalities and 9.57 per 100,000 dives for decompression illness (DCI).[1] Physical injuries can have a psychological impact on divers and the death of a diver can result in psychological injury to the survivors. However, psychological injury related to diving is a subject that is not well documented. Much of the psychological research related to diving risks has focused on anxiety and panic behaviour.[2,3] A handful of studies have examined the effectiveness of relaxation methods and mental skills training for dive anxiety especially in novice scuba students.[4,5] There has been limited investigation of the impact of scuba diving on neuropsychological functioning and neuropsychological impairment following DCI injury.[6,7] The only published reports on the psychological treatment of dive injury are a series of case studies of DCI-injured technical divers from the north-eastern United States of America.[8,9] The present report describes the psychological treatment of an instructor for a post-traumatic stress reaction following the death of her student while on a training dive.

Case report

BACKGROUND

A drysuit specialty course student died during an ocean-training dive in British Columbia, Canada. Within hours of the fatality, a police recovery team member recommended the student's diving instructor seek counselling and a fellow instructor made the referral. The student's instructor was female, thirty-seven years old, had been diving for five years and had been an instructor for four years. She had logged approximately 400 dives with 200 hours of bottom time. She had no previous psychiatric, alcohol abuse or other drug abuse history and was not taking any prescribed medication. There was no history of non-diving-related traumatic events other than the death of her father five years earlier.

Approximately four months prior to the fatality, she was the instructor on an open water course ocean-training dive in which one of her students nearly drowned and was air evacuated to hospital. Her conduct relating to the near drowning had been reviewed by her certification agency and she had been cleared to return to work.

INCIDENT

The death occurred on the first ocean-training dive of the course. The student was a certified advanced diver and had logged 37 dives, but it was her first cold water dive. The instructor lost contact with her while at depth (approximately 12 metres' sea water) with visibility of two metres. After a brief underwater search the instructor surfaced in a light chop and could see no sign of bubbles. She did a second search then went to shore and called rescue services. The police recovery team found the student diver's body on the bottom very close to where she was last seen. Subsequent investigation by the provincial coroner's office found the cause of death to be drowning secondary to an arterial air embolism that occurred during a rapid ascent.

TREATMENT

Initial consultation with the instructor was five days following the student diver's death. She was finding it difficult to eat and "hard to focus on tasks". She was "getting upset easily" (i.e., angry) and found herself "getting emotional" (i.e., crying) unexpectedly. She was isolating herself from other staff, having pictures from the incident "pop into my mind" throughout the day and dreaming about the fatal dive. Her symptoms were consistent with a diagnosis of acute stress disorder (DSM IV 308.3).[10]

The events of the near-drowning incident and the fatality were reviewed. She was given information on post-traumatic stress reactions and a pamphlet on stress reactions that can occur after a dive incident. Self-care guidelines were outlined, including a review of food intake, alcohol use and sleep hygiene. She identified two people in her life she would feel safe talking to about what happened. She was encouraged to contact and talk with them. A brief description was given of what psychological treatment would involve if she wanted further professional help. She decided she would wait and see how she did and initiate contact if she wanted further assistance.

Three weeks later the instructor called to request additional help. She was particularly concerned that she was still having difficulty concentrating at work and avoiding diving. Over the following 15 weeks she had four 1.5-hour sessions of psychological treatment. Treatment consisted of a combination of eye movement desensitization and reprocessing (EMDR) and skill-based, graded exposure cognitive-behaviour therapy (CBT) assignments between sessions.

With EMDR, the beginning or earliest recollection of the traumatic experience is used as the starting point for the desensitization phase of the treatment.[11] The instructor believed she was responsible for the fatality because she had "not done enough" for her student. She held this same belief about herself for the near-drowning incident that had occurred four months prior to the fatal incident. Consequently, the disturbing memory that was used as the starting point for EMDR processing was when she first noticed there was something wrong on the instructional dive in which the near-drowning incident occurred.

Consistent with the procedural steps of EMDR therapy, she was directed to focus on the traumatic experience. She was asked a series of questions that identified what beliefs she held about herself, what emotions and body sensations she was experiencing, and how distressed she was on an 11-point subjective units of distress scale (SUDS) from 0 to 10 (0 = completely calm to 10 = as distressed as possible). She was instructed to notice what she had just reported she was experiencing as she recalled the traumatic event and simply notice what happens while listening to auditory bilateral stimulation through headphones. The stimulation played for approximately 30 seconds, at which point she was encouraged to rest for a moment and report what happened (i.e., thoughts, images, feelings, sensations that occurred during the 30-second set of stimulation). Sets of stimulation are repeated until the client has nothing new to report during the sets and is not experiencing any distress while thinking of the incident. How long this takes varies considerably and is not readily predictable.

By the second treatment session, twelve weeks post fatality, she had been cleared by her certification agency to return to work as an instructor. She was teaching pool sessions and acting as Dive Master on ocean-training dives. She confided she was very tense when in the water and had an episode of "near panic" when a student needed to be taken to shore because of hypothermia. She was afraid of losing contact with the diver. Recollection of the near-drowning incident was still distressing; consequently, EMDR processing of this event was continued. In addition, she was given the first of a series of CBT in-water exercises to practise between sessions. She was instructed to do a shallow dive with a buddy she trusted (i.e., not a student) in a sandy bay and practise diaphragmatic breathing at depth until calm (i.e., low SUDS). Second, she was directed to instruct her buddy not to move. Then she was to turn away from her buddy and repeat diaphragmatic breathing until calm.

At the third treatment session, fifteen weeks post fatality, the EMDR processing continued. She had completed the in-water exercise and was back instructing on ocean-training dives. She noticed that her breathing rate increased rapidly in 'silt-out' low visibility conditions. She was instructed to repeat the previous in-water exercise and extend it by purposely kicking up silt. With visibility of near zero, she was to breathe from the diaphragm until calm.

Nineteen weeks post fatality, EMDR processing continued at the fourth and final treatment session. Processing of the near-drowning incident was completed. While recalling the incident, she was calm and self-confident. She had not experienced any further episodes of "near panic". Other than the assigned in-water exercises, since the fatality she had avoided doing any personal pleasure diving. She was instructed to undertake a favourite local dive with a trusted buddy. Key points of the dive were mentally rehearsed and combined with diaphragmatic breathing. Instruction was given on how to apply this exercise on the dive.

In follow-up interviews two months (28 weeks post fatality) and nineteen months (112 weeks post fatality) after the final treatment session, she was working as a dive instructor without any restrictions. She had not experienced any further episodes of increased air consumption, respiratory distress or near panic.

The Impact of Event Scale – Revised (IES-R) was used to provide a measure of the instructor's functioning.[12] The IES-R is a short self-report measure of overall distress and three clusters of post-traumatic stress symptoms: avoidance, intrusive experiences and hyperarousal. With reference to the diver fatality, she was asked to rate on a five-point scale how distressing each of twenty-two items was for her (0 = none to 4 = extreme). She completed the instrument at the first interview, the final treatment session (19 weeks) and at follow up 28 and 112 weeks after the fatality (see Table 1). At first interview, her responses indicated elevated levels

Table 1
Patient's Impact of Event Scores (IES-R)

Symptom type	Time since fatality			
	5 days	19 weeks	28 weeks	112 weeks
Overall	2.55	1.23	0.23	0.18
Avoidance	2.75	1	0.23	0
Intrusion	3.14	1.43	0.25	0.43
Hyperarousal	1.71	1.29	0	0.14

of disturbance on all scales. At the final treatment session her distress about the fatality was no longer clinically significant. This improvement was maintained for both follow-up interviews.

Discussion

Post-traumatic stress is characterised as a response to an event that involves actual or threatened death or serious injury.[10] The event can involve a threat to one's own physical integrity, or witnessing or otherwise being involved in such an event. Typically, the focus of care for divers involved in a diving incident has been on their physical injuries. In one of the few published reports of psychological injury related to diving, Hunt described her interviews of three technical divers who had each suffered a case of DCI.[8] Her focus was on the diving-related inner conflicts the divers were experiencing in light of their DCI 'hits'.

In the case presented, the dive instructor was referred for psychological assistance by a colleague after a student died while in her care. However, patient history-taking revealed that four months prior to the fatality another one of the instructor's students had nearly drowned while in her care. Both the fatality and the near drowning meet the DSM-IV diagnostic criteria for an event that is likely to provoke a traumatic stress response (i.e., acute stress disorder and post-traumatic stress disorder); however, the instructor did not seek psychological services after the first incident. It is noteworthy that for both the near drowning and the fatality incidents, neither her employer nor her certification agency offered her psychological assessment or assistance.

A diver can also be involved in a dive incident, escape physical injury, but be psychologically harmed by the experience. In the case described, the instructor sustained psychological injury even though she was not physically harmed in either incident. In a follow-up study of the psychological impact on those involved in dive incidents in the Florida Keys, post-traumatic stress symptoms in both divers and the dive instructors were noted. Provision of psychological services to both the divers involved in an incident and the dive professionals who respond to the incident was advocated.[13]

Both the EMDR approach used in-session and the CBT approach used for the in-ocean assignments are empirically-based recommended treatments for post-traumatic stress.[14,15] The instructor's response to the treatment was comparable to that reported in outcome studies of EMDR. For instance, in a 15-month follow up of 66 adults who were treated with three 1.5-hour sessions of EMDR, there was a 68% reduction in the mean number of post-traumatic stress symptoms for all participants.[16]

While improvement typically begins rapidly with EMDR, the amount of processing required for an incident to no longer be distressing for the patient can vary considerably. In this case, rather than there being a single trauma, there were two (i.e., the near drowning and the fatality) that were thematically connected for the instructor. In both incidents she felt responsible for what had happened to the students. In the course of tracing her associated thoughts, feelings, body sensations, and images about the near drowning using EMDR, various connections were made spontaneously with the fatality. By the fourth treatment the near-drowning incident was no longer distressing and she was experiencing only a few mild post-traumatic symptoms related to the fatality. The instructor was satisfied with her improvement so she sought no further treatment.

When the instructor reported she experienced dive anxiety and near panic when she returned to ocean diving, CBT exercises that included diaphragmatic breathing were introduced to complement the EMDR treatment. One of the advantages of this approach is that the patient is able to practise in the natural setting where the dive anxiety is experienced (e.g., at depth in the ocean) and the treating psychologist's presence is not required.

Breathing more slowly is frequently advocated as a means of controlling dive anxiety and preventing panic. Breathing and relaxation training have been used successfully to reduce the intensity and frequency of anxiety episodes in patients suffering panic disorder and is a common intervention for anxious divers. For divers it is a way of coping with self-perceived breathing and exertion discomfort.[2] Mental skills practice that included relaxation training has been shown to slow the respiration rate and increase the self-confidence of novice divers performing scuba skills but there is some evidence that, when applied to diving, the positive effects of relaxation training and mental rehearsal are task specific.[4,5]

In my work with divers I have found that dive anxiety following a dive incident is frequently context specific. The anxiety occurs in conditions that share characteristics with the original traumatic incident. The instructor was experiencing anxiety in situations that, by way of the shared characteristics, were reminders of both the near drowning and the fatality. There was a rapid onset of anxiety that included increased air consumption and respiratory distress. The in-ocean breathing exercises used in this case represent the clinical extension of practices that have been used with sub-clinical cases of dive anxiety. The exercises used in this case followed a graded exposure hierarchy that began with breaking visual contact then purposely creating low visibility 'silt out' conditions. Concurrent with the EMDR in-session treatment, recreating these conditions as part of CBT assignments that included practising diaphragmatic breathing successfully reduced her anxiety and improved her self-confidence.

Acknowledgement

The author wishes to thank the dive instructor for her permission to publish the details of her case.

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Dr Gary Ladd, BA(Hon), MSc, EdD, is a registered clinical psychologist in private practice, with a special interest in dive psychology

Address for correspondence:
330-1200 Burrard Street
Vancouver BC, Canada V6Z 2C7
Phone: *+1-604-682-5467*
E-mail: *<Gary@PsychoDiver.com>*

The Baromedical Research Foundation

The Baromedical Research Foundation has been awarded a substantial research grant from Sechrist Industries, Inc., to study hyperbaric oxygen's radiation sensitisation effects in the treatment of squamous cell carcinomas of the head and neck. It involves both Phase I (dose escalation) and Phase III (randomised and double-blinded) components at four participating centres in the USA, including The Mayo Clinic. Foundation Director Dick Clarke notes "The best treatment for this form of cancer is not presently known. There is clearly room for long-term survival improvement, with tumor hypoxia a limiting factor in its control and eradication. This important award provides the opportunity to fully investigate the potential of hyperbaric oxygen to impact survival".

For further information contact:
<www.baromedicalresearch.org>

The Baromedical Research Foundation is a non-profit organization dedicated to the scientific advancement of hyperbaric medicine.

Two divers with acute vertigo and loss of balance

Graham McGeoch

Key words
Scuba diving, vertigo, decompression illness, inner ear decompression sickness, inner ear decompression illness, inner ear barotrauma, case reports

Abstract

(McGeoch G. Two divers with acute vertigo and loss of balance. *Diving and Hyperbaric Medicine*. 2007; 37: 40-41.)
Two case histories are reported of divers who presented with acute symptoms of vertigo, imbalance and unilateral hearing loss. In one case, a working diagnosis of decompression illness was made and he received recompression therapy with complete resolution of his symptoms. In the other, a working diagnosis of inner ear barotrauma was made and he was treated conservatively. Six weeks later, he remained mildly unsteady particularly when playing sport. Readers are invited to comment on the cases.

Introduction

Along with the report from the Hawaii hyperbaric unit on their experience of isolated inner ear decompression illness in recreational scuba divers breathing air published in this issue,[1] two cases are presented for readers to consider. Were the diagnoses correct? Where were the lesions? And was the management appropriate in both cases?

Case 1

A 30-year-old truck driver was on a six-month dive instructor's course. He was on his twelfth dive with the course but had dived many times in Australia before being trained. He had not dived for six days before the event. He went for a day trip to a sub-alpine lake; it was June and snowing. He dived to 7.2 metres for 30 minutes, suffering from mild mask squeeze and a headache from the cold. He swam to the shoreline along the bottom. He took his regulator out of his mouth when he stood up, and lost his balance. He reported feeling disorientated and mildly nauseated, and said that the ground looked like the ocean. He had some blood from his nose but no ear pain. There was no rotatory component, tinnitus or hearing loss.

He rang the Diver Emergency Service and presented as instructed to the regional emergency department. History included a high alcohol intake at times although not on the day of presentation (a blood alcohol of zero confirmed this). He was reviewed by the duty ENT registrar who noted a mildly ataxic gait. Sharpened Romberg's test was positive, as was Unterberger's test (to the left). Weber test was central with positive Rinne's test on both sides. Vestibular provocation tests were normal. His external canals had small exostoses, and the tympanic membranes were atrophic but moved easily with Valsalva and showed no signs of barotrauma. The fistula test was negative. Pure-tone audiometry revealed a moderate, high-frequency notch on the left with an air conduction threshold of 55 dB at 4 kHz. (Note that on the following day his mother reminded him that his hearing loss was long standing due to a truck tyre exploding near him.) He finally arrived in the hyperbaric medicine unit at midnight, 12 hours after diving. His affect was slightly elevated, heel-to-toe walking unstable and slow, sharpened Romberg's test less than 5 seconds, and finger-to-nose coordination slow with no other neurological signs.

A working diagnosis of decompression illness presumed to be from cerebral arterial gas embolism was made and a trial of recompression initiated. He was reviewed in the second air break and sharpened Romberg's test was now 60 seconds with no unsteadiness. An RN62 treatment table was completed without incident, followed by a second treatment, using an 18:60:30 protocol, 14 hours later. He remained asymptomatic. An MRI scan to follow up his hearing loss was normal.

Case 2

A 32-year-old, previously fit and healthy farmer went for a single boat dive off the coast in moderately rough conditions. He was an experienced diver. He dived for 25 minutes to 21 metres and surfaced slowly without the ascent rate meter on his dive computer flashing any warnings. The dive was uneventful until he surfaced, when he suffered true vertigo very quickly. He vomited and noted right-sided tinnitus. He discussed his symptoms with his GP and the regional emergency department. He was advised to rest at home overnight, but he remained with poor balance and vertigo the following morning. His GP rang the duty doctor at the nearest hyperbaric medicine unit and he was transferred by ambulance with IV fluids and 100% oxygen.

On arrival in the hyperbaric medicine unit, his symptoms had not improved on oxygen. There were no neurological signs, including no nystagmus, but he was unsteady on trying to stand or walk. A specialist otorhinolaryngologist was consulted, who noted tuning-fork tests consistent with a right-sided sensorineural hearing loss. Pure-tone audiometry showed a mid-tone dip and a high-tone dip with thresholds that were, at worst, only 15–20 dB worse than in the left ear.

Inner ear barotrauma was the working clinical diagnosis and he did not undergo recompression treatment. He did not improve with 36 hours of bed rest, although the high-tone dip disappeared. MRI scan of the brain and inner ear was normal.

Six weeks later he remained unsteady, particularly when tired, and had difficulty playing tennis. He had no tinnitus or awareness of hearing loss. Audiometry was symmetrical and electronystagmography normal. Valsalva manoeuvre did not affect his balance. He remained unsteady on balance testing.

Reference

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Graham McGeoch, MB, ChB, FRNZCGP, is a consultant in the Hyperbaric Medicine Unit, Christchurch Hospital, New Zealand, and a general practitioner with extensive diving medicine experience

Address for correspondence:
Graham McGeoch
Hyperbaric Medicine Unit, Christchurch Hospital
Private Bag 4710
Christchurch, New Zealand
Phone: *+64-(0)3-364-0045*
Fax: *+64-(0)3-364-0017*
E-mail: *<graham_m@pegasus.org.nz>*

Editor's comment:
Readers, especially those with experience in managing such cases, are invited to submit their comments on any aspects of these two cases but most particularly in relation to the diagnoses and their management.

The poetry doctor

Logbook entry of diver: D. Nile

I'm feeling very tired,
So tired I want to sleep.
It must have been the finning
As I sped up from the deep.

My right shoulder is aching,
An ache that's dull and dead.
It must have been the lifting
Of my tank above my head.

My fingers are all tingling
With pins and needles in my palm.
It must be a carpal tunnel
Compressing nerves trapped in my arm.

My head has constant throbbing,
A hammer in my brain.
It must be all the sunlight
Aggravating a migraine.

Both legs have a slight weakness
With a mild numbness combined.
It must be my tight weight belt
Pressing firmly on my spine.

I'm going to take a pain killer
Then a nap so I'll revive
As after lunch and a beer
There's time for two more dives.

John Parker
<www.thepoetrydoctor.com>

BRITISH HYPERBARIC ASSOCIATION
Annual General Meeting
1st - 4th November 2007

The 2007 annual meeting of the British Hyperbaric Association will be held in Oban, on the west coast of Scotland, from the 1st to the 4th of November. As well as a full and varied programme of presentations, BHA2007 will also offer an exciting pre-meeting diving programme.

E-mail: info@bha2007.org

Articles reprinted from other sources

Research report: systematic reviews

Ornella Clavisi with Michael H Bennett

Key words
Reprinted from, research, evidence, medical database, Cochrane library

Abstract

(Clavisi O, Bennett MH. Research report: systematic reviews. *Diving and Hyperbaric Medicine*. 2006; 37: 42-4.)
This report attempts to provide a brief overview of systematic review methodology. Systematic reviews apply (and report) an explicit and scientific approach to the identification, selection, appraisal and synthesis of evidence on a focused clinical question. A protocol for the review is developed *a priori* to limit the potential for the data of individual studies to influence the review. Reviews investigating the effect of healthcare generally include only randomised controlled trials. An essential part of the systematic review process is to critically appraise the studies selected. One of the most common analysis techniques used in systematic reviews is meta-analysis, whereby the results of individual studies are statistically pooled to give an overall estimate of effect. A useful adjunct to the meta-analysis is the funnel plot, which is primarily used to detect publication bias.

This instalment of the Research Report [of ANZCA] attempts to provide a brief overview of systematic review methodology and provide those with a keen interest with some useful resources. To start it is important to understand that a systematic review is different from a standard narrative review. Put simply, systematic reviews apply (and report) an explicit and scientific approach to the identification, selection, appraisal and synthesis of evidence on a focused clinical question – narrative reviews do not.[1] In terms of linking the evidence to clinical decisions narrative reviews can be unreliable.[2–4]

Summarising the evidence has proved to be a science in itself,[4] and just like conventional research the first step is to develop a protocol outlining the methods of your review. The aim of the protocol is to explicitly define how you will proceed with the review. Setting down the process (and disseminating it, if possible) means your review will be far less likely to be subject to bias through the differential selection of studies or selection of outcomes *post hoc*. In developing your protocol you will need to define your clinical question, develop your search strategy, select the databases you intend to search, establish your inclusion and exclusion criteria for selecting your studies, and outline how you intend to analyse the results.

It is important to establish these methods *a priori* in order to limit the potential for the data of individual studies to influence the review (for example excluding studies with unexpected or undesirable results).[5] Undoubtedly the most influential world organisation in this area is the Cochrane Collaboration, and they publish a thorough handbook that guides the novice step by step through the process. The Collaboration can be found at <http://www.cochrane.org/>. The following references are two examples of review protocols relevant to diving and hyperbaric medicine published on the Cochrane library.[6,7]

Development of a defined clinical question

For a systematic review to work you need a research question that is clear and well focused.[8] The question provides the framework for the whole review. Generally, there are four prime considerations when formulating good evidence-based questions:

1 the **P**atient population in which you are interested
2 the **I**ntervention you wish to investigate
3 the treatment alternative you want to **C**ompare it to
4 the most suitable **O**utcome(s) by which to estimate clinical effectiveness and safety.

A good mnemonic for this is 'PICO' (patient, intervention, comparator and outcome). The following is an example of a well-formulated clinical question regarding the usefulness of a therapeutic intervention: "For patients suffering serious neurological decompression illness, does the addition of lignocaine therapy, compared to standard hydration and recompression protocols alone, result in any improvement in neurological disability or quality-of-life measures?"

Searching and locating the evidence

When searching and locating the evidence for systematic reviews the ultimate goal is to identify *all* high-quality studies on your topic. One of the ways in which your search can be maximised is to search multiple electronic databases such as Medline, Embase, PubMed and the Cochrane Central Register of Controlled Trials (one of the main reasons for searching more than one database is that there are differences in the journals and articles that each of them index). It is also important to consider unpublished or 'grey' literature such as theses, internal reports, non peer-reviewed journals and industry reports, as these may also uncover relevant studies. All of the databases listed above can be accessed through specialty college, university or major hospital websites. If you have not used such library website resources before, you may need to register for a user name and password. For example, the Australia and New Zealand College of Anaesthetists website is <http://www.anzca.edu.au/libonlinejournals/index.htm> and, for fellows and trainees, a user name and password can be obtained at <http://www.anzca.edu.au/reg/anzca_reg.cfm>.

You will need to document how you searched these databases. If you are unfamiliar with developing a search strategy or are unsure about the syntax you should use (which can vary between databases), Trisha Greenhalgh has published a guide for searching Medline, which is a good introduction.[9] Your local medical librarians are great resources who are well trained to help you.

Selection of relevant studies

Decisions regarding which studies to include in your review will depend on your research question. For example you may wish to limit your review based on:

- study design e.g., include only randomised controlled trials
- types of participants e.g., you may want to include studies of adult patients only and exclude children
- types of interventions
- outcome measures and
- language.

Reviews investigating the effect of healthcare will generally include only randomised controlled trials as they are widely accepted as the gold standard for assessing the effectiveness and safety of a particular treatment. However, a cohort study may be more appropriate for reviews investigating the accuracy of diagnostic tests. You will also need to consider whether it is worth placing specific language restrictions on the articles you include. A study by Egger showed that there was a language bias in randomised controlled trials published in English and German, whereby RCTs of negative findings were more likely to be published in German language journals.[10]

Quality assessment

The interpretation of results is dependent on how bias was limited in the study. An essential part of the systematic review process is to critically appraise the studies that you have selected. The critical appraisal process is essential in determining whether the results are clinically important and can answer the review question in a valid way. For randomised controlled trials the accepted criteria for assessing methodological quality include:[11]

- quality of concealment of random allocation
- clarity of inclusion/exclusion criteria
- adequacy of information about study withdrawals
- adequacy of description of treatment and control groups at study entry.

Data analysis

As part of the protocol you will need to plan the statistical analyses that you will use as part of your review. One of the most common techniques used in systematic reviews is meta-analysis whereby the results of individual studies are statistically pooled to give an overall estimate of effect. The value of using this technique is that it can improve the overall precision of the effect and increase power (i.e., the probability of detecting a statistically significant effect if one exists). However, meta-analysis is not always appropriate, particularly if the results of the individual studies differ greatly from one another. The decision about when studies can be pooled and when they should not be is difficult and involves both statistical and clinical judgements. Statistically, one can test for heterogeneity across studies using a number of techniques.[12] The use of such mathematical tools should always be grounded in an informed clinical interpretation of whether or not the patients, interventions and outcomes are really similar enough to justify pooling; for example, should one pool paediatric and adult patients?

Generally, if the results do differ you should explore why this variability exists; for example, it may be that the studies investigate different patient populations, interventions may differ in terms of dosage or route administration, or there may be differences in how outcomes measures were defined. It is also important to note that one of the limitations of meta-analysis is that it cannot control for sources of bias from individual studies. In the end a good meta-analysis of badly designed studies will result in poor validity.

A useful adjunct to the meta-analysis is the funnel plot, which is primarily used to detect publication bias. A funnel plot is essentially a scatter plot of the treatment effect against the sample size. In the absence of bias the plot should resemble a symmetrical inverted funnel. An asymmetric funnel indicates the presence of publication bias or systemic differences between smaller and larger studies.[5]

Additional reading

For those with a keen interest in conducting a systematic review one of the most comprehensive resources is the *Cochrane handbook for systematic reviews of interventions*.[13] The Cochrane Anaesthesia Review Group (CARG) also has a guide for authors wishing to develop a systematic review for the Cochrane library.[14] This is the only review group with specialist diving and hyperbaric input and would be the best group to approach in either of those fields.

For those interested in reading systematic reviews in the area, there are 15 completed reviews and two published protocols on the Cochrane databases concerning diving and hyperbaric medicine and related subjects. Those interested in performing a review should contact the CARG at <http://www.cochrane-anaesthesia.suite.dk/> for general advice on how to proceed and we would recommend using the Cochrane handbook as a resource even if you decided to proceed independently with your review. Most of the randomised diving and hyperbaric medicine evidence is summarised at <www.hboevidence.com> and many of the existing systematic reviews are available in a doctoral thesis at <http://www.library.unsw.edu.au/~thesis/adt-NUN/public/adt-NUN20060808.155338/index.html>.

Happy reviewing!

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Ornella Clavisi, BSc(Hons), MPH, is Research Coordinator for the Australian and New Zealand College of Anaesthetists Trials Group
Michael H Bennett is Senior Staff Specialist, Department of Diving and Hyperbaric Medicine, The Prince of Wales Hospital, Randwick, NSW, Australia

Address for correspondence:
ANZCA
630 St Kilda Road
Melbourne Vic 3004
Phone: *+61-(03)-8517-5326*
Fax: *+61-(03)-8517-5346*
E-mail: *<oclavisi@anzca.edu.au>*

Clavisi O. Research report: systematic reviews, was originally published in the *Bulletin of the Australian and New Zealand College of Anaesthetists*. 2006; Oct: 10-11, and is kindly reproduced with permission of ANZCA.

The original article has been edited and additional material for increased relevance to diving and hyperbaric medicine provided by Dr Michael Bennett, Department of Diving and Hyperbaric Medicine, The Prince of Wales Hospital, Randwick, NSW 2031, Australia.

Evaluation of the System O_2 Inc portable non-pressurized oxygen delivery system [Abstract]

Pollock NW, Hobbs GW

Objective: To evaluate the performance of the System O_2 portable non-pressurized delivery system ($SysO_2$). This device produces oxygen through chemical reaction and might have utility for emergency/field use.
Methods: Performance was evaluated with 10 unmanned trials conducted under standard laboratory conditions. Measures included oxygen flow (mean and peak), total oxygen yield, and system weight-indexed yield.
Results: Oxygen flow peaked at 5.74 ± 0.28 L•min^{-1} (mean ± SD) at 16.9 ± 1.5 minutes before rapidly falling to zero. Mean flow was 2.98 ± 1.52 L•min^{-1} with a total yield of 62.9 ± 6.6 L. Mean oxygen fraction was 0.96 ± 0.15. The weight per unit of oxygen is substantially higher than for commercially available pressurized cylinders; e.g., 47.7 vs. 10.2 g•L^{-1} for the small 246 L M9 cylinder.
Conclusions: Given the limited flow rate and supply duration, we believe the $SysO_2$ system does not offer significant advantage over the available pressurized oxygen systems as a source for emergency oxygen.

Department of Anesthesiology, Center for Hyperbaric Medicine and Environmental Physiology, Duke University Medical Center, Durham, NC, USA

Reprinted with kind permission from Pollock NW, Hobbs GW. Evaluation of the System O_2 Inc portable non-pressurized oxygen delivery system. *Wilderness Environ Med*. 2002; 13: 253-5.

Key words
Reprinted from, first aid, resuscitation, oxygen, equipment, performance

Editor's comment: Dr Pollock advises that this device appears no longer to be marketed, though the Editor has seen it in the South Pacific region in recent years. A variety of small portable oxygen devices for resuscitation have been marketed over the years that have similar limited performance characteristics. There may be a place for international regulations to ensure oxygen resuscitation equipment meets minimum standards.

The absence of hearing loss in otologically asymptomatic recreational scuba divers [Abstract]

Taylor D McD, Lippmann J, Smith D

We undertook a retrospective cohort study of 16 experienced recreational scuba divers and 16 matched non-diver controls to determine the prevalence of hearing loss and, if present, the likely causes of this loss. Each subject was required to be aged 55 years or less and to have no history or likelihood of hearing loss. An audiologist, blinded to each subject's group status, undertook all examinations. There were no significant differences in group demographics. All divers were highly experienced (median number of dives 725). Comparison of mean hearing thresholds (range 250–8000 Hz) revealed no significant differences between divers and non-divers for both air and bone conduction studies. The only exception was at 6000 Hz where the air conduction threshold was significantly higher in divers than in non-divers ($p = 0.03$) However, there were no significant differences in Pure Tone and High Frequency averages. We conclude that experienced recreational scuba divers do not have elevated hearing threshold levels overall when compared to non-diver controls. This conclusion differs from that of investigators who have examined the hearing of experienced professional divers. Further investigation is indicated to further investigate this discrepancy and to determine whether the apparent hearing loss among the divers at 6000 Hz was an isolated departure from normal hearing thresholds or, in fact, the result of diving.

Emergency Department, Royal Melbourne Hospital, Victoria; Diver Alert Network (DAN) S.E. Asia-Pacific; Vicdeaf, Victoria, Australia

Reprinted with kind permission from Taylor D McD, Lippmann J, Smith D. The absence of hearing loss in otologically asymptomatic recreational scuba divers. *Undersea Hyperb Med*. 2006; 33: 135-141.

Key words
Reprinted from, ear barotrauma, hearing, scuba diving

Problems associated with scuba diving are not evenly distributed across a menstrual cycle [Abstract]

St Leger Dowse M, Gunby A, Phil D, Moncad R, Fife C, Morsman J, Bryson P

The problems encountered during scuba diving may be a contributing factor in an episode of decompression illness (DCI). Evidence exists that there may be a relationship between the position in the menstrual cycle and the occurrence of DCI. We examined, by prospective observation in female recreational scuba divers, any interaction between reported problems during diving (RPDD) and the position in the menstrual cycle. A total of 533 women, aged between 14 and 57 years, returned diaries for > 6 months, with 61% returning diaries for 3 consecutive years. A total of 34,625 dives were reported within 11,461 menstrual cycles between 21 and 40 days in length, with 65% of women reporting at least one RPDD. Logistic regression showed a significant non-linear relationship between the position in the menstrual cycle and RPDD ($p = 0.004$). RPDD were not evenly distributed over the menstrual cycle; the rate per 1,000 dives varied from 39.2 at start of the cycle to 19.7 during week 3, and 31.9 in week 4. We concluded these field data suggest a possible correlation between the incidence of RPDD and the position in which they occurred in the menstrual cycle.

Diving Diseases Research Centre (DDRC), Plymouth, UK, The University of Texas Health Science Center, Houston, Texas, USA and Derrford Hospital, Plymouth, Devon, UK

Reprinted with kind permission from St Leger Dowse M, Gunby A, Phil D, Moncad R, Fife C, Morsman J, Bryson P. Problems associated with scuba diving are not evenly distributed across a menstrual cycle. *J Obstet Gynaecol*. 2006; 26: 216-21.

Key words
Reprinted from, scuba diving, health surveys, women, menstruation, decompression sickness

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Cigarette smoking and decompression illness severity: a retrospective study in recreational divers [Abstract]

Buch DA, El Moalem H, Dovenbarger JA, Uguccioni DM, Moon RE

Background: Severe decompression illness (DCI) could be more likely in cigarette smokers because of airway obstruction or vascular disease. The present study evaluated the severity of DCI as a function of cigarette smoking in recreational divers.
Methods: We examined all DCI reports recorded in the Divers Alert Network (DAN) database from 1989 through 1997. Smoking history was quantified as heavy (> 15 pack-years), light (0 to 15 pack-years), and never smoked. DCI symptoms were classified as severe (alteration in consciousness, balance or bladder/bowel control, motor weakness, visual symptoms, convulsions), moderate (other neurological symptoms), or mild (pain, skin, or non-specific symptoms). The proportional odds model and generalised logits were used for the adjusted analysis when accounting for other covariates.
Results: There were 4,350 patients included in the analysis. After adjustment for confounding variables, heavy smokers were more likely to have severe vs. mild symptoms than nonsmokers (OR = 1.88) (95% CI 1.36, 2.60) or light smokers (OR = 1.56) (95% CI 1.09, 2.23). Heavy smokers and light smokers were more likely to have severe vs. moderate symptoms than nonsmokers (OR = 1.36) (95% Cl l.06, 1.74) and (1.22) (1.02, 1.46), respectively. Although these data do not reveal whether smoking predisposes to DCI, the results are consistent with a tendency, when DCI occurs, for cigarette smoking to trigger more severe symptoms.
Conclusions: The data suggest that when DCI occurs in recreational divers, smoking is a risk factor for increased severity of symptoms.

Department of Anesthesiology, Center for Hyperbaric Medicine and Environmental Physiology, Duke University Medical Centre, Durham, NC, USA

Reprinted with kind permission from Buch DA, El Moalem H, Dovenbarger JA, Uguccioni DM, Moon RE. Cigarette smoking and decompression illness severity: a retrospective study in recreational divers. *Aviat Space Environ Med***. 2003; 74: 1271-4.**

Key words
Decompression sickness, smoking, diving, embolism

Scuba diving and pregnancy: can we determine safe limits? [Abstract]

St Leger Dowse M, Gunby A, Moncad R, Fife C, Bryson P

No human data, investigating the effects on the foetus of diving, have been published since 1989. We investigated any potential link between diving while pregnant and foetal abnormalities by evaluating field data from retrospective study No.1 (1990/2) and prospective study No.2 (1996/2000). Some 129 women reported 157 pregnancies over 1,465 dives. Latest gestational age reported while diving was 35 weeks. One respondent reported 92 dives during a single pregnancy, with two dives to 65 m in the first trimester. In study No.2 > 90% of women ceased diving in the first trimester, compared with 65% in the earlier study. Overall, the women did not conduct enough dives per pregnancy, therefore no significant correlation between diving and foetal abnormalities could be established. These data indicate women are increasingly observing the diving industry recommendation and refraining from diving while pregnant. Field studies are not likely to be useful, or the way forward, for future diving and pregnancy research. Differences in placental circulation between humans and other animals limit the applicability of animal research for pregnancy and diving studies. It is unlikely that the effect of scuba diving on the unborn human foetus will be established.

Diving Diseases Research Centre (DDRC), Hyperbaric Medical Centre, Plymouth, UK, and The University of Texas Health Science Center, Memorial Hermann Center for Hyperbaric Medicine, Houston, Texas, USA

Reprinted with kind permission from St Leger Dowse M, Gunby A, Moncad R, Fife C, Bryson P. Scuba diving and pregnancy: can we determine safe limits? *J Obstet Gynaecol*. 2006; 26: 509-13.

Key words
Reprinted from, scuba diving, health surveys, women, pregnancy

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Decompression disease with breath-hold dive [Abstract]

Harms JD, D'Andrea C, Benhamou S, Archambaud E

Introduction: We report two cases of decompression disease with two breath-hold divers.
Clinical account: The divers (50 and 30 years old) presented neurological disorders immediately after repetitive dives down to 37 m for one and 60–70 m for the other. One patient presented right hemiparesis with a Broca's aphasia, and the other had right hemiparesis with a central vestibular syndrome. The first was treated with one hyperbaric oxygen treatment (HBOT) session (2.8 ATA); the symptoms declined. The second diver needed seven HBOT sessions. The first breath-hold diver had a scan before his HBOT which showed three bubbles and the two patients had perfusion-weighted magnetic resonance imaging (MRI) after the HBOT which showed T2-weighted hyperintensities corresponding to their symptoms. The MRI suggests a venous infarction for the first diver and arterial for the second. The research right-to-left shunt by transoesophageal contrast echocardiography was negative for both.
Discussion: Both divers used additional weight in order to speed up descents in series. Imaging revealed the formation of gas bubbles in the first diver's neurological venous system and arterial cerebral embolism for the second. The first diver with important MRI lesions clinically improved with one HBOT session whereas the other with minor lesions needed seven HBOT sessions.
Conclusion: These two cases show that weight-accelerated apnoea dives can induce decompression disease, though the diving conditions were different.

Unite de Soins Hyperbares, Service de Neuroradiologie, Groupe Hospitalier Sud Reunion, Ile de la Reunion, France

Reprinted with kind permission from Harms JD, D'Andrea C, Benhamou S, Archambaud D. Decompression disease with breath-hold dive. *European Journal of Underwater and Hyperbaric Medicine*. 2006; 7: 59.

Key words
Reprinted from, breath-hold diving, decompression sickness, case reports

Editor's comment: This abstract from the 2006 EUBS Conference is reproduced to add to recent data.[1,2]

1 Wong RM. Decompression sickness in breath-hold diving. *Diving and Hyperbaric Medicine.* 2006; 36: 139-44.
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Irukandji Taskforce guidelines for the emergency management of Irukandji syndrome

P Pereira, M Corkeron, M Little, D Farlow

These guidelines have been developed for use in Queensland Health hospitals and emergency departments. They have been approved by the Prevention and Response Working Group of the Queensland Irukandji Taskforce and were endorsed by the Taskforce on 29 January 2007.

Irukandji syndrome is described as a tropical marine sting (usually minimal discomfort) followed in 15–40 minutes by significant systemic symptoms of pain, agitation, and restlessness, and clinically associated with signs of catecholamine excess. A small number go on to develop cardiac failure. There have been two fatalities in Queensland in patients who have presented with Irukandji syndrome, both of whom succumbed to intracerebral bleeds.

Where a patient is suspected to be experiencing Irukandji syndrome the following guidelines may be found useful.

Over the phone advice may be sought through the Poisons Information Centre, Phone: 131 126.

Additional notes to guidelines flow chart

1 Initial resuscitation

- Application of vinegar, if not already administered.
- Attention to airway, breathing and circulation.
- Cardiac arrest managed as per standard protocols.

2 Hypertension

- Control of hypertension may be life saving given that both Irukandji-related deaths succumbed to intracerebral haemorrhage.
- Nitrates should be used as first-line antihypertensives for severe hypertension.
- IV phentolamine has been used successfully and may influence pain as an additional effect.

3 Investigations

- If available, all suspected Irukandji syndromes should have:
  On arrival:
    - Pathology: FBC, UEC, Mg, cTnI
    - 12 lead ECG
    - CXR
- An echocardiogram may be required if there is clinical or radiographic evidence of cardiovascular instability.

4 Maintenance

- Infusions can be reduced or ceased after 4 hours and recommenced if there is recurrence of symptoms or signs (see appendix 4).
- Monitoring is required if there is an abnormal initial cTnI or continuing severe symptoms.

5 Disposition

- Many patients settle after initial boluses of opiates and can be discharged home after 4 hours (even if they are experiencing mild symptoms) with simple analgesia, provided their symptoms are resolving and investigations are normal.
- If they require narcotic or magnesium infusions they should be admitted for observation and management. Management in hospital for at least 6 hours after the cessation of infusions is mandated and may require admission. If no opiate or magnesium has been required for 6 hours, and symptoms have resolved, the patient may be discharged.
- For any patients with ongoing severe pain, or cardiac abnormalities on ECG, CXR or raised Troponin, there is a risk they may deteriorate further and warrant high dependency monitoring with serial ECGs, CXR and cTnI.

For overt cardiac failure or the need for phentolamine infusions, or if there is evidence of neurological dysfunction the patient should be admitted/transferred to an ICU for aggressive management.

Reprinted with the kind permission of the Working Group of the Queensland Irukandji Taskforce.

The information on this page has been slightly condensed to fit; the material removed being already displayed in the flow chart opposite. The complete Taskforce guidelines including the detailed appendices on magnesium sulphate, glyceryl trinitrate and phentolamine infusions can be found on the SPUMS website <www.spums.org.au/information_and_research>.

Key words
Reprinted from, first aid, jellyfish, marine animals, toxins, resuscitation, treatment, flow chart

Guidelines for the Management of Irukandji syndrome

Dx Irukandji Syndrome → **First**

Apply high flow oxygen
Establish monitoring (ECG, SpO2)
Check blood pressure
Establish IV access

Pain And/Or Hypertension → **Then**

1. Opiate analgesia: Fentanyl 0.5mcg/kg q5min, up to 4 doses
   Morphine 0.05mg/kg q5min, up to 4 doses
2. GTN spray: 2 puffs q5min until infusion started
   (contraindicated in patients on Viagra/Levitra etc)
3. MgSO4: 0.15mmol/kg over 15min
   then infusion (for analgesia and hypertension)

Adjuncts:
- Midazolam:25mcg/kg q5min up to 4 doses or,
- Chlorpromazine or promethazine 0.3 mg/kg IV over 10 minutes

? Controlled

YES, Completely →

Observe q30min for 4hr

If symptoms and signs have been controlled on simple analgesics then may be discharged home for LMO F/U.

If initial cTnI is raised then admit for monitoring O/N

YES, but Pain returns →

Seek assistance (RING PIC 131126 or/and your regional ICU)
Readminister analgesic
And commence infusion. *See appendices*
Patient will require admission and can be discharged when symptom free for 6 hours.

NO ↓

Persistent Pain And/Or Hypertension → **Call for help (PIC)**

If on opiates: commence opiate infusion
add MgSO4 bolus and infusion
If on MgSO4: readminister MgSO4 bolus,
add opiate + opiate infusion if necessary
For BP control:commence GTN infusion unless contraindicated,
Discuss with PIC regarding:
a) MgSO4 infusion,
b) Phentolamine infusion

POISONS Info Centre: 131126

Opiate side effects and precautions

Respiratory depression
Reduced level of consciousness
Increased nausea
Itch
Urinary retention
Ensure naloxone is available

Hypotension from GTN

May be related to unsuspected use of a selective phosphodiesterase inhibitor (Viagra/Levitra). If BP doesn't improve with cessation of GTN, aggressive IV fluids and adrenaline will be required.

$MgSO_4$ side effects and precautions:

Flushing and mild to moderate injection site pain are common

Hypotension may occur especially if the pt is dehydrated or on antihypertensive drugs
If significant hypotension occurs: Stop infusion
Give 10ml/kg Hartmanns solution stat
Consider calcium gluconate

Cardiac toxicity has not been reported in humans without antecedent disturbance of neuromuscular function. Serum level is not a useful guide to either therapy or toxicity. Dose limits are determined by maintenance of reflexes and clinical effect

Obituary

Henry Valance 'Val' Hempleman MA, PhD

Physiologist
Born: 25 March 1922
Died: 14 July 2006

Dr Val Hempleman, whose name will rank alongside those of other notable scientists such as Professors JS Haldane and Leonard Hill, died aged 84 on 14 July 2006. Val's work in the field of decompression procedures provided the next quantum leap in decompression techniques after some 100 years' experience with Haldanian theories.

His work has undoubtedly saved many lives and countless cases of decompression sickness worldwide. Beneficiaries of his achievements include naval, commercial and recreational divers, submariners and caisson tunnel workers, all of whom require safe decompression procedures.

Val was born in Neasham, Darlington, UK, on 25 March 1922. His father, Harry Hempleman, was a sea captain who worked between New Zealand and the UK. Val's keen interest in science and his natural academic ability won him a scholarship to Hymers College, Hull. One of his earliest experimental projects almost blinded him when, at the tender age of 13, he managed to blow himself up, together with the garden shed in which he had built a home-made laboratory.

His academic prowess continued to excel and Val obtained a place at St Catherine's College, Cambridge University, where he studied inorganic chemistry and physics. His degree work was interrupted by the Second World War when in 1942 he was called up to work as a research scientist for the Royal Navy.

He joined the staff of *Vernon II*, a Royal Navy physiological laboratory, then located at Peel Cottage, Alverstoke. One of the principal areas of research at the time was the investigation of the effects of explosions on personnel in or under water. These included military divers who were required to clear the European ports of mines and booby-traps left behind by the Germans. Val was one of the volunteers who exposed himself to the effects of underwater explosions by standing up to his neck in the sea whilst explosive charges were detonated closer and closer to him.

At the end of the War he returned to university and completed his degree, leaving with a First Class Honours degree in Chemistry. His first job came in 1946 in the Wellcome Physiological Research Laboratory in Beckenham, Kent, where he used electrophoretic techniques to produce chemotherapeutic agents to fight pertussis infections. However, the allure of the Royal Navy physiological research proved too great and in 1949 he re-joined *Vernon II*, now renamed the Royal Naval Physiological Laboratory, as a scientific officer.

Val's career in decompression table development started immediately and he willingly became a human guinea pig to test his own theories. On one occasion he nearly died from mercury vapour poisoning when a mercury thermometer accidentally broke whilst he was confined under pressure inside a steel chamber.

Perhaps Val's single, most notable achievement came in 1952 when he published his new theory on decompression procedures and the calculation of safer decompression schedules. The Royal Navy at the time needed the capability to dive deeper than ever before, largely because submarines could now operate deeper. Should a Royal Navy submarine ever need rescuing, then divers needed to be able to reach it. It was Val Hempleman to whom they turned to provide the essential, safe decompression procedures.

Exactly fifty years ago, in 1956, the Royal Navy proved to the world that divers could reach the world record depth of 600 ft. Lieutenant George Wookey successfully reached 600 ft from *HMS Reclaim* in a Norwegian fjord and, despite overstaying his planned duration at depth due to an entanglement of his gas hose and life line, was safely decompressed.

In the 1960s, Val turned his attention to the plight of caisson tunnel workers who traditionally had suffered very badly from the effects of working under pressure. In 1966, he produced a set of decompression tables that virtually eliminated the cases of decompression sickness. The tables were very successfully adopted at a major caisson tunnel project in Blackpool and the tables themselves hence became known as "The Blackpool Tables". They have since become globally accepted as the industry standard.

Val took over as Superintendent of the Royal Naval Physiological Laboratory in 1968 shortly after gaining his Doctor of Philosophy for his research into the prevention of decompression sickness. About this time, researchers around the world had concluded that the limit of deep diving was around 1,200 ft and that there was a "helium barrier" that prevented divers going any deeper, without risk of convulsions and death. With a dedicated team of scientists led by Dr Peter Bennett, and Val's essential decompression procedure, the Laboratory successfully debunked the so-called helium barrier in 1970 when two of its scientists, John Bevan and Peter Sharphouse, carried out a world-record simulated dive to 1,535 ft. The achievement was heralded by the Americans as “a hyperbaric moon-landing”. Congratulations poured into the Laboratory from eminent scientists in all parts of the world. Another leap forward was made in 1980 when two more scientists, Martin Garrard and Mark English, reached a simulated depth of 2,165 ft in the same chamber.

Val was honoured to receive the prestigious Albert R Behnke Jr Award of the Undersea Medical Society in 1976. This was the first time the award had ever gone to a non-American citizen. The following year he received the Queen’s Silver Jubilee Medal and when he retired in 1982 he received the Imperial Service Order.

Val had been a founder member of the Underwater Engineering Group of the Construction Industry’s Research and Information Association and of the European Undersea Biomedical Society. He was also a member of the Undersea and Hyperbaric Medical Society, the Ergonomics Research Society and the Medical Research Council’s Panel on Decompression Sickness.

Val was the quintessential gentleman scientist. Despite a formidable international reputation he remained the embodiment of modesty and humility. He was endowed with patience, tolerance, compassion, old-world charm and a lively, self-effacing sense of humour. Val leaves a widow, Barbara, and two married sons, Andrew and Robert.

John Towse and John Bevan

This obituary first appeared in *Underwater Contractor*

Editor’s comment:

I first met Val Hempleman in 1964 when, as a third-year medical student, I was part of a Cambridge University diving team that trained with the Royal Navy on its first semi-closed circuit rebreather. We were guinea pigs for testing the RNPL heliox decompression tables (created by Hempleman and Peter Barnard) over the 45 to 70 msw range.

I vividly recall our band of long-haired students being allowed to sit in on a morning session in the library attended by, amongst others, Val, Barnard, a newly-arrived young surgeon-lieutenant called David Elliott and a famous applied mathematician. A vigorous debate ensued regarding the mathematics of gas exchange dynamics under pressure, much of which went over my head. After the mathematician left, Val, with his inimitable chuckle and wry grin (see photo), concluded that it was all very well, but took no account of what actually happened in the body!

Over the ensuing years, Val repeatedly supported a fledgling United London Hospitals Diving Group in our amateur research endeavours, probably completely against Navy regulations, lending us equipment and manpower. He was always cheerfully willing to give advice on our enthusiastic student endeavours. He was indeed the “quintessential gentleman scientist”!

Michael Davis

Key words
Obituary, decompression, models, tunnelling, saturation diving, research

Letter to the Editor

Asthma and scuba diving

Dear Editor

It would be churlish to fail to respond to the provocative suggestion contained in The Editor's Offering[1] that the absence of a response to the ANZ Thoracic Society's discussion paper should be taken to mean that Robyn Walker's paper[2] should be accepted as the final word on the subject. It is possible to read her paper as a description of the differing views on this problem that exist in Australia, New Zealand, and the UK without finding any convincing evidence of a proven relationship between the presence of 'asthma' and its relevance to the fatal dive outcome.

The paper quotes Neuman et al as finding a fatal accident rate of 1 asthmatic in 2,132 deaths, and the UK experience has reportedly not found any scuba diving fatalities as a consequence of the BSAC's relaxed attitude to asthma. It would be easy to show that there is a far higher relationship between age over 40 and cardiac deaths in divers than that of deaths related to asthma, so if the objective is to reduce diving-related deaths the former condition offers an obvious management option.

With respect to the ANZ Thoracic Society's views, it would be helpful to have a detailed report of any examination it has made of fatalities involving asthmatics before reaching its conclusions concerning asthma and diving. It is generally accepted that there are many asthmatics who scuba dive without [reported] asthma-related problems. This does not mean that asthma is a harmless condition, merely that it is not necessarily a significant factor leading to scuba diver deaths. The National Asthma Council of Australia reportedly estimated that about 40% of Australians at some time will have symptoms to which the 'asthma' label can be applied, so there is clearly need for more work before it becomes possible to identify the group who are at special risk.

In many of the cases described in my provisional reports where the decedent had a possible history of asthma, there were significant other factors that played a critical part in converting a survivable incident into a fatality. I am aware that this letter will 'stir the possums' but, as this is probably the result the Editor had in mind when he made his comment, I am prepared to act the part of the 'devil's advocate' to get the discussion going. 'Asthma' is diving medicine's shibboleth and it is clearly time to reconsider the matter taking into account available case reports.

To start discussion the following data may be of interest:

- New Zealand 1959–1999 [3,4]
  119 scuba deaths 5 with asthma history
- Australia 1950–2001[5–9]
  279 scuba deaths 18 with some asthma history.

It should be noted that in all of the New Zealand cases the divers were either grossly inexperienced or were untrained, and there was only one case in which asthma could be implicated.[8] In the Australian series there were two in which asthma could be implicated [81/1, 84/5], in one of them the victim having previously been advised his next diving incident could be fatal. In two there was insufficient evidence as to whether or not asthma may have been a factor [98/4, 96/2], while in the remainder there was no reason to implicate asthma.

References

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Douglas Walker,
Project Stickybeak,
E-mail: *<diverhealth@hotmail.com>*

Key words
Letters (to the Editor), asthma, deaths, scuba diving

SPUMS Annual Scientific Meeting 2007

Dates: April 15 - 20

Venue: Oceans Resort, Tutukaka, Northland, New Zealand

Guest Speaker

Neal Pollock, PhD

Themes

From mountain high to ocean deep – the physiological challenges of extreme environments

Workshop: Medical aspects of technical diving

Neal Pollock is a research physiologist at the Center for Hyperbaric Medicine and Environmental Physiology, Duke University Medical Center, Durham, NC. He is also heavily involved in DAN International and was Chief Editor of the recent DAN guidelines for scuba diving and diabetes. He has worked in Antarctica and been involved in high-altitude physiology studies. He thus brings a wealth of expertise to our meeting and is an excellent speaker.

Other confirmed speakers include:
Carl Edmonds, Foundation President, SPUMS
Simon Mitchell, Auckland Hospital
Richard Smerz, Hawaii
Martin Sayer, Dunstaffnage, Scotland
Andrew Fock, Melbourne
Michael Bennett, Sydney
Michael Lang, Smithsonian Institute
Ian Millar, Melbourne

This will be an outstanding meeting in a beautiful area of New Zealand, with superb diving at one of the world's finest sub-tropical diving sites – The Poor Knights Islands. You will need a wetsuit, but don't let that put you off!

Registration forms and details are available on the Society website <www.SPUMS.org.au>
Daily registration details are also available on request to <spumsadm@bigpond.net>

Co-convenors: Mike Davis and Simon Mitchell

Enquiries and Submission of Abstracts (300 words maximum) to:
Associate Professor Michael Davis
PO Box 35, Tai Tapu 7645, New Zealand
E-mail: <michael.davis@auckland.ac.nz>
Phone: +64-(0)3-329-6857; **Fax:** +64-(0)3-329-6810

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Journal review

The International Journal of Diving History, volume 2 (1)

Nigel Phillips (ed)

ISBN 0 9543834 3 5
London: The Historical Diving Society; 2006.
Copies may be purchased from the Secretary of the HDS, c/o Little Gatton Lodge, 25 Gatton Road, Reigate, Surrey, RH2 0HB, UK.
Price: 9.50 GBP (+ P&P for rest of world)

The first issue of this annual journal described the development of the one-atmosphere diving suit as well as providing an entertaining account of "alternative uses for divers and the diving bell in nineteenth century England". This second issue presents papers from a joint meeting of the British and Norwegian Historical Diving Societies in Bergen, Norway in 2006 devoted to the early development and use of the diving bell in Scandinavia and Great Britain.

At that meeting, a replica of Triewalds' original bell was operated successfully, including supplying fresh air to the bell from lowered wine barrels and a flexible tube. Rather than focusing on his bell, the importance of Edmond Halley's diver's helmet to allow the diver to work outside the bell for the first time is described in detail. This was an innovation long before its time as it was largely forgotten for more than two centuries, but is the precursor of modern bell diving.

The tragic death of Charles Spalding and his nephew in his bell whilst attempting salvage on a wreck is a fascinating detective story. A final paper describes what is known of the tools divers used to break into wrecks and recover items, some as large as heavy cannon. The privations these men had to endure, immersed to the waist for long periods in cold water with little protection, are hard to contemplate.

This is an excellent publication for anyone interested in the history of diving.

Michael Davis, Editor

DIVING HISTORICAL SOCIETY AUSTRALIA, SE ASIA

All enquiries to:
Diving Historical Society Australia, SE Asia,
PO Box 2064,
Normansville, SA 5204,
Australia
Phone: +61-(0)8-8558-2970
Fax: +61-(0)8-8558-3490
E-mail: <bob@hyperbarichealth.com>

THE UNIVERSITY OF AUCKLAND
FACULTY OF MEDICAL AND HEALTH SCIENCES

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

Enquiries from registered medical practitioners are now being accepted for 2008 for the Masters and Postgraduate Diploma programmes in diving and hyperbaric medicine.

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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 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 their 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

ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE COURSES 2007

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Advanced	06/08/07	to	10/08/07

DMT Full Course

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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>

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

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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)

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>

AUSTRALIAN AND NEW ZEALAND COLLEGE OF ANAESTHETISTS ANNUAL SCIENTIFIC MEETING

Venue: Melbourne Exhibition and Convention Centre

The Diving and Hyperbaric Medicine Special Interest Group session will be held on 28 May 2007, 1530–1700 hr

For more information contact:
<anzca2007@meetingplanners.com.au>
or: <margaret.walker@dhhs.tas.gov.au>

HYPERBARIC TECHNICIANS and NURSES ASSOCIATION
15th ANNUAL SCIENTIFIC MEETING

Dates: 09 to 11 August 2007
Venue: Stamford Plaza, Adelaide

Guest speakers Professor Des Gorman, Mr Dick Clarke and Associate Professor Mike Davis

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

UNDERSEA and HYPERBARIC MEDICAL SOCIETY
Annual Scientific Meeting 2007

Dates: 14 to 16 June 2007
Venue: The Ritz-Carlton, Kapalua, Maui

General information and online registration can be found at <http://www.uhms.org/Meetings/AMMeetingsMain.htm>

For additional information:
Lisa Wasdin, c/o Undersea and Hyperbaric Medical Soc.
PO Box 1020, Dunkirk, Maryland 20754, USA
Phone: +1-410-257-6606 extn 104
Fax: +1-410-257-6617
E-mail: <lisa@uhms.org>

ASIAN HYPERBARIC & DIVING MEDICAL ASSOCIATION (AHDMA)
THIRD SCIENTIFIC MEETING 2007

Dates: 12 to 15 April 2007
Venue: Sanur Paradise Plaza Hotel, Bali, Indonesia

Registration details and further information contact:
E-mail: <secretary@ahdma.com>
Website: <www.ahdma.com>

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.

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

The DES numbers are generously supported by DAN-SEAP

PROJECT STICKYBEAK

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

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

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