

# Diving and Hyperbaric Medicine

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and the European Underwater and Baromedical Society*

**SPUMS**

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**EUBS**



## **Scientific diving safety in North America**

**Lax attitude to alcohol and diving in UK recreational divers**

**A forensic medical analysis of the “honeymoon dive”**

**Irukandji – the tiny box jellyfish with a big punch**

**TCOM for the upper limb**

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

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### Alcohol and scuba diving

Alcohol has always been a prominent part of the social fabric of recreational diving, and I well remember, back in the 1960s on our university diving club trips to South Wales, how we used to drive to the pub for lunch and a pint or two between morning and afternoon dives, then spend most of the evening back at the pub drinking. Such behaviour is still prevalent, as described in this issue in the Plymouth survey of alcohol consumption and attitudes, and this is not limited to UK divers.<sup>1</sup> Over my half century of diving, I have regularly witnessed (and admit to having participated myself, when younger) divers drinking to excess of an evening then diving the following morning. Such behaviour seems relatively common even amongst diving medical practitioners, who should perhaps know better. Almost certainly excessive alcohol intake contributed to one case of neurological decompression sickness at a SPUMS Annual Scientific Meeting some years ago. Thus, both the evidence from the UK survey and anecdote show that drinking alcohol whilst diving is commonplace amongst recreational divers.

There is a well-established relationship between alcohol consumption and drowning in the general population; a typical case that highlights this occurred only recently in my community, when a 20-year-old man with a blood alcohol level of 145 mg 100 ml<sup>-1</sup> failed to take a bend, crashed his car into the river and drowned. However, we know little about the relationship between alcohol and diving morbidity and mortality. In an analysis of 100 consecutive scuba diving deaths reported in Project Stickybeak during the 1980s, “*excess alcohol*” was recorded in the blood of only four divers, though not all divers were tested.<sup>2</sup> In a review of snorkelling and scuba diving-related deaths in New Zealand between 1980 and 2000, a blood alcohol level was measured in only 43% of the 169 bodies undergoing autopsy.<sup>3</sup> Five of 24 snorkellers and four of 48 divers had a positive blood alcohol, but in only three drownings was this considered a possible contributing factor.

The guidelines for diving-related autopsies in Australia and New Zealand (ANZ), promulgated by the Royal College of Pathologists of Australasia, advise that blood and urine should be preserved for alcohol and carbon monoxide analysis and a drug screen.<sup>4</sup> Despite this, fatality reports from the Antipodes in the past decade contain virtually no information on the results of these analyses.<sup>5,6</sup> Although poor dive planning and poor decision making are common risk factors identified in these and many other reports on diving deaths, whether or not alcohol played any part is essentially unknown. A very recent review of 40 fatal diving accidents in western Norway from 1983 through 2007 reported that in the 31 divers in whom the cause of death was documented as drowning, one diver had a high blood

alcohol concentration, whilst alcohol was found in the urine of two others, indicating previous consumption.<sup>7</sup>

To improve our understanding of the role alcohol plays in diving deaths, it is important that all future published reports include toxicology data, and that more emphasis is placed on ensuring that autopsies are performed in accordance with the recommended guidelines. In addition, police records, where possible, need to include a drinking history for the 24 hours prior to the fatal dive.

### Tri-continental conference – Réunion 2013

A unique academic and social experience takes place 22–29 September, 2013 on the island of Réunion in the Indian Ocean, when the SPUMS, EUBS and Southern African Underwater and Hyperbaric Medical Association combine for a tri-continental conference. Registration and submission of abstracts open on 20 December. Conference facilities on Réunion are relatively limited, so there is room for about 180 delegates at the planned venue. This opportunity for the three societies to gather together is likely to be a memorable experience. All members are encouraged to book early as it will be a ‘first come, first served’ situation.

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### Key words

Editorials, alcohol, diving deaths, autopsy, meetings, medical society

Michael Davis

# The President's page

Costantino Balestra, President EUBS

Is your state...steady?

For many years, the fields of diving and hyperbaric medicine has shown how to approach our understanding of the effects of environmental stressors on human pathophysiology. It has demonstrated the importance of oxygen and has learnt not to fear this oxidative molecule (*occidere* in Latin means 'to kill'). The contentious arguments between the good and the bad sides of oxygen highlight the dichotomy that exists in the literature – on the one hand, one finds interesting reports on the potential benefits of supplemental oxygen and, on the other, statements such as

*“the benefits of supplemental oxygen are not yet confirmed, and new findings suggest that potential side-effects should be considered if the inspired oxygen concentration is increased above what is needed to maintain normal arterial oxygen saturation.”*<sup>1,2</sup>

This demonstrates the diversity of current opinion, and how hyperoxic (not necessarily hyperbaric) and hypoxic states can potentially be manipulated.<sup>3,4</sup> Some see parallels between Dr Jekyll and Mr Hyde and oxygen,<sup>3</sup> but I would rather consider oxygen as a multifaceted molecule, not simply as good and bad.

The 'steady state' approach might be responsible for this situation. We have been formatted for so long to assess responses (micro- or macroscopic) according to a very stable and controlled situation. Newer technologies and the speed of response of modern instrumentation allow us to adopt a different approach and to understand the 'versatility' of oxygen in new and better ways. The environmental sciences are probably chiefly responsible for such a development, since their approach is based on the 'coping reaction' to stressors and, of course, the speed of adaptation involved. An excellent example, described at the last EUBS meeting by an Israeli group, is that even 'old' neurological lesions can respond in a favorable way to 'oscillations' of the partial pressure of oxygen – a rather unexpected outcome, if viewed from a classical perspective.

'Pulsed/variations/oscillations/acute exposures'...are some of the terms used in the literature to characterize unsteady states or transient steady ones. We have been studying steady-state pathophysiology for many years (around 200 years); however, the future would seem to be in facing new paradigms, probably less easy to cope with but opening new frontiers.

Finally, it looks like oxygen is more of a 'slasher' than a bicephalic entity. Slasher is a term coined by Marci Alboher to describe a growing number of people who cannot give

Figure 1



a single answer to the question “and what do you do for a living?” to which the answer might be music teacher/webmaster/personal trainer...

Oxygen is clearly a slasher, a multifaceted actor, and this reality, on the one hand, attracts markedly divergent opinions and, on the other, ensures many new ideas for research. This multi-faced head seen on a building in Bergen, Norway (Figure 1) reflects the way to truly understand oxygen I believe.

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## Key words

Medical society, meetings

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# Original articles

## The incidence of decompression illness in 10 years of scientific diving

Michael R Dardeau, Neal W Pollock, Christian M McDonald and Michael A Lang

### Abstract

(The incidence of decompression illness in 10 years of scientific diving. Dardeau MR, Pollock NW, McDonald CM and Lang MA. *Diving and Hyperbaric Medicine*. 2012;42(4):195-200.)

**Background:** The American Academy of Underwater Science (AAUS) constitutes the single largest pool of organizations with scientific diving programmes in North America. Members submit annual summaries of diving activity and any related incidents.

**Methods:** All diving records for a 10-year period between January 1998 and December 2007 were reviewed. Incidents were independently classified or reclassified by a four-person panel with expertise in scientific diving and diving safety using a previously published protocol. Subsequent panel discussion produced a single consensus classification of each case.

**Results:** A total of 95 confirmed incidents were reported in conjunction with 1,019,159 scientific dives, yielding an overall incidence of 0.93/10,000 person-dives. A total of 33 cases were determined to involve decompression illness (DCI), encompassing both decompression sickness and air embolism. The incidence of DCI was 0.324/10,000 person-dives, substantially lower than the rates of 0.9-35.3/10,000 published for recreational, instructional/guided, commercial and/or military diving.

**Conclusions:** Scientific diving safety may be facilitated by a combination of relatively high levels of training and oversight, the predominance of shallow, no-decompression diving and, possibly, low pressure to complete dives under less than optimal circumstances.

### Key words

Decompression illness, decompression sickness, occupational health, safety, scientific diving, epidemiology

### Introduction

Scientific diving is diving performed by individuals that is necessary to and part of a scientific research or educational activity, in conjunction with a project or study under the jurisdiction of any public or private research or educational institution or similar organization. Divers can join programmes with or without prior diver training or experience. Once in the programme they undergo medical evaluation, skill evaluation and diver training. Diving operations are required to adhere to formal programme rules, including depth and, often, task restrictions. Scientific diver currency requires meeting standards of minimum diving activity, refresher training and periodic medical review. A diving officer, acting on behalf of an institutional diving control board, is typically responsible for the training and monitoring of all scientific diving activity, ensuring compliance with rules and safe and effective dive team operations. While much of the diving is conducted as shallow, multi-level, no-decompression exposures, operations are conducted under a range of conditions, from tropical to polar, fresh and saltwater, sea level and high altitude, demanding both skill and appropriate real-time decision-making to prioritize safety. The safety record of scientific diving programmes is generally recognized as very good, but the published documentation is limited.

A review of adverse events reported within the scientific diving community concluded that total pressure-related injury rates from 1998 to 2005 were similar to those calculated by the US Occupational Safety and Health Administration (OSHA) for scientific divers during the late 1970s.<sup>1</sup> The computation of injury rate per 100 workers per year was matched to the earlier OSHA method. Both studies included minor barotrauma as well as decompression illness (DCI – the collective term for decompression sickness [DCS] and arterial gas embolism [AGE]) but did not address the incidence of only DCI. The limited reports on the incidence of DCS for scientific diving range from 0/10,000 person-dives in Australia to 2.8/10,000 person-dives in the Antarctic.<sup>2,3</sup> These rates are relatively low when compared to the 1.4–35.3/10,000 person-dive estimates for commercial and military diving communities, but additional documentation is required.<sup>3</sup>

The American Academy of Underwater Sciences (AAUS) was formed in 1977 as a collection of organizational member programmes representing a range of public and private academic institutions, educational entities and research units with active involvement in scientific diving. AAUS membership requires programmes to submit annual summaries of dives, mode of diving and any incidents associated with scientific diving. These diving records make

AAUS a major source of data on scientific diving in North America. Our goal was to determine the incidence rate of DCI in a large and diverse record of scientific diving.

### Methods

We reviewed 10 years of diving records reported by AAUS organizational members, from January 1998 through December 2007. Human subjects research approval for the study was provided by the Divers Alert Network's institutional review board.

A four-person review panel, experienced in scientific diving, the administration of scientific diving programmes, and diving safety, reviewed all submitted incident reports. While incident types (hyperbaric, near drowning, etc) were defined for reporting purposes, there was some latitude for diving safety officers to determine what was reportable.<sup>1</sup> A four-step filtration process was employed to remove cases representing other-than-DCI. The first step excluded records that were 'non-events' (submission error) or 'no injury' cases. The second excluded cases that were not pressure-related. The third excluded cases of minor barotrauma (e.g., ear squeeze). The remaining cases (possible DCI) were then classified or reclassified as 'DCI', 'ambiguous' or

'not DCI' using a modified version of previously described standardized criteria designed for objective post hoc, non-clinical assessment (Table 1).<sup>4</sup> The panel reviewed all possible DCI cases independently and then came together to assign final classification based on consensus decision. Contentious or incompletely documented cases were further investigated through interviews with involved persons. Ambiguous cases were considered to be cases of DCI for the computation of incident rates.

All data in the present study reflect person-dives, that is, even when a team of two or more dives together, each diver reports the dive as an individual event. Incident rates and 95% binomial confidence intervals (CI) are presented as cases per 10,000 person-exposures. A Chi-square contingency table was used to compare annual differences in DCI across reporting years. Significance was accepted at  $P < 0.05$ .

### Results

Annual scientific diving activity reported by AAUS members appears in Figure 1. The number of members reporting increased substantially during the study period (ranging from 54 to 94), in turn increasing the number of divers (ranging from 2,716 to 4,101) and person-dives tallied

**Table 1**

Case (diagnosis) classification/reclassification (adapted from<sup>4</sup>); AGE –arterial gas embolism, DCI – decompression illness

#### Cases classified as 'not DCI'

- Cases with single dives to less than 9 metres' sea water (msw) and symptoms that could not be attributed to AGE;
- Cases with symptom onset times more than 48 hours after the last dive or altitude exposure;
- Cases with signs and symptoms likely due to a non-diving cause of injury upon review of medical history;
- Isolated headache, dizziness, anxiety, general weakness, fatigue, or subjective numbness and tingling of both hands and feet, in the absence of other symptoms or without objective findings.

Note: Cases with no response to recompression were reviewed extensively before being classified as 'not DCI'.

#### Cases classified as 'ambiguous'

- Cases with sufficient exposure but minimal or atypical symptoms;
- Cases in which symptoms resolved spontaneously without recompression in less than 20 minutes with surface oxygen or less than 60 minutes without oxygen;
- Cases with confounding medical conditions that could explain the symptoms;
- Combinations of headache, dizziness, anxiety, general weakness, fatigue, and subjective numbness and tingling of both hands and feet, in the absence of other symptoms or without objective findings.

#### Cases classified as 'DCI'

##### *Decompression sickness:*

- Cases with a dive depth of at least 9 msw;
- Joint/limb pain, skin/lymphatic symptoms, constitutional/non-specific symptoms;
- Serious neurological, cardiopulmonary, mild neurological and simultaneous presence of pain and constitutional symptoms.

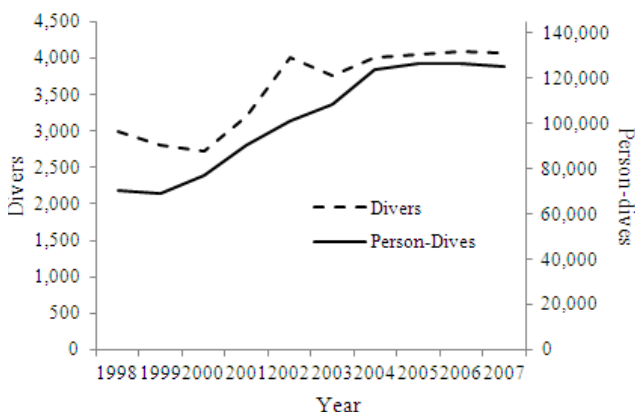
##### *AGE:*

- Cases with symptom onset in less than 15 minutes post-dive;
- Cases with cerebral neurological symptoms, signs or findings;
- Cases with symptom duration greater than 15 minutes.

Note: Rapid ascent, out-of-air incident, or the presence of cardiopulmonary symptoms increased the confidence of an AGE diagnosis.

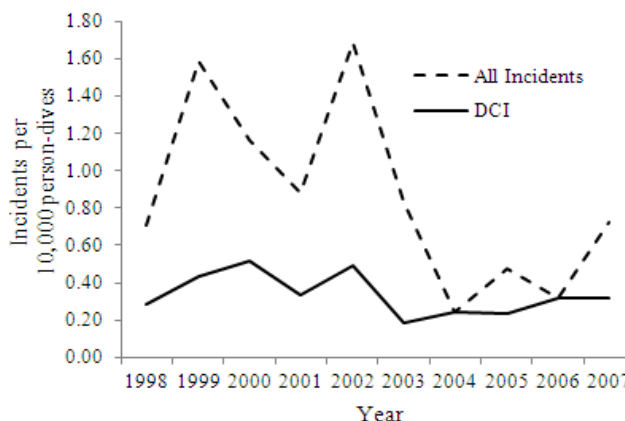
**Figure 1**

Number of divers and reported scientific dives by year



**Figure 2**

All incidents and DCI cases reported



annually (ranging from 68,598 to 126,831; Figure 1). The number of dives completed by individual organizational members varied tremendously, based on the size of the diving programme and active scientific diving projects. Most organizational members were American institutions, with only three to five based outside the United States for any given year.

The 10-year study period captured 1,019,159 person-dives and 102 incidents occurring in conjunction with these exposures. No case involved multiple victims of a single event. A summary of the case count by year before and after filtration and/or reclassification to include only DCI cases appears in Figure 2. Steps to improve the reporting of organizational member diving activity began with the 2004 reporting cycle and culminated in the implementation of a formal training programme for new diving safety officers in 2006. It is possible that the apparent decline in reporting non-DCI events was associated with heightened awareness gained through these efforts.

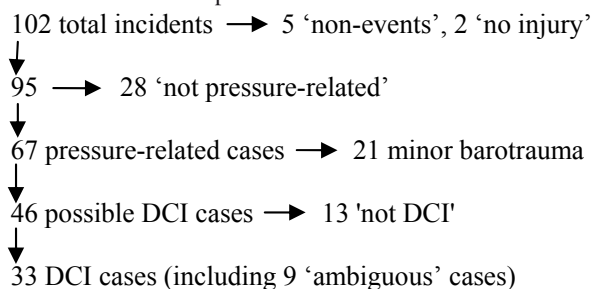
The stepwise filtration of incident reports is summarised in Table 2. The first step excluded seven cases; five as ‘non-events’ and two as ‘no injury’. The second step excluded 28 cases as ‘not pressure-related’ (including two fatalities resulting from medical emergencies – one a myocardial

infarction following an unremarkable checkout dive and the other a case of unexplained sudden death following a very short, shallow exposure). The third step excluded 21 cases of mostly minor barotrauma, yielding 46 cases of possible DCI.

The 46 cases of possible DCI we identified included 13 that were treated with recompression but then classified as ‘not DCI’. Of these, five involved a history of back or shoulder injury that did not respond to hyperbaric treatment, five involved unrelated medical conditions that were initially submitted as DCS, and three cases involved symptoms more likely related to environmental conditions (thermal stress and anxiety). In only one case did we ‘overturn’ a physician diagnosis of DCS (in agreement with a follow up by another physician who ruled out DCS). In one other case, we retained a classification of DCS when a physician changed his diagnosis to rule out DCS following recompression therapy. This incident involved a diver who reported having shoulder pain pre-dive that felt better at depth and returned post-dive (he had dived two days earlier). The pain was fully resolved upon completion of a US Navy Treatment Table 6. Ultimately, 33 cases were classified as DCI, 25 with fully evolved symptomology and eight with ambiguous symptoms. Recompression therapy was reported to be successful in 28 of the 33 DCI cases; 19 with a single treatment and nine with multiple treatments.

**Table 2**

Stepwise case filtration

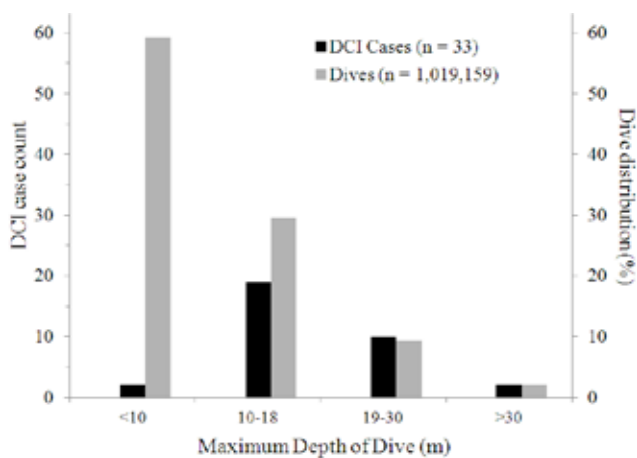


The 95 valid incident reports yielded an all-events incidence rate of 0.93/10,000 person-dives. The 33 DCI cases yielded a rate of DCI of 0.324 per 10,000 person-dives (95% CI 0.234 to 0.424). The annual rates of DCI were not significantly different ( $X^2$  [df 9; crit 16.92] = 3.32), ranging from a low of 0.18/10,000 persons-dives in 2003 to a high of 0.52/10,000 person-dives in 2000 (Figure 2).

The distribution of maximum depth for all captured dives was 59% < 10 metres’ sea water (msw), 30% 10–18 msw, 9% 19–30 msw and 2% > 30 m (Figure 3). Exposures with a maximum depth < 10 msw included only one case diagnosed

**Figure 3**

Depth distribution of DCI cases (count) &amp; dive distribution (%)



as an arterial gas embolism and one ambiguous DCI case. All but four DCI incidents occurred on dives with maximum depths between 9 and 30 msw. Two DCS cases occurred on dives to depths in excess of 40 msw.

### Discussion

DCI is a relatively rare event, requiring monitoring of exposures over a broad geographic area and a long time period to yield meaningful rates.<sup>5</sup> A number of incidence measures have been published, but all with much smaller exposure numbers than the current study (ranging from 14,944 to 700,000 exposures). DAN's Project Dive Exploration estimates of the incidence of DCI in the recreational community to be 2.0–4.0/10,000 person-dives.<sup>4,6,7</sup> This is higher than previously reported rates of 0.90/10,000 person-dives (DCS) and 0.96/10,000 person-dives (DCI).<sup>8,9</sup> DCS rates among divemasters and instructors have been estimated at 12.7–15.2/10,000 person-dives.<sup>10</sup> The rate of DCI among military sport divers has been estimated at 1.34/10,000 person-dives.<sup>11</sup> Shallow, no-decompression dives among navy divers produced incidence of DCS of 2.9/10,000 person-dives.<sup>12</sup> The US National Oceanic and Atmospheric Administration (NOAA), which conducts both working dives as well as scientific dives, reported a DCS incidence of 1.8/10,000 person-dives.<sup>13</sup> The incidence of DCS in commercial decompression diving has been reported to be as high as 35.3/10,000 person-dives.<sup>14</sup> A more recent study reported commercial diving DCS incidence rates ranging from 1.4 to 10.3/10,000 person-dives depending on the depth of dive operations.<sup>15</sup>

Long-standing Antarctic scientific diving programmes are managed by several nations.<sup>16,17</sup> The incidence rate of DCS for Antarctic scientific diving is reported as 2.8/10,000 person-dives (there were no cases of AGE).<sup>3</sup> Outside of Antarctic scientific diving, DCS/DCI incidence rate estimates in the scientific diving community are lower than in other diving populations.<sup>3</sup> Estimates range from 0/10,000

dives to 0.6/10,000 person-dives.<sup>2,18</sup> The zero estimate was based on 14,944 person-dives and the 0.6/10,000 estimate included only one case of DCS in 15,711 exposures. The rate of 0.32 incidents per 10,000 person-dives reported in the current study falls within this range. The requirements for routine diving medical surveillance, equipment maintenance requirements, and additional training and oversight combined with the predominance of shallow, no-decompression diving, may result in lower incident rates in the scientific community than in other diving populations.<sup>5,19</sup>

Risk estimate efforts have several limitations. A frequent challenge of epidemiological studies is the accurate quantification of all relevant activity, effectively the denominator needed to compute incident rates. Exposure to DCI among recreational divers has been determined using prospective studies, or more roughly estimated by surveys or by surrogate counts such as cylinder fills.<sup>4,6,9,11,20</sup> Less available are the data generated by occupational diving programmes that require routine logging of both dives and incidents. An additional complication of studying DCI is the potential confounding of clustering as injury may be likely to affect multiple individuals on a shared dive. It is not always clear whether the reported denominator is the number of dives or the number of person-dives.<sup>18</sup>

A major challenge is the sometimes idiosyncratic and often difficult-to-define nature of DCI. Given the difficulty of diagnosis, combined with a tendency to treat conservatively, it is not surprising that many cases treated as DCI may in retrospect be classified or reclassified as 'not DCI' or 'ambiguous'. Of 435 cases of DCI reported in the recreational diving community treated with recompression, 85 (20%) were objectively reclassified as not DCI, making it clear that appropriate incident rate computation is dependent upon careful evaluation of individual cases.<sup>6</sup> In another study 10 of 104 recompressed cases were reclassified as 'not DCI'.<sup>11</sup> The current study resulted in the reclassification of 13 of 46 cases from possible DCI to 'not DCI'. It is important to note that the classification/reclassification criteria used in this study were intended to enable objective post hoc assessment for scientific, not clinical purposes. While the reviewers in the current study all had extensive experience with professional diving, none were medical clinicians. The lack of clinical expertise could lead to errors in case classification and our findings are not intended to challenge clinical skill or decision-making.

Notwithstanding evidence that DCS may be over-reported and often treated conservatively, there are also an unknown number of unreported cases. Prior to the 1980s, when minor symptoms of pain were more accepted as a routine part of diving, divers may have been reluctant to report symptoms. Even with the current emphasis on early reporting and the greater accessibility to treatment, some divers may still be hesitant to report minor symptoms. This situation produces some uncertainty with the estimated numerator as well.



There may also be some variability in incidents deemed reportable by individual institutions. Some might choose to report only cases in which time loss or injury occurs. Others might choose to report all events, regardless of cost or outcome. Data collection could be improved by comprehensive definition of reportable events, changing from annual reporting to near-real-time reporting of incidents, and adding further structure to case-review procedures.

Documenting the degree of risk associated with a given dive or dives is also problematic. We have presented the maximum depth of the dive in which the incident occurred or followed, but this may miss information of potentially substantial value. Decompression stress can be influenced by the specific profile of a given dive and also by previous dives in a series. AAUS diving records do not currently include depth-time profiles for dives and information regarding dives preceding an incident dive is frequently incomplete, effectively making it impossible to quantify decompression stress independent of outcomes. Our data do confirm a high level of safety for dives conducted in less than 10 msw depth. This is certainly expected in terms of decompression safety and a welcome observation regarding severe barotrauma. The total number of cases of DCI is too small to make strong statements regarding the distribution of DCI in the depth categories greater than 9 msw. The progressive nature of scientific diver depth authorization does help to ensure that divers have greater experience for increased working depths, which may promote safety.

AAUS represents a substantial number of programmes involved with scientific diving, but many agencies and organizations conducting scientific diving do not report to AAUS. For example, NOAA conducted 208,459 person-dives between 1981 and 2004, of which some would certainly meet the definition of scientific diving.<sup>13</sup> Similarly, the Alaska Department of Fish and Game made over 10,933 person-dives between 1990 and 2000.<sup>21</sup> Ultimately, while capturing an impressive amount of activity, AAUS dives are not the only scientific dives performed by US organizations.

Despite the limitations of this study and many others evaluating diving risk, it does appear that scientific diving represents one of the safer forms of diving. This safety may be facilitated by a combination of relatively high levels of training and oversight, the predominance of shallow, no-decompression diving and, possibly, low peer or institutional pressure to complete dives under less than optimal circumstances. Additional research to compare the decompression stress of actual exposures, the pressure to conduct dives, reporting practices, and other variables that exist between the diving sub-fields could provide useful insights to understand the real risks.

## Conclusions

We reviewed incidents reported in conjunction with 1,019,159 scientific dives documented by AAUS organizational members from January 1998 through December 2007. A total of 95 valid incidents were reported, yielding an all-incident rate of 0.931/10,000 person-dives. Case-by-case review indicated that 33 of the cases involved DCI. The incidence of DCI was 0.324/10,000 person-dives (including ambiguous cases). This rate is substantially lower than the previously published rates for recreational diving, instructional/guide diving, commercial and military diving. Data collection efforts may be improved by developing real-time incident reporting guidelines instead of relying primarily on annual reporting, and developing additional protocols for immediate follow up of defined cases.

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#### Conflict of interest

All four authors are current or past members of the AAUS Board of Directors.

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# Alcohol and UK recreational divers: consumption and attitudes

Marguerite St Leger Dowse, Christine Cridge, Steve Shaw and Gary Smerdon

## Abstract

(St Leger Dowse M, Cridge C, Shaw S and Smerdon G. Alcohol and UK recreational divers: consumption and attitudes. *Diving and Hyperbaric Medicine*. 2012;42(4):201-207.)

**Introduction:** Scuba diving demands information processing, recall, reasoning, decision making and the ability to take control of situations under different scenarios. Anecdotal evidence suggests that some divers consume alcohol to excess around the time of a dive. This study investigates alcohol consumption and attitudes to alcohol in United Kingdom (UK) recreational divers.

**Methods:** A questionnaire addressing diving demographics, general health, type and frequency of alcohol consumption, and attitudes to drinking alcohol around the time of diving was available for anonymous completion online between September 2010 and January 2011.

**Results:** Records from 818 divers were analysed. Older divers were more likely to exceed the weekly alcohol units recommended by the UK government compared to younger divers ( $P < 0.001$ ), but binge drinking was associated with younger divers ( $P = 0.014$ ). Diving when considering themselves unfit to drive a car was reported by 151 (18.5%) respondents and 187 (22.9%) had witnessed a diving incident which they felt was attributable to alcohol. Only 313 (38.3%) respondents reported a responsible attitude to alcohol by their dive clubs both under normal circumstances and whilst on a dive trip.

**Conclusion:** Some divers undertook diving activities when potentially over the legal limit to drive a car and demonstrated a possible lack of understanding of the effects of alcohol beyond dehydration. Divers considered club attitudes to drinking and diving to be less responsible when on a diving trip. Some divers took a more responsible attitude to alcohol consumption having witnessed a diving incident which was potentially related to alcohol.

## Key words

Alcohol, health, recreational divers, survey, world wide web

## Introduction

The effects of alcohol are a major health issue, and the burden of alcohol-related health problems to society as a whole has been widely studied.<sup>1-7</sup> Gender, weight, age, activity, comorbidities and ethnic origin govern the response of an individual to alcohol consumption in both the acute setting and over time. Not only is the excessive use of alcohol a risk factor in disease processes, it is a leading causative factor in accident and injury. The effects of alcohol on human responses in differing activities, environments and situations have been reported.<sup>8-15</sup> Alcohol impairs psychomotor ability, including cognition, reaction time, judgment and visual function, and recommendations and legislation by authorities and governments internationally regarding activities such as flying and driving reflect this.<sup>13-15</sup> In addition, the downstream effects of excessive alcohol consumption in the form of a hangover cause impaired cognitive and physical performance with subsequent problems including work absenteeism and reduced productivity.<sup>16-21</sup>

Recreational scuba diving is a sport requiring information processing, recall, reasoning, decision making, attention and the ability to take control of a given situation in any number of scenarios: on shore, in the boat, at the water surface or underwater. These are all situations in which behaviour and performance may be affected by the inappropriate use of alcohol within a given time frame prior to diving. Studies have shown an increased risk where alcohol has

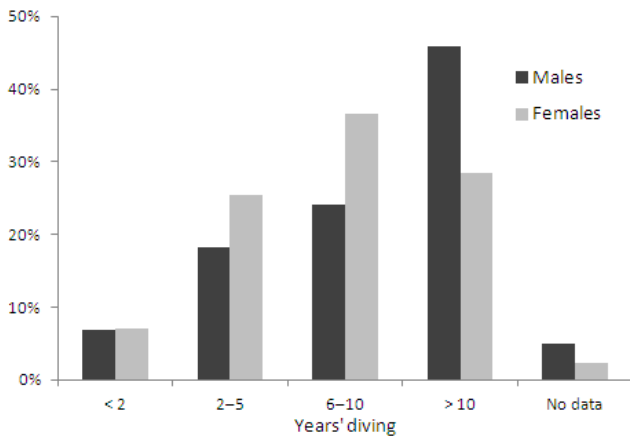
been consumed around the time of aquatic activity, and a relationship between reduced capability and alcohol intake has been demonstrated.<sup>22-26</sup> Dehydration and increased nitrogen narcosis resulting from alcohol intake have also been described.<sup>27-29</sup>

Recreational scuba diving facilitates socialising as a group, thus encouraging the consumption of alcohol. Dive training by the accredited bodies advises that divers do not drink an excess of alcohol the night before a dive, though no formal recommendations with regard to units of alcohol imbibed exist. Anecdotal data suggest that some divers clearly dive the morning after consumption of what may be considered excessive amounts of alcohol the night before, and sometimes dive with a hangover. Studies with the primary aim of observing United Kingdom (UK) diver alcohol habits have not been published. Scrutiny of the last 10 years of British Sub-Aqua Club (BSAC) incident reports shows only passing reference to alcohol consumption, where appropriate within a specific report, but no focus on the prevalence of alcohol consumption around the activity of diving or its effects.

The aim of this study was to gain an insight into the general alcohol habits of divers and to utilise the outcomes to initiate an educational programme for the promotion of safer diving. Although divers were asked if they had ever witnessed a diving incident which, in their opinion, could be attributed to alcohol, no attempt was made to gather data directly

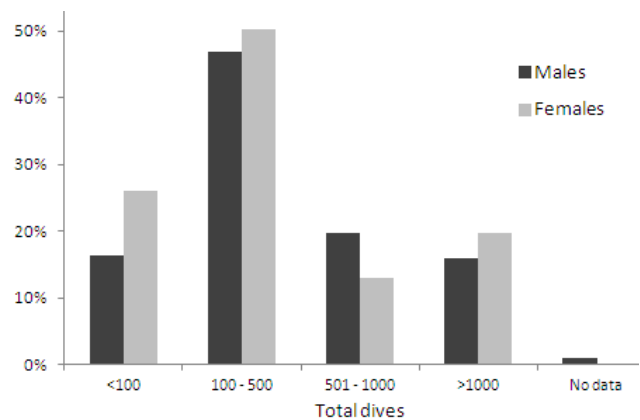
**Figure 1**

Years of diving experience: males and females



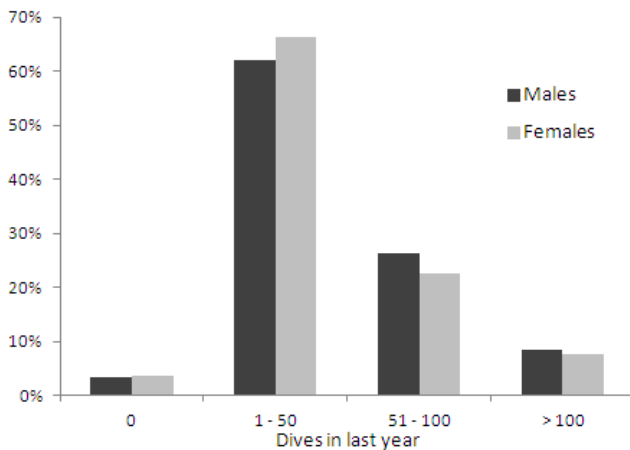
**Figure 2**

Total dives since learning: males and females



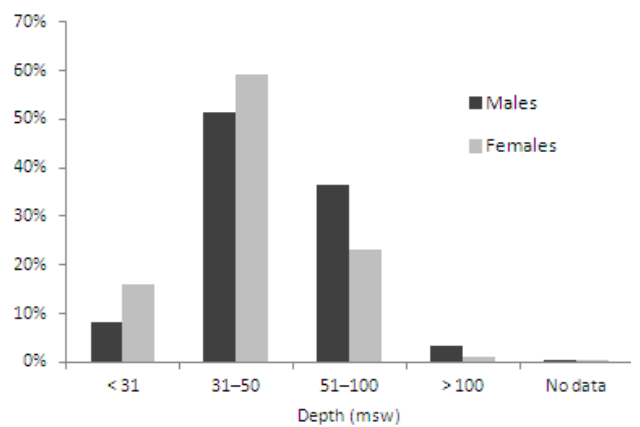
**Figure 3**

Total dives in last year: males and females



**Figure 4**

Maximum depth ever dived: males and females



linking alcohol intake with risk of an incident or rates of decompression illness (DCI).

**Methods**

A web-based questionnaire was compiled entitled *Diving and Alcohol*,\* and was available for anonymous completion online between September 2010 and January 2011 through the Diving Diseases Research Centre (DDRC) website. It was publicized by the UK recreational diving organizations and diving magazines. The questionnaire included diver and diving demographic questions used in previous DDRC field data studies.<sup>30,31</sup> These included age, gender, diving organization affiliation, number of years' diving experience, number of dives since learning to dive, number of dives in the last year and maximum depth ever dived. Health-related questions included whether the diver was taking prescribed medication, if they had completed a self-declaration medical form, had taken advice from a medical referee or had undergone a diving medical examination.<sup>32</sup> Alcohol

questions focused on the diver's understanding of the UK government recommendations for alcohol intake: how frequently divers drank (every day, four or more times a week, two to three times a week, two to four times a month, monthly or less, and never), and amount in units for each gender (males three to four units per day, females two to three units per day).<sup>4</sup> A unit was defined as approximately equal to 250 ml of ordinary-strength beer, lager or cider (alcohol by volume (ABV) 3-4%), or a small 25 ml measure of spirits (ABV 40%) or 175 ml of red wine (ABV 12%). Binge drinking is defined by the National Health Service and National Office of Statistics as drinking more than double the daily recommended units of alcohol in one session.<sup>4,33</sup> Questions concerning the types of alcohol consumed, alcohol health-related problems, shortest time alcohol was used prior to diving, whether the diver had dived when they considered themselves unfit to drive a car, the attitude of their dive club under normal conditions towards alcohol and the attitude when away on a diving trip were also included. Questions were fixed option yes/no where applicable. Divers

\* **Footnote:** Copies of the questionnaire are available from the corresponding author, e-mail: <marguerite@mstld.co.uk>.

were also asked to add additional information with free text if they considered they had witnessed a diving incident that in their opinion could have been attributed to alcohol. The questionnaire was initially piloted for understanding and validity of responses and compared with national data, and with diver and diving demographics.<sup>4,30,31</sup> The Chair of the Cornwall and Plymouth Research Ethics Committee confirmed that ethics approval was not required for this study.

All age groups were used in the analyses. Data, where appropriate, have been reported as median (range) or percentages and 95% confidence intervals (95% CI). Chi-square tests were used to examine the relationships between the following: gender and frequency of alcohol intake; age and number of alcohol units in a week; age and diving when over the legal limit to drive a car; and age and binge drinking. A significance level of 0.05 was applied throughout. Statistical analysis was performed using SPSS version 17.

**Results**

Self-reported records were received from 818 respondents (79% male, 21% female; median age 43 years, range 17–74). There were proportionally more females (121/169, 71.6%) than males (334/649, 51.5%) in the 16 to 44 age groups, and thus fewer females (48/169, 28.4%) than males (315/649, 48.5%) aged 45 and over. Diver and diving demographics are shown in Figures 1–4. A total of 46,092 dives (males 37,268, females 8,824) were reported in the last year (median 40, range 0–999). Altogether, the respondents reported a total of 541,228 dives (males 444,933, females 96,295) since learning to dive (median 320, range 6–14,000). The depths of dives reported by all respondents ranged from 10 to 210 metres’ sea water (msw).

**ALCOHOL – UNDERSTANDING UK GOVERNMENT RECOMMENDATIONS**

Divers were asked whether they understood the UK

government recommendations for daily intake of alcohol units for males and females. Overall, there was a reasonable understanding by both males and females of their own and each other’s recommended maximum daily intake. A total of 695 (84.9%, 95% CI 82.5 to 87.4%) respondents either returned the correct answer for the recommended daily alcohol intake or erred on the side of caution and underestimated the recommendations. The remaining 123 (15.1%, 95% CI 12.6 to 17.5%) either did not know or overestimated the government recommendations.

**HEALTH AND ALCOHOL**

A total of four males (0.5%) admitted that since learning to dive they had suffered alcohol health-related problems, with weight gain, and/or abdominal pain, and diarrhoea reported by three of the four respondents. The fourth respondent admitted to a “*semi-breakdown*”, attending out-patient services for treatment for alcohol abuse, abstaining for 10 years but having three relapses in the previous six months, during which time he had been diving. He had completed a diving medical self-assessment form but had not sought advice from a diving medical referee or had a physical examination. A total of six (0.73%) further respondents reported hospital attendance for alcohol-related accidents with broken bones, concussion, and a car crash being reported.

**TYPE, FREQUENCY AND UNITS OF ALCOHOL**

*Type*

More males (47.6%, 95% CI 43.7 to 51.4%) than females (27.6%, 95% CI 20.9 to 34.3%) reported drinking beer, lager, or cider, whilst more females (47%, 95% CI 39.6 to 54.6%) than males (33%, 95% CI 29.3 to 36.6%) reported drinking wine (Table 1).

*Frequency*

Alcohol consumption habits differed between genders (Table 1). When considering the frequency of drinking

**Table 1**

Alcohol habits and frequency for male and female divers

<b>Type of alcohol in week*</b>	<b>Males</b>		<b>Females</b>		<b>Total</b>	
<i>n</i> (%)	1,032	(78.5)	283	(21.5)	1,315	
Strong beer, lager or cider	491	(47.6)	78	(27.6)	569	(43.3)
Wine	341	(33.0)	133	(47.0)	474	(36.0)
Spirits	175	(17.0)	63	(22.3)	238	(18.1)
Fortified wine	15	(1.4)	3	(1.0)	18	(1.4)
Alco pops	10	(1.0)	6	(2.1)	16	(1.2)
<b>Frequency of intake (%)</b>						
<i>n</i> (%)	649	(79.3)	169	(20.7)	818	
Every day	76	(11.7)	10	(5.9)	86	(10.5)
4 or more times a week	125	(19.2)	36	(21.3)	161	(19.7)
2–3 times a week	236	(36.4)	51	(30.2)	287	(35.1)
2–4 times a month	129	(19.9)	53	(31.3)	182	(22.2)
Monthly or less	55	(8.5)	15	(8.9)	70	(8.6)
Never	28	(4.3)	4	(2.4)	32	(3.9)

**Table 2**

Numbers (%) of divers by age who did or did not consume more alcohol than the weekly government recommendations

Age group	16–24 years	25–44 years	45 and older	Total
<i>n</i> (%)	53 (6.5)	402 (49.1)	363 (44.4)	818
Yes	10 (18.9)	87 (21.6)	126 (34.7)	223 (27.3)
No	43 (81.1)	315 (78.4)	237 (65.3)	595 (72.7)

**Table 3**

Numbers (%) of divers by age who did or did not binge drink

Age group	16–24	25–44	45 and over	Total
<i>n</i> (%)	53 (6.5)	402 (49.1)	363 (44.4)	818
Yes	16 (30.2)	65 (16.2)	52 (14.3)	133 (16.3)
No	37 (69.8)	337 (83.8)	311 (85.7)	685 (83.7)

**Table 4**

Numbers (%) of divers who self-reported diving whilst considering themselves unfit to drive a car

	Over weekly limits	No alcohol/within weekly limits	Total
<i>n</i> (%)	221 (27.5)	583 (72.5)	804
Yes	64 (29.0)	87 (14.9)	151 (18.8)
No	157 (71.0)	496 (85.1)	653 (81.2)

alcohol fewer females (5.9%, 95% CI 2.3 to 9.3%) than males (11.7%, 95% CI 9.3 to 14.2%) consumed alcohol every day ( $P = 0.009$ ), and more females (31.4%, 95% CI 24.5 to 38.3%) only consumed alcohol two to four times a month than males (19.9%, 95% CI 16.9 to 23.1%). More males (4.3%) than females (2.4%) were teetotal.

#### Units

The maximum daily number of alcohol units ranged from 0 to 33 (median 4). The number of units consumed weekly was investigated in relation to the government-recommended weekly amount of units (11–21 per week males, 8–14 per week females) with age as a factor (Table 2). There was a significant effect of age showing that older divers aged 45 years and over (34.7%, 95% CI 29.8 to 39.6%) were more likely to exceed the recommended weekly amount of units than divers of 16–24 years (18.9%, 95% CI 8.3 to 29.4%) and 25–44 years (21.7%, 95% CI 17.6 to 25.7%) age groups ( $P < 0.001$ , Table 2). When daily alcohol consumption was examined with age as a factor, binge drinking was associated with a small but significant number of divers in the 16–24 years age group ( $P = 0.014$ , Table 3).

#### ALCOHOL AND DIVING

A total of 151 (18.5%, 95% CI 15.8 to 21.1%) respondents admitted to diving when considering themselves unfit to drive a car. Further analysis showed that age was a significant factor, with younger divers more likely to dive when over the limit, and older divers more likely to exercise caution ( $P = 0.009$ ). Table 4 shows divers who exceeded the recommended weekly alcohol limits were also significantly more likely to dive whilst unfit to drive a car ( $P < 0.001$ ).

A total of 282 (34.5%, 95% CI 31.2 to 37.7%) respondents admitted consuming alcohol between six hours and less than 30 minutes before a dive. A significant number (73.5%, 95% CI 66.5 to 80.5%) of the group who had undertaken diving activities when unfit to drive a car also admitted drinking alcohol six hours or less before a dive ( $P < 0.001$ ). Sixteen divers (1.95%) reported consuming alcohol less than 30 minutes before a dive. Only 313/715 (39.4%, 95% CI 36.0 to 42.8%) respondents were in agreement that their dive clubs demonstrated a responsible attitude to alcohol under normal circumstances and also whilst away on a dive holiday/weekend. In general, the respondents considered their club to have a less responsible attitude to alcohol when away for diving weekends or holidays.

A diving incident that might be alcohol related, in their opinion, was reported to have been witnessed by 187 (22.8%, 95% CI 20.0 to 25.7%) of respondents. Some respondents recorded observations or described first-hand experiences with regard to alcohol and diving, together with their opinions (Table 5).

#### Discussion

Alcohol consumption in the UK is of increasing concern to the government and health authorities.<sup>4,33</sup> It is a global problem affecting both genders, all age groups, and all social classes and can be attributed to 4% of deaths worldwide.<sup>1,4,5</sup> Depending on consumption levels and variables such as age, body weight, health, alcohol tolerance and social environment, alcohol affects the ability to organize, orientate and concentrate; whilst judgment, decision making, mood and visual acuity are impaired to varying degrees.<sup>7</sup> Alcohol

**Table 5**

Free-text examples: alcohol and perceived diving incidents

**ID1.** *I have witnessed two diving incidents due to excessive alcohol consumption, both involving the person still being drunk the morning after drinking far too much alcohol.*

**ID2.** *My buddy suffered DCI; we had conducted a 40+ msw dive requiring 12-minute deco and a 3-minute safety stop. It was a square profile and we had identical dives over the previous week, the only difference in our activity was the night before the dive in question, I had one pint of beer and went to bed; he stayed out for at least four more beers before retiring.*

**ID3.** *Part of the attraction of diving is its inherent 'social' aspect. It is well understood that alcohol dehydrates you and that dehydration is a contributory factor in DCI. I have frequently 'over-indulged' as have my colleagues and dived, yet we remain 'responsible' as we take our dive marshalling and supervision roles seriously. We know our buddies and their capabilities well and assess the risks on a case-by-case basis. I am not condoning drinking and diving in any way; I just accept the risk and dive, drink and assess accordingly.*

**ID4.** *Many people in our diving club still drink heavily during a diving weekend. One experienced diver is well known for sinking a couple of pints at lunchtime in between dives. There can be a lot of pressure on people in a club/group situation to drink whilst away on a diving trip, whether [in the] UK or abroad.*

**ID5.** *I have seen one guy pulled from the water and he died. He had drunk a lot the night before a deep dive course.*

**ID6.** *We are very responsible with regards alcohol following a fatality after which the inquest found a quantity of alcohol in the blood.*

**ID7.** *I notice that those who drink within 24 hours of a dive suffer excessive narcosis at depth and are more likely to panic and abort even in perfect conditions.*

**ID8.** *Over 20 years I have witnessed and dealt with several DCI incidents that were undoubtedly due to alcohol consumption leading to dehydration. Some of these DCI events were quite serious. Despite warnings, some divers were determined to drink multiple units of alcohol on Friday night and dive on Saturday morning. Ignorance of the consequences of alcohol consumption with diving is common, but some divers are wilfully in denial.*

The self-reported data in this study demonstrate that some divers admitted to knowingly drinking alcohol to excess around the time of their diving activities, and sometimes dived when they felt they were over the limit to drive a car. Statutory blood alcohol content (BAC) is used as a measure of intoxication for medical and legal purposes. The threshold limits for driving a motor vehicle vary between countries; in the UK the maximum legal BAC is 80 mg of alcohol per 100 ml of blood. The relationship between alcohol consumed and the BAC of any specific individual is dependent on many factors, including the number of units consumed over a given number of hours, the body mass index of the person and the immediate history of food intake. Carbonated drinks speed up alcohol absorption, whilst food in the stomach will slow down the process. Gender also plays a role, with women, particularly younger women, in general having a lower tolerance threshold than men, due to lower alcohol dehydrogenase levels. Some medications may prevent alcohol dehydrogenase from metabolizing alcohol, thus exacerbating its effects. All these factors affect the speed that the liver can process the alcohol consumed; the alcohol that cannot be metabolized remains in the bloodstream and is measured as BAC.

National data comparing the attitudes of drinking and driving within legal limits shows drivers have their own individually set limits, often based within the concept of the legal limit to drive.<sup>4</sup> Divers have no recommended drink-diving limit and therefore there is no such 'psychological' guidance. This may, in part, be owing to the issues surrounding drinking and diving in the UK having been inadequately addressed to date, together with the lack of formal literature with regard to the effect of alcohol and/or hangover on accidents and fatalities within the recreational diving industry. Universally, accident and incident reports within the diver training bodies have not specifically focused on alcohol consumption around the time of a dive.

Divers generally do not regard diving after drinking the night before, or diving with a hangover, as the legal equivalent of 'drink driving'. Free text gathered by the survey (Table 5) illustrates that attitudes to alcohol consumption in conjunction with diving activities become more responsible when a diver has actually witnessed an incident that they perceive to have been attributable to alcohol. Some divers additionally observed an increased susceptibility to nitrogen narcosis under the influence of alcohol, whilst others felt they observed an attitude of drink-dive denial amongst some divers.

Historically the dive training organizations have focused on the dangers associated with dehydration which occurs due to the diuretic effects of alcohol and which may increase the risk of DCI.<sup>28</sup> In general, there has not been a policy of expanding lectures to impart a broader knowledge and understanding of the metabolic effects of alcohol or alcohol hangover. Personal communications show this policy may be

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hangover is also known to affect cognitive function.<sup>18-20</sup> These factors suggest alcohol consumption to be a contra-indication to safe diving, possibly increasing the risk of a diving incident.

owing to the dilemma facing the diver training organizations; namely that a strategy of policing the enjoyment of alcohol could result in damage to membership of a sport with a heavy social reliance, particularly in the UK where there is an emphasis on club membership.

The aviation industry and the legislation of governments worldwide have sought to address the issues surrounding the effects of alcohol and BAC.<sup>1,4,14,33</sup> The European Community is currently reviewing the whole issue of alcohol and driving, as is the UK government.<sup>34</sup> Road-traffic and aviation accidents have been the subject of much scrutiny to date.<sup>14,34</sup> In line with today's litigious society it is possibly time for the diving industry to give greater educational emphasis to the effects of alcohol and post alcohol effects (hangover) in relation to diving on cognitive, visual and vestibular function.<sup>14</sup> Headache, gastrointestinal upset, and fatigue have been observed as post-consumption effects, and some studies have shown decreased cognitive ability even though the subject may be unaware of their impairment.<sup>15,21</sup>

Of added interest in this study were the background health data of the participants, which showed that of the 172 respondents currently taking prescribed medications, 16 (9.3% of this subset) had not completed a diving medical self-assessment form, and 80 (46.5%) had not sought advice from a diving medical referee. This poses the question regarding the hidden effects of alcohol and some prescribed medications. The six divers who admitted they had attended hospital for alcohol-related accidents, though small in number, illustrate that some divers drink to excess with consequent results that may endanger others. Additionally, the 151 (18.5%) divers who said that they had gone diving when they were unfit to drive a car should be of serious concern. Further interrogation of these data showed that over two-thirds of this sub-group (98) had aborted a dive at some time due to one of the following: headache, vomiting, still drunk, not thinking straight and general fatigue. All these symptoms could be attributed to alcohol hangover.

This was a self-reporting study; respondents were not selected or recruited. The study did not seek to establish any relationship between diving accidents, or DCI and alcohol consumption. The authors acknowledge these data may suffer from selection bias in as much as divers who consume alcohol may be more likely to respond or divers who consume alcohol may not respond due to embarrassment; or conversely divers who do not consume alcohol may not respond to the study. Anonymous on-line survey data may suffer from fictitious submissions, though multiple submission programming was implemented in this study in order to prevent this occurrence. On-line data collection benefits from being efficient with respect to time and cost for the researcher and participant alike. The facility to expand question stems according to response, reduce illogical responses, eliminate difficulty interpreting handwriting and an improved ability to address sensitive

issues are all benefits of on-line data collection. Although many respondents in this study were experienced divers, the diver and diving demographics were similar to previous diving studies.<sup>30,31</sup> The divers in this study were active and dived more regularly than might be expected from some sport diving groups in other countries. However, the well-entrenched culture of UK club diving follows the trend of regular, year-round weekly diving through socializing and weekly club meetings. This results in the average number of dives per year per UK diver perhaps being greater than would be expected when compared with a dive shop/school environment and organizations that may also cater for a slightly different socio-economic cohort.

The study alcohol data reflected the national data in the following criteria: beer, lager and cider were most popular with men, and wine the most popular with women; more men than women drank alcohol every day; more men than women exceeded the recommended daily limit on the days they did consume alcohol; men were more likely than women to exceed the weekly recommended limit for alcohol intake; and there is a relationship between age and exceeding the weekly recommended limit.<sup>4</sup> These data provide a useful insight into the everyday drinking habits of UK sport divers, and indicate that the current guidance of advising not to consume alcohol in excess in close proximity to diving activities may no longer be adequate. It could be argued that the term 'excess' is ambiguous and which needs to be defined.

## Conclusions

This study demonstrates that, in this cohort, a number of respondents were diving when they would have considered themselves over the legal limit to drive a car. The timing of dives after consumption of alcohol demonstrates a greater need for a more comprehensive understanding of the effects of alcohol beyond dehydration. Divers considered that the attitude to drinking and diving was not as responsible when away on a diving weekend or holiday; also some divers had been influenced to take a more responsible attitude to alcohol consumption having witnessed what they considered to be an alcohol-related diving incident. Perhaps there is now an opportunity for diver training organisations to implement a more wide-ranging approach to the subject of alcohol and diving within their respective training programmes and consider a consensus of guidelines on the subject.

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# Transcutaneous oximetry measurement: normal values for the upper limb

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## Abstract

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**Introduction:** Several studies define normal transcutaneous oximetry measurements (TCOM) for the chest and lower limb, but not the upper limb. Standardised healthy-subject reference values for upper limb TCOM would make interpretation of these measurements in disease or injury more meaningful.

**Aim:** To determine 'normal' TCOM values for the upper limb in healthy non-smoking adults.

**Method:** Thirty-two healthy volunteers (16 male, 16 female) had TCOM performed on the chest and at five upper limb positions: lateral aspect of the upper arm midway between the shoulder and elbow; lateral aspect of the forearm, dorsum of the hand, thenar and hypothenar eminences. Measurements were taken using the TCM400 Monitoring System (Radiometer) with subjects breathing room air and whilst breathing 100% oxygen.

**Results:** Room-air TCOM values (mean (SD), 95% confidence interval (CI)) were: chest: 50 (11.4) mmHg, 95% CI 46.0 to 54.2; upper arm: 53 (9.3) mmHg, 95% CI 49.7 to 56.4; forearm: 45 (11.3) mmHg, 95% CI 40.4 to 48.6; dorsum of hand: 39 (8.5) mmHg, 95% CI 35.5 to 41.7; thenar eminence: 54 (7.7) mmHg, 95% CI 51.7 to 57.2; and hypothenar eminence: 57 (7.5) mmHg, 95% CI 54.1 to 59.6. All readings showed a substantial increase when subjects breathed 100% oxygen. Using the currently accepted threshold for tissue hypoxia of < 40 mmHg, six forearm and 14 dorsum of the hand TCOM readings would have been classified as hypoxic.

**Conclusion:** Normal upper limb TCOM readings are less than those established for the lower limb. Using lower-limb reference standards could result in false-positive determinations of tissue hypoxia. We recommend TCOM  $\leq$  30 mmHg as indicative of tissue hypoxia in the upper arm, thenar and hypothenar eminences, and  $\leq$  20 mmHg in the forearm and dorsum of the hand.

## Key words

Transcutaneous oximetry, hyperbaric oxygen therapy, wounds, patient monitoring, standards

## Introduction

Transcutaneous oximetry measurement (TCOM) is the process of measuring oxygen tension (partial pressure) on the skin. Originally used in neonatology, TCOM estimates tissue oxygenation non-invasively by measuring the diffusion of extracellular oxygen into a heated sensor on the skin.<sup>1,2</sup> TCOM is clinically useful in determining wound healing potential, selecting amputation level, evaluating revascularisation procedures and assessing the severity and progression of peripheral vascular disease.<sup>3</sup> TCOM has also become an essential component of wound assessment in hyperbaric medicine, as the patients most likely to benefit from hyperbaric oxygen therapy are those with demonstrated peri-wound tissue hypoxia that responds to hyperoxia.<sup>2</sup>

In order for TCOM data to be clinically useful, knowledge of normal values in healthy populations is required. Early studies have reported normal values for the chest and several sensor positions on the lower limb, as well as the reproducibility and reliability of these readings.<sup>4-9</sup> Recent reviews define lower-limb tissue hypoxia sufficient to impair or prevent wound healing as a transcutaneous oxygen partial pressure ( $P_{tc}O_2$ ) < 40 mmHg.<sup>2,10,11</sup> Corresponding healthy-subject reference data for the upper limb are not available, perhaps because the lower limbs are more commonly

affected by vascular pathology and, consequently, attention has focused on this area.<sup>12</sup>

Despite the lack of standardised healthy-subject reference values for the upper limb, researchers and clinicians have used TCOM in investigations of upper limb peripheral vascular disease, hemiplegia, scleroderma, lymphoedema, complex regional pain syndrome (CRPS) and surgical procedures.<sup>12-18</sup> A few papers focusing on the upper limb have included values for healthy or normal control subjects.<sup>14,16,19</sup> However, attempts to identify normal reference TCOM data from these studies are limited by variations in technique, subject posture, electrode placement, electrode temperature, and the use of unclear and inconsistent operational definitions for 'normal' and 'healthy.' The aim of this study was to determine normal TCOM values for the upper limb in healthy, non-smoking adult subjects.

## Methods

Ethics approval for this study was granted by the Human Research Ethics Committee of the Townsville Health Services District. Thirty-two (16 male, 16 female) subjects recruited from the hospital staff and general population participated in the study. Exclusion criteria included subjects younger than 18 years; current or former smoker;

known cardiovascular disease including treated or untreated hypertension; significant respiratory disease and any other significant medical condition. Subjects with one arm, or scarring or skin conditions on the upper limb, were also excluded. As subjects were required to have a plastic hood placed over their head to receive oxygen during part of the study, severe claustrophobia was a further exclusion criterion.

All participants were given a study information sheet and informed consent was obtained. Subjects refrained from consuming food or caffeine or performing heavy exercise for two hours prior to participating in the study. Basic demographic data were collected, including dominant hand, weight and height. Oxygen saturation, blood pressure, and pulses on both upper limbs were recorded. The subjects were placed in a supine position on a hospital bed with their head slightly raised on one pillow for the duration of the study. They were offered a blanket for comfort and to limit any vasoconstrictive effects of being cold. The room temperature was maintained between 22.0 and 22.5°C. The participants rested quietly while the sensors were placed.

Participants were randomised to have sensors placed on their right or left arm. The sensor sites were prepared by shaving hair if necessary, wiping clean, rubbing with an alcohol swab and drying with gauze. One sensor was placed as a central reference on the chest at the second intercostal space in the mid-clavicular line.<sup>3,11,20</sup> Five sensors were placed on the arm and hand. One sensor was positioned midway between the highest bony point on the shoulder and the olecranon process on the lateral aspect of the upper arm. Another was sited 5 cm distal to the brachial crease on the lateral aspect of the forearm. One sensor was placed centrally on the dorsum of the hand between the third and fourth metacarpal bones, attempting to avoid large superficial vessels. The final two sensors were placed on the palmar aspect of the hand, on the thenar and the hypothenar eminences. The leads were secured in place with tape to prevent pull on the sensors. Subjects were requested to keep talking to a minimum during the study.

All TCOM assessments were performed by the same technician using the TCM400  $P_{tc}O_2$  Monitoring System (Radiometer Medical ApS, Bronshøj, Denmark). The TCM400 has six electrodes and can record  $P_{tc}O_2$  data from all six sensor sites simultaneously. The electrode temperatures were pre-set to 44°C and atmospheric and zero point electrode calibrations were performed as per the manufacturer's recommendations. A 'humidity correction factor' was calculated from the room temperature, saturated water vapour pressure and relative humidity and input into the machine according to the TCM400 operator's manual.<sup>21</sup>  $P_{tc}O_2$  values are displayed by the TCM400 in mmHg units as are values reported throughout the TCOM literature and, therefore, have not been converted to kPa in this paper.

We used the TCOM protocol described by Sheffield, which is commonly used in hyperbaric medicine to identify tissue hypoxia and responsiveness to hyperoxia.<sup>22</sup> Part of the protocol includes a 45° limb elevation challenge to identify the presence of large or small vessel disease in the lower limb. Arm elevation is a common treatment ordered for arm injury, post-operative care and oedema management, therefore data on the effects of arm elevation on tissue oxygenation may be useful. It was decided to keep this manoeuvre as part of our TCOM protocol.

Initial normobaric room-air readings from all sensors were recorded after a minimum 20-minute equilibration period, allowing all sensor readings to stabilise.<sup>4</sup> The arm was then elevated to 45° above horizontal and rested on a foam wedge, with sensor readings again recorded after five minutes. The arm was returned to the horizontal position for a minimum five-minute period allowing all sensor readings to re-stabilise, and another set of readings were recorded to ensure TCOM had returned to baseline (data not shown). The subjects then breathed 100% oxygen for 10 minutes via a clear plastic head hood with a soft neck seal, with sensor readings recorded at the end of the 10-minute period. All sites were inspected for injury from sensor warming. No evidence of skin injury was recorded. All collected data were de-identified and recorded onto a pre-formatted worksheet. This information was entered into and all analyses were performed using SPSS Version 17.0.

#### STATISTICAL ANALYSIS

The primary output of this study was a determination of the normal range of TCOM readings when measured on the arm of healthy volunteer subjects. Baseline demographic characteristics of male and female subjects were compared using Fisher's Exact Test or Student's t-test, as appropriate. Descriptive statistics (mean, standard deviation, 95% confidence interval (CI)) are reported for TCOM readings for the six sensor sites. Differences between TCOM readings for male and female subjects were evaluated using Student's t-test. Based on previous reports of mean TCOM readings at other upper limb sites ranging from approximately 58 to 74 mmHg with a standard deviation of approximately 10 mmHg,<sup>13-15,17</sup> the sample size of 32 subjects was expected to allow us to estimate TCOM readings with a 95% CI of  $\pm 3.5$  mmHg for the overall group, and to have 80% power (with  $\alpha = 0.05$ ) to detect a 10 mmHg difference in mean TCOM readings of males versus females using Student's t-test. Correlations between baseline perfusion measures of systolic blood pressure (SBP), diastolic blood pressure (DBP), and oxygen saturation ( $SpO_2$ ) in the randomised limb and room-air as well as on-oxygen TCOM readings at each sensor site were evaluated using linear regression, with Bonferroni correction for multiple observations.

**Table 1**  
Demographic and baseline characteristics of the 32 subjects

Variable	Males (n = 16)	Females (n = 16)	Combined
Age (yr, mean (SD))	46.1 (0.8)	47.5 (13.0)	46.8 (11.8)
< 50 years old (n)	9	8	17
Body mass index (kg m <sup>-1</sup> , mean (SD))	26.5 (2.9)	27.3 (7.1)	26.9 (5.4)
Underweight (BMI < 20) (n)	0	1	1
Overweight (BMI > 25) (n)	10	2	12
Obese (BMI > 30) (n)	2	4	6
Oxygen saturation (SpO <sub>2</sub> ) (%), mean (SD))	97.2 (1.2)	98.0 (1.5)	97.6 (1.4)
Heart rate (beats min <sup>-1</sup> , mean (SD))	66.7 (9.8)	70.6 (17.1)	68.6 (13.9)

**Table 2**

Mean (standard deviation) and 95% confidence interval (95% CI) for TCOM readings for each sensor at each protocol stage (mmHg);  
\*  $P < 0.001$  for difference between male and female subjects (see text)

Sensor (mmHg)	Room air (20 min)	Arm elevated (5 min)	Oxygen(10min)
<b>Chest</b>	50.1 (11.4)	51.2 (11.7)	358.1 (53.5)
95% CI	46.0–54.2	47.0–55.4	338.8–377.3
<b>Upper arm</b>	53.0 (9.3)	53.1 (10.4)	379.8 (67.8)
95% CI	49.7–56.4	49.3–56.8	355.3–404.2
<b>Forearm</b>	44.5 (11.3)	40.7 (11.3)	298.4 (68.1)
95% CI	40.4–48.6	36.6–44.8	273.8–322.9
<b>Dorsum</b>	38.6 (8.5)	29.4 (9.8)	217.4 * (73.5)
95% CI	35.5–41.7	25.9–33.0	191.0–243.9
<b>Thenar eminence</b>	54.4 (7.7)	46.0 (9.1)	248.0 (48.1)
95% CI	51.7–57.2	42.8–49.3	230.7–265.4
<b>Hypothenar eminence</b>	56.8 (7.5)	51.6 (7.7)	206.3 (60.7)
95% CI	54.1–59.6	48.8–54.3	184.5–228.2

## Results

Data were collected from all 32 subjects. Demographic and baseline data are shown in Table 1. The subjects ranged in age from 25 to 78 years. More men than women were overweight (Fisher's Exact Test,  $P = 0.022$ ), but otherwise there were no differences in the baseline demographics of males and females.

There was also no association between TCOM measurements and age, body mass index or hand dominance (right versus left). Baseline measures of perfusion were clinically normal in all subjects: mean (standard deviation (SD)): BP<sub>systolic</sub> = 117.6 (9.9); BP<sub>diastolic</sub> = 71.0 (9.4); and oxygen saturation = 97.6 (1.4). All but two subjects were right-handed.

The TCOM readings for each sensor site were normally distributed, both in the aggregate and for males and females separately. The mean (SD) and 95% confidence intervals for the sensor readings at each protocol stage are shown in Table 2.

The only significant difference between male and female TCOM readings were the on-oxygen measurements at the sensor placed on the dorsum of the hand

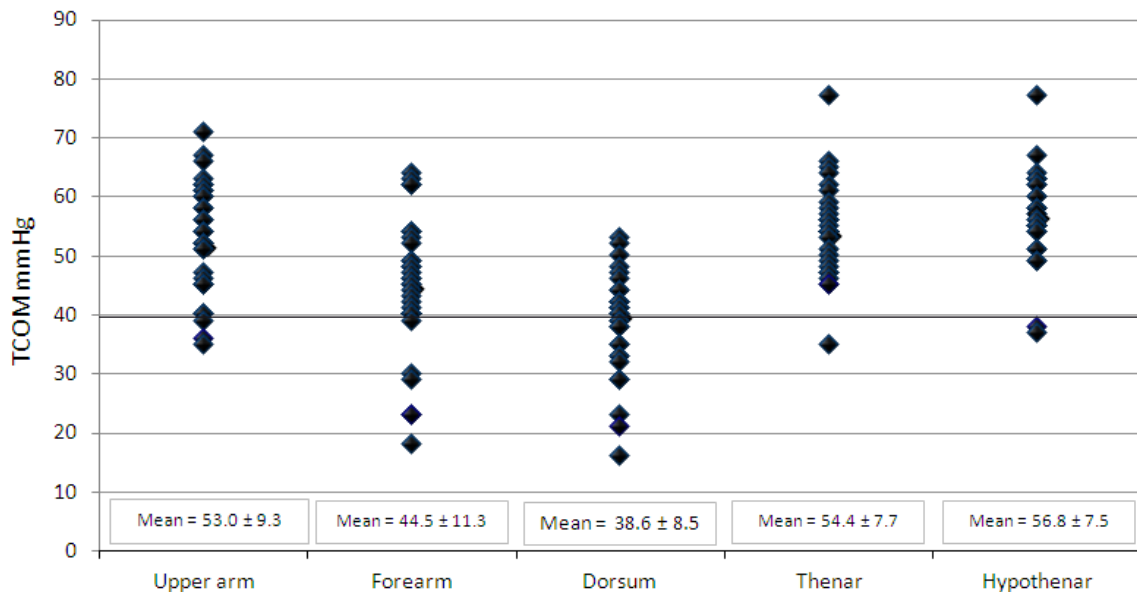
(260.1 (95% CI 222.4 to 297.7) versus 174.8 (95% CI 149.5 to 200.0); Student's  $t = -4.006$ ,  $P < 0.001$ ). Expert consensus is that in normal subjects breathing 100% oxygen at normobaric pressure, TCOM on the extremities always increase to a value  $\geq 100$  mmHg.<sup>10</sup> However, at the dorsum sensor site two readings in females failed to reach this threshold.

Figure 1 shows the distribution of the TCOM readings obtained during the 20-minute room-air stage of the study protocol. Using the lower extremity reference value of 40 mmHg, 16.25% of the upper extremity readings obtained in our healthy volunteers would have been identified as 'hypoxic'.

There was a counter-intuitive negative correlation between both baseline BP<sub>systolic</sub> and room-air TCOM reading ( $\beta = -0.35$ ,  $r^2 = 0.163$ ,  $P = 0.022$ ), and baseline SpO<sub>2</sub> and on-oxygen TCOM readings ( $\beta = -19.1$ ,  $r^2 = 0.129$ ,  $P = 0.043$ ) at the dorsum sensor site, but neither of these remained significant after adjusting for multiple comparisons. There were no other significant correlations between perfusion measures and TCOM readings at any sensor site.

**Figure 1**

Distribution of TCOM readings at each sensor site on the upper limb (&lt; 40 mmHg is regarded as hypoxic in the lower leg)



## Discussion

TCOM is a non-invasive method of estimating tissue oxygenation for both the upper and lower limbs. The current normal reference values being used to interpret upper limb TCOM data originate almost entirely from chest and lower limb studies. This study demonstrates that the lower limb reference values lack specificity when used for upper limb TCOM. The inadequacy of using the lower-limb reference value of 40 mmHg is most apparent for the forearm and dorsum sensors: 18.8% of the forearm and 43.8% of the dorsum TCOM readings in our healthy subjects would be classified as 'hypoxic' using this value. Using a reference value of 30 mmHg for the upper arm as well as the thenar and hypothenar eminences would accurately characterise 100% of those TCOM readings; a much lower reference value of 20 mmHg (approximately two standard deviations below the mean reading in healthy subjects) would be required to accurately characterise 97% of the forearm and dorsum TCOM readings of this study.

Three papers have reported TCOM for the upper limb of normal healthy subjects. Cutaneous hypoxia in patients with systemic sclerosis (scleroderma) was investigated using the forearm as the measurement site, comparing their TCOM data with those of 10 'normal' controls.<sup>14</sup> However, the forearm TCOM exceeded 90 mmHg in one of the controls and 100 mmHg in another, suggesting air leak during measurement and precluding the use of these figures as upper limb reference values.

The reliability of TCOM on the dorsum of the hand was investigated in healthy volunteers and stroke patients with and without CRPS.<sup>16</sup> The dorsum TCOM from 18 healthy

controls averaged 74.4 (11.8) mmHg on the first day of measurement, and 71.3 (10.3) mmHg on the second day of measurement. These values are substantially higher than the dorsum mean TCOM readings obtained in our study. This might be explained by the positioning of the patients. They recorded dorsum TCOM with subjects sitting upright with their arms resting on a table at the height of the heart, as opposed to the standard supine posture used in most clinical situations and studies, including ours.<sup>16</sup>

Planar optical oxygen sensors were compared to TCOM during tourniquet-induced forearm ischaemia in six non-smoking healthy males.<sup>19</sup> Forearm TCOM readings of 70.8 (19.1) mmHg again were higher than the mean forearm TCOM reading found in our study. However, that study used a lower than recommended electrode temperature of 40°C, which might introduce measurement bias into the results.

In our study, we attempted to control for factors that may unduly influence our results. Recent exercise, caffeine intake, cigarette smoking,<sup>23</sup> room temperature, subject posture, electrode temperature, calibration, and measurement technique all may alter TCOM. Therefore, we carefully adhered to defined inclusion and exclusion criteria and used a standardised measurement protocol. We attempted to duplicate the room environment and electrode temperature used in earlier studies. Previous TCOM studies on normal subjects were performed at a room temperature maintained between 21°C and 23°C.<sup>4,6,7,9</sup> Our study was performed in a draft-free room in the hospital environment at a temperature of 22.0–22.5°C. In line with earlier studies, our electrodes were set to 44°C, a temperature that promotes maximal vasodilatation but limits the risk of thermal injury.<sup>4,5,7–9,22,24</sup>

A possible explanation for the differences in our results compared to those of prior studies is that the TCM400 monitoring system may measure tissue oxygenation differently than earlier models. A curious observation is that our study recorded no normobaric room-air TCOM > 80 mmHg, yet such high values are prevalent in earlier lower limb studies.<sup>4,5,8,9</sup> We are unaware of any published studies evaluating measurement validity in different TCOM machines measuring the same physiologic value. The manufacturer of the TCM400 reports the device is accurate to within  $\pm 2$  mmHg.<sup>21</sup>

It is common practice to place a sensor on the anterior chest wall as a central reference that is reported to provide information regarding the cardio-respiratory status of the patient. Some clinicians use it to provide a 'relative value' with which to compare the TCOM value obtained near the wound site, and others calculate a 'regional perfusion index' (limb TCOM/chest TCOM) to aid limb assessment.<sup>11,20,22</sup> The conventional view is that the chest sensor measurement, unaffected by peripheral vascular disease, would be at least as high as the limb values. The mean chest sensor value in our study was lower than the mean values for the upper arm and two hand sensor sites. In fact, the chest sensor reading was below that of at least one arm/hand sensor reading in more than three-quarters of our healthy subjects. This differential was most pronounced for the thenar and hypothenar sensors, where 78% and 75% of the sensor readings, respectively, were greater than the chest sensor reading. One subject's room air chest sensor value was 13 mmHg, with arm/hand sensor readings ranging between 38 and 63 mmHg. This was confirmed by changing the TCOM machine and electrolyte solution and repeating the study at a later date.

A recent study investigating the chest and foot reference values of TCOM in diabetic patients compared to non-diabetic patients, also using the TCM400 monitoring system, similarly found the chest sensor TCOM readings in healthy non-diabetic patients were low with wide variation (chest  $58.22 \pm 12.47$ ); indeed values in the 80s were considered outliers in that study.<sup>25</sup> The study used a different electrode temperature (43°C) and room temperature (25°C), and did not input a humidity control factor, suggesting those aspects of the TCOM protocol may not explain the low chest TCOM values observed in either study. Perhaps a more plausible explanation for low and varied chest TCOM values is that the values simply reflect a varied inter-individual tissue composition at this measurement site. A recent expert consensus statement confirms that a percentage of patients have an abnormally low chest TCOM reading, and the value of this site as a central reference is questionable.<sup>10</sup>

Our study has limitations. The selection of suitable sensor sites was dictated by the availability of flat surface areas where a fixation ring could be applied. Additionally, we wanted sites that would be clinically useful and relevant to the conditions and pathologies that affect the upper

limb. The dorsum of the hand and palmer surfaces fit the above requirements; however, these are not straightforward measurement sites. The dorsum of the hand is dominated by bony metacarpals and large superficial blood vessels which we attempted to avoid during measurement. However, in attempting to explain the low values at this sensor site during air breathing and 100% normobaric oxygen, it is feasible that they could be due to the influence of de-oxygenated blood in the large superficial vessels close to the skin at this site. This could also be a possible explanation for the significantly lower values found in females breathing 100% oxygen; anecdotally the blood vessels in female subjects were often noticed to be more prominent.

The conventional view is that the palmer surfaces are not suitable measurement sites because areas of thickened skin are thought to produce artificially low TCOM values.<sup>11,20</sup> Contrary to this view, our study found that the palmer sensor sites recorded the highest TCOM with the least dispersion. Further studies investigating TCOM on palmer surfaces may be worthwhile. Our study was also limited in that we used one instrument type for TCOM. A further study comparing earlier and later model machines might be worthwhile but, as discussed above, the manufacturer of the TCM400 reports an accuracy of  $\pm 2$  mmHg.<sup>21</sup> Finally, our study speaks only to the specificity of healthy, disease-free upper limb TCOM values; we cannot comment on the sensitivity of our proposed thresholds in patients who have tissue hypoxia.

## Conclusion

Normal upper limb TCOM readings are less than those established for the lower limb, and using lower-limb reference standards could result in false positive determinations of tissue hypoxia. Due to the wide variability in TCOM at the different sensor sites, we recommend TCOM  $\leq 30$  mmHg as indicative of tissue hypoxia in the upper arm, thenar eminence, and hypothenar eminence, and a TCOM  $\leq 20$  mmHg as indicative of tissue hypoxia in the forearm and dorsum of the hand. The value of the chest sensor as a central reference is questionable.

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# Review article

## Irukandji syndrome: a widely misunderstood and poorly researched tropical marine envenoming

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### Abstract

(Carrette TJ, Underwood AH, Seymour JE. Irukandji syndrome: A widely misunderstood and poorly researched tropical marine envenoming. *Diving and Hyperbaric Medicine*. 2012;42(4):214-223.)

Irukandji syndrome is a poorly defined set of symptoms that occur after envenoming by certain species of jellyfish, primarily cubozoans or 'box jellyfish'. Envenomed victims can show symptoms ranging from headaches, severe pain, nausea and vomiting to pulmonary oedema, cardiac failure and severe hypertension resulting in death. Historically, this syndrome appears to have been misdiagnosed and reported cases are undoubtedly a significant underestimation of the prevalence of this syndrome. The variation in symptoms has resulted in a myriad of treatments though none has been established as definitive. Effective pain relief with opioids is the most immediate priority. Although the annual numbers of envenomations are generally low, the associated financial costs of this envenomation may be comparatively high, with suggestions that it could run to millions of dollars per season in northern Australia alone. The syndrome has been well documented from many areas along the east coast of northern Australia, leading to the belief that it is an Australian oddity. However, with an increase in medical knowledge and improved diagnosis of the condition, it appears that envenomations causing Irukandji syndrome are an increasing marine problem worldwide.

### Key words

Marine animals, jellyfish, envenomation, clinical toxicology, toxins, first aid, pain, treatment, epidemiology, review article

### Introduction

The expression 'Irukandji syndrome' (a disease caused by envenomation from certain marine cnidarians) first appeared in the early 1950s to describe a set of debilitating symptoms that had been documented in Australian bathers since the 1920s. Although not considered a major health priority in Australia, the syndrome does represent a substantial cost, not only to public health, but also to tourism through fear and potential misinformation to visitors to the tropical regions.

The definition of Irukandji syndrome has varied widely over time because of the diverse range of symptoms and severity experienced. While this syndrome may be fairly innocuous to some, others have experienced severe symptoms and complications as a result of envenoming. In general, mild pain is felt at the sting site at the time of initial contact, which fades with time and when overshadowed by the delayed onset of severe systemic symptoms, especially pain, and including hypertension, tachycardia and, in extreme cases, pulmonary or cerebral oedema. There have been two recorded deaths associated with Irukandji syndrome.<sup>1-12</sup> Why patients experience a difference in the severity of stings is unknown; however, theories related to the extent of exposure and the species responsible have been suggested. Despite symptoms resolving in a matter of hours in most sting victims' reports of continued complications lasting days and even weeks have been published.<sup>5,7,13</sup>

In 1964, the first causative agent of the syndrome was identified in northern Australian waters by pathologist Jack Barnes, namely *Carukia barnesi*, a small carybdeid species (Figure 1). Since then, other species have been shown to give rise to the syndrome and the term 'Irukandji' is now used to describe all carybdeids whose sting may result in Irukandji syndrome.<sup>14</sup> To date, seven carybdeid species are recorded as causing the syndrome.<sup>14</sup> However, with up to 17 species implicated in various parts of the world, not all of which are members of the carybdeid family, confusion has surrounded exactly which species do give rise to this syndrome.

The appropriate first aid for the Irukandji syndrome is constantly debated, with treatment varying between physicians and treatment centres. However, the control of pain is the immediate and main priority with Irukandji patients as pain is a major, and often severe symptom.<sup>7</sup> Additional to the confusion in treatment is the potential for misdiagnosis of such a cryptic condition. No definitive test is available to confirm Irukandji syndrome and, as such, misdiagnosis can include a variety of conditions displaying similar symptoms.

Once thought to be geographically confined, the actual distribution of this syndrome has never been fully defined. There have been reports from various Australian locations as well as from other tropical and a few temperate locations worldwide. The species responsible and timing of these



events, like so many areas relating to this syndrome, remain poorly researched. This paper aims to distinguish fact from fiction in Irukandji syndrome and to review the research associated with it in Australia and throughout the world.

### History of Irukandji syndrome

The term 'Irukandji syndrome' was coined by Hugo Flecker in 1952 to refer to his earlier-described Type A stings, first recorded in 1945 and, at that time, of unknown origin.<sup>3,4,6,15,16</sup> 'Irukandji' was the name of an indigenous tribe that formerly inhabited the coastal regions around Cairns, Australia, from the Mowbray River in the north to Trinity Inlet in the south.<sup>17</sup> Members of this tribe knew that at certain times of the year people often left the water displaying debilitating symptoms. However, what is not well known is that these symptoms were first described much earlier in the Philippines.<sup>18</sup> In a series of eight cases, what is now termed 'Irukandji syndrome' was documented in swimmers bathing off a wharf in Manilla, with the offending organism suggested to be a jellyfish. This also seems to be the first report of the use of vinegar as a first-aid treatment for the syndrome, although its first-aid potential here appears to have been limited.<sup>18</sup>

Since its discovery, the occurrence of Irukandji syndrome has been regularly recorded in the literature. When in 1945 several cases presented simultaneously from beaches around the Cairns region, northern Australia, it was surmised that the causative agent was an unknown organism producing non-severe local symptoms but severe systemic symptoms.<sup>19</sup> However, not all beaches in the region recorded Irukandji syndrome even though well patronized by bathers.<sup>17</sup> By 1964, no further progress had been made in finding the causative agent, but it was hypothesised that Irukandji syndrome was caused by an organism that was:

- small;
- colourless and transparent;
- must at times be present in considerable numbers;
- motile.<sup>4</sup>

In an attempt to uncover the identity of the agent, Barnes conducted the first published controlled envenoming by an unknown species of cubozoan jellyfish. He tested two specimens, one on himself and his son, the other on a lifeguard. The initial sting was described as feeling like the envenoming of a small Bluebottle (*Physalia* sp.) which could be caused by the tentacles or the bell.<sup>4</sup> Within a short space of time, all three subjects developed Irukandji syndrome. The species in question was later named *Carukia barnesi*, ('Car' from carybdeid and 'ukia' from Irukandji, 'barnesi' from Barnes).<sup>20,21</sup>

Although a great deal of time and effort was placed into elucidating additional causes of the syndrome, none were found. As such, the term 'Carukiosis' was proposed instead of Irukandji syndrome or 'Type A sting' to better reflect the causative agent of the disease.<sup>22</sup> However, with later

**Figure 1**  
*Carukia barnesi*



work implicating further species, the term Carukiosis was abandoned.<sup>21</sup> It was 40 years before evidence was produced of a second species of cubozoan causing Irukandji syndrome with an additional five species being shown in the following three years to cause the syndrome.<sup>14,23</sup> Although it has been suggested that yet more species may be implicated, there is presently no direct evidence to support these claims.<sup>24–26</sup> The term 'Irukandji' is now routinely used to encompass any jellyfish that causes the set of systemic symptoms characteristic of the syndrome.

### Cost to the community

Although Irukandji syndrome is of minor concern to medical practitioners, it represents a major cost to northern Australian communities in terms of public health, leisure and tourism.<sup>27,28</sup> However, attribution of a direct monetary cost to this syndrome is highly problematic. There is little doubt that Irukandji syndrome presents a significant workload to emergency departments in presentations, retrievals and admissions: approximately half of stings resulting in Irukandji syndrome require admission, whilst a significant amount of time and resources are required to retrieve envenomed patients, many of whom are offshore and require helicopter assistance.<sup>27–29</sup> For example, in northern Australia in the 1998–99 Irukandji season there were 30 helicopter retrievals for Irukandji stings from remote locations such as offshore islands on the Great Barrier Reef at an average cost of AUD2,000–4,000 per patient (approximate total cost of AUD90,000).<sup>27</sup> In total, it is thought that the direct costs of retrieving and treating patients with Irukandji syndrome in northern Australian waters are AUD1–3 million per year.<sup>27</sup>

Additional to these direct costs are the indirect effects that media reports have on tourism. Like many marine animal injuries, there has been a disproportionate amount of media attention given to the Irukandji syndrome with much of it being inaccurate and poorly substantiated.<sup>29</sup> This often gives the impression that the waters are unsafe, which may have a direct negative impact on tourism.<sup>30</sup>

### Definition of the syndrome

The majority of Irukandji stings are initially innocuous, with very little pain at the sting site. Unlike the majority of other cnidarian envenomings, the markings at the site of envenomation are usually not in accordance with the physical characteristics of the bell or tentacles of the medusae.<sup>21</sup> It has been suggested that most stings occur by contact with the bell and stings from tentacles are less frequent; however, there are few data to support this.<sup>31</sup> Sting sites are often an oval area of erythema with a series of irregularly spaced papules, often referred to as “goose pimples”, which may be up to 2 mm in diameter.<sup>32</sup> These papules usually develop within about 20 min from the time of the sting and fade soon after; however, the erythema may persist for some time.<sup>4,17,27,32</sup> Unlike many cnidarian stings, Irukandji stings do not give rise to dermo-necrotic lesions.<sup>33</sup>

### LOCAL PAIN

Variability in both the initial response and the later systemic reaction is a characteristic feature in Irukandji syndrome. Initial pain ranges from “quite severe” to absent.<sup>4,10,13,17,31,34–36</sup> Local pain is said to diminish, with mild discomfort occasionally persisting until it is overshadowed by more dramatic symptoms.<sup>4</sup>

### LATENT PERIOD

Unlike the majority of cnidarian envenomings, there is generally a delay from the time of the sting to the onset of systemic symptoms. This has been reported to range from 5 to 120 minutes with an average of 25–40 minutes.<sup>4,13,17,19,36</sup>

### RANGE OF SYMPTOMS

Patients with Irukandji syndrome routinely show systemic symptoms, which may include headache, backache, nausea, vomiting, abdominal cramps, overall body pain, hypertension, tachycardia, feelings of impending doom, pulmonary and/or cerebral oedema and death (Table 1).<sup>1–12</sup> However, presently there exists no universally accepted definition of the syndrome.

### DISTINCT DIFFERENCES/VARIATION

The large variation displayed between envenomed casualties has led to many theories for these differences. For example, a positive correlation between the severity of the sting and

either the duration of jellyfish contact, or the time to first-aid administration has been postulated.<sup>4,21</sup> Similarly, thicker skin regions or presence of body hair may provide partial protection from an Irukandji sting, leading to differences in sting severity depending on the envenomed area of the victim.<sup>4</sup> Geographical variations have also been proposed to account for these disparities, suggesting different potential causative agents.<sup>1,5,7,8,11,27</sup>

### SEVERE SYMPTOMS

Severe envenomings do occur, often resulting in cardiac complications.<sup>1,7,12,40–43</sup> In one study, 30% of patients experienced some degree of heart failure, while 22% experienced elevated troponin levels in another.<sup>7,27</sup> Severe cardiac dysfunction has been reported in several cases.<sup>7,40–42,44</sup> Pulmonary oedema has been recorded but is considered to be rare.<sup>2,40,41,45,46</sup> There are no published data on repeat envenomings over time with the same victim; however, what few reports do exist suggest that there is no additional risk from subsequent encounters.<sup>4,15</sup>

### DEATHS FROM IRUKANDJI SYNDROME

The first reported death in Australia from Irukandji syndrome was in January 2002 at Hamilton Island; however, the cause is speculative as no supporting evidence of envenoming (for example the presence of nematocysts on the victim) was obtained nor was a post-mortem performed.<sup>11,47,48</sup> This patient had a pre-existing cardiac condition with a history of an aortic valve replacement and was taking warfarin.<sup>11</sup> Because of these factors, it has been suggested that death may have been due to this pre-existing condition and not a direct effect of the envenoming.<sup>48</sup>

The second recorded death occurred on the outer Great Barrier Reef in April 2002.<sup>7,11,12</sup> This patient, a 44-year-old male, suffered a sting to his chest while snorkelling 25 km north of Cairns. Within 15 minutes he displayed signs of Irukandji syndrome and was evacuated to Cairns Base Hospital. A cranial CT was performed and an intracerebral haemorrhage was discovered in the right frontal lobe. The patient underwent a craniotomy, but died 13 days post sting. Nematocysts removed from the sting site were identified as those from a large (> 20 mm) *Carukia barnesi*, making this the first definitive death reported from this species.<sup>12</sup>

### DURATION OF THE SYNDROME

While some Irukandji stings appear to resolve within a matter of hours, it is estimated that around 10–70% of patients require hospital admission and treatment for 24–72 hours with full resolution of symptoms after a maximum of several days.<sup>4,5,7,21,34–36,45</sup> However, continued complications have been reported as lasting anywhere from weeks to months.<sup>1,7,35,38,42,49,50</sup>

**Table 1**

Symptoms	Description	Reference
Local	Symptoms from Irukandji syndrome patients recorded in the literature	
	Profuse sweating, generalised hyperhidrosis	3,4,10,11,17,21,35
	Initial sting site sweating with entire body sweating later	34
	No sweating of sting site	3
	Tremor	9
	Erythema or welts, diaphoresis or flushing	3,4,8
	Moderate to severe pain	1,5
	Mild discomfort at sting site persisting until overshadowed by more severe symptoms; 5 minutes post sting the site marked by patch of erythema typically oval in shape, 5 by 7 cm wide	4
	Acute pains in affected part, minimal rash at sting site with slight redness and raised vesicles	3
	Small insignificant puncture	17
Musculoskeletal	Absence of swellings	17,19
	Violent cramps and muscle pain	5,9,17
	Long-lasting joint pain	3,4
	Cramping and spasms of intercostals and diaphragm	4,10,31
	Severe and boring pain in sacral or lower back area	4,10,31
	Muscle pains and cramps in all four limbs, abdominal pains and cramping, rigid abdominal wall	3
	Hyperactive deep reflexes	3
Gastrointestinal	Lie prostrate	37
	Painful vomiting and retching, excessive vomiting, nausea	2-5,8,9,17,19
Neurological	Colicky pains in epigastrium	3,19
	Distressed on presentation, anxiety	5,8
Cardiac	Anxiety with feeling of impending doom, restlessness	10
	Severe frontal or global headache, mild headache	2,4,36,37
	Hypertension, tachycardia and systolic hypertension in 50%	7-10
	Global cardiac dilatation with left ventricular dysfunction	11
	Elevated troponin levels, T-wave inversion and ST-segment depression, mild to moderate impairment of systolic function with segmental hypokinesia	7
Miscellaneous	Irregular heart beats	3
	Myocardial infarction	38
	Cardiogenic shock	36
	Oliguria, renal impairment	11
	Priapism, allergic reactions, expiratory wheeze	11,27
	Localised piloerection (sometimes generalised), uncontrolled tremor, hyperventilation	10
	Difficulty in breathing, dry mouth, burning eyes, sharp prickling sensation, cold, violent shivering, marked neutrophil leucocytosis within first hour, cough in 57%	4,10
	Squirting redness of sting sites	34
	Raised temperature, pyrexia	3
	Shock, collapse	37
Over-stimulated sympathetic system	39	
Periorbital oedema	27	
Pulmonary oedema	36	

**First aid**

In the initial treatment of Irukandji syndrome the main hindrance to first-aid measures is the often minor initial nature of the sting.<sup>45</sup> There is a plethora of untested

and ineffective first-aid treatment for Irukandji patients including, but not restricted to meat tenderiser, fresh water, aluminium sulphate, figs, mustard, manure, urine and papin.<sup>51-54</sup> A pressure immobilisation bandage (PIB) was once thought to be appropriate first-aid treatment with little

if any evidence to support its introduction.<sup>36</sup> Data now exist that suggest that the application of a PIB may actually have the potential to worsen patients' symptoms by increasing the venom load.<sup>12,42,43,46,55</sup> Similarly, the use of ice packs is now believed to have no effect on the management of the Irukandji syndrome.<sup>45</sup> Conversely, there is mounting evidence that the use of heat is beneficial for cubozoan envenomed victims.<sup>9,35,51,53-56</sup>

### Vinegar

Possibly the most misunderstood first aid for Irukandji syndrome is the use of vinegar. Reports exist that dousing the envenomation site with vinegar is of little benefit, contradicting a theory that vinegar alters the pH of the protein toxin thus rendering it less biologically active.<sup>36,54</sup> However, there are no data to support either of these assumptions. The use of vinegar originated from studies on the first aid for the large box jellyfish, *Chironex fleckeri*.<sup>57</sup> This study showed that vinegar caused permanent de-activation of all undischarged venom-containing nematocysts but was not effective in decreasing the pain displayed by an envenomed victim, nor did it de-activate the venom.

Further studies have shown that vinegar is effective in nematocyst inactivation in a least five species of carybdeids.<sup>13,32,58,59</sup> Given the small area of envenomation in most victims (and hence the small number of nematocysts employed) compared to the potential severity of the syndrome, any prevention of nematocyst discharge is likely to be advantageous.<sup>40</sup> Presently, the accepted first-aid treatment for Irukandji syndrome is the application of vinegar for a minimum of 30 seconds, then monitoring the patient and treating symptomatically.<sup>46</sup> Victims should not re-enter the water as delayed effects may impair breathing, muscle power and co-ordination, increasing the risk of drowning.<sup>34</sup>

### Medical care

Evidence into the most efficient treatment for control of Irukandji syndrome has been described as anecdotal at best with no standard protocol which gives consistent and effective control of pain, and with treatment varying with attending physician.<sup>28,60</sup> Historically, treatment has included the use of trichlorethylene, sodium phenobarbital, calcium chloride and calcium levulinate, calcium gluconate, systemic antihistamines, corticosteroids, frusemide, dobutamine, hydralazine, sodium nitroprusside, glyceryl trinitrate, streptokinase, aspirin, propranolol administered with nitrates and morphine infusions, ataraxic drugs such as chlorpromazine and butyrophenones, phentolamine and diazepam.<sup>13,20,35,36,38,40,41,44,45,61,62</sup> Although substantial debate exists over the best treatment, it is widely accepted that the control of pain in the envenomed victim is the immediate major priority.<sup>5,46</sup>

Intravenous morphine and pethidine have been the predominant opioids used over the years.<sup>13,34,38,40,46</sup> However, concerns have been raised over the use of pethidine because of its direct myocardial and respiratory depressant effects, and the toxic metabolite (norpethidine) produced when used in humans.<sup>41,46,47,60</sup> As a result, fentanyl has been suggested as the opioid of choice rather than morphine or pethidine.<sup>5,41,46,63</sup> Early application of promethazine had reportedly displayed potential for reducing the amount of narcotics required; however, a more recent retrospective analysis of hospital patients records spanning over 20 years did not support this.<sup>5,46,63</sup>

To date, the most novel approach to the treatment of Irukandji syndrome has been the use of magnesium. Its use is based on its ability to decrease vascular resistance in hyperadrenergic states and its potential to suppress catecholamine release, inhibit calcium influx, noradrenalin and possibly acetylcholine release, decrease sympathetic terminal receptivity to catecholamines and reduce catecholamine-induced myocardial necrosis.<sup>32,64-66</sup> However, much variation in its effectiveness has been reported; authors generally agree that the use of magnesium infusions should not be regarded as routine treatment until further definitive evidence is collected or until other treatment approaches have failed.<sup>62,64,66</sup>

At present, no antivenom exists for Irukandji envenomings; however, there has been some investigation into the use of *Chironex fleckeri* (the large box jellyfish) antivenom in envenomed victims.<sup>39,67</sup> Although there appeared to be some reduction in the symptoms and opioid requirements when this antivenom was administered in one study, the overall effects were not deemed beneficial, while in another it was ineffective.<sup>39,67</sup>

### MISDIAGNOSIS

Historically, the poor understanding of the Irukandji syndrome and its possible complications, coupled with the minimal or absent sting marks at the site of the envenoming and its initial mildness have led to it being misdiagnosed.<sup>11,36</sup> These misdiagnoses have included acute appendicitis, decompression illness, gastric poisoning, peptic ulcer, ruptured spleen, ruptured ectopic pregnancy and myocardial infarction.<sup>1,4,16,27,34,60,62,68</sup> Similarly, Irukandji syndrome may, in fact, have indirectly caused deaths that have been attributed to drowning. Victims may conceivably drown if in deep water at the onset of Irukandji syndrome because of cramps and respiratory muscle spasm severe enough to cause death from asphyxia and water inhalation.<sup>11,18,34-36</sup>

### WHY THE DELAY?

The delay in manifestation of symptoms is one of the most significant indicators of the syndrome, but one of the

least understood. Current theories for this delay include the possibility that a period of time is required before the toxins are metabolised in an envenomed victim or that the already active venom requires time to travel from the site of initial deposition to the toxin target site.<sup>34</sup> Simple logic would suggest that if the toxins need time to metabolise, this delay would be mirrored in prey items; however, this does not appear to be the case. Although the literature on feeding ecology is scarce, in one species, *Carukia barnesi*, the toxic effects of the venom on prey items is rapid with envenomed fish usually succumbing within minutes.<sup>69</sup> Additionally, intravenous injection of the Irukandji venom causes hypertensive crisis and death in rats in a similar time frame to that caused by *Chironex fleckeri* venom, namely within minutes.<sup>65,70,71</sup> Thus, the delay in symptoms would not appear to be caused by a latent period of time for the venom to become active.

Alternatively, the reason for the delay has been linked to the path the venom travels to reach its target. It is known that the venom components in *C. barnesi* venom are large (50–100 kiloDaltons, kDa) and, therefore, may travel via the lymphatics, similar to the pathway for snake venoms, thus causing the characteristic 20–30 minute delay in the expression of symptoms.<sup>46,69</sup>

#### Causative agents

As mentioned earlier, it has become evident that the Irukandji syndrome may be caused by a various of species of jellyfish and in both hemispheres.<sup>7,10,18,35,38,39,48,49,59,62,65,72–74</sup> Unfortunately, as these cnidarians are often relatively small in size and difficult to identify precisely even when creatures are seen, accurate identification of an envenoming is relatively rare.<sup>75</sup> Evidence of species causing the symptoms range from speculative to definitive evidence where the victim collected the specimen at the time of envenoming.<sup>14,25</sup> Presently, 17 species of cnidarians, including 14 different

**Table 2**

Species implicated in the Irukandji syndrome

<i>Physalia physalis</i> , “Bluebottle” <sup>35,61</sup>
<i>Cyanea</i> sp., “Lion’s mane” <sup>15,76</sup>
<i>Carukia barnesi</i> <sup>3</sup>
<i>Rhizostoma</i> sp. <sup>15</sup>
<i>Gonionemus oshoro</i> <sup>77</sup>
Unidentified “Morbakka” carybdeids <sup>10</sup>
<i>Gerorgia rifkinae</i> , aka “Darwin Carybdeid” <sup>78</sup>
Unnamed carybdeid <sup>23</sup>
<i>Carukia shōju</i> <sup>26</sup>
<i>Malo maxima</i> <sup>14,26</sup>
<i>Alatina rainensis</i> <sup>79</sup>
<i>Alatina nr mordens</i> <sup>14</sup>
<i>Carybdied</i> spp “Fire jellies” <sup>14</sup>
<i>Carybdea alata</i> <sup>14,51</sup>
<i>Carybdea xaymacana</i> <sup>14</sup>
Unknown jellyfish, Thailand <sup>50</sup>
<i>Malo kingii</i> <sup>24</sup>

carybdeids, have been implicated in causing Irukandji syndrome (Table 2); however, the data supporting many of these claims are speculative. Not all carybdeids are capable of causing Irukandji syndrome. For example, no systemic symptoms have been caused by envenomings from *Carybdea sivickisi*, *Carybdea rastonii*, *Carybdea marsupialis* or *Tripedalia binata*.<sup>4,15,72–74,80–83</sup>

#### Distribution of Irukandji syndrome

Generally, Irukandji syndrome is thought to be a tropically based disease, found around coral reefs in northern Australia; however, no real research has been conducted into the true distribution of the syndrome. Irukandji syndrome has been recorded from many locations in Australia, Torres Strait, Hawaii, Fiji, coastal Thailand, Puerto Rico, Manilla Bay

**Figure 2**

Global distribution of documented Irukandji syndrome stings



in the Philippines, the Gulf Sea, Key West Florida, the French West Indies, Bonaire in the Caribbean, Timore Leste, Papua New Guinea, Japan, North Wales in the United Kingdom and throughout the Indonesian archipelago (Figure 2).<sup>4,8,9,14,15,18,21,27,34,35,37,38,40,45,50,51,59,62,75,77,84–86</sup> Within geographic locations, near-shore reefs and islands may influence the presence or absence of animals causing the syndrome. For example, there is a higher than expected incidence of stings for particular beaches in far northern Australia that have closely located near-shore islands.<sup>4</sup>

At the northern and southern extremes of this distribution, the season usually occurs only in a few of the warmer months of the year, increasing with proximity to the equator where it may be present all year round.<sup>2,7,15,21,46</sup> Also, marked differences in trends of occurrence may occur with location. In Hawaii, cases of Irukandji syndrome increase dramatically in conjunction with the monthly aggregation cycle of *Carybdea alata*, a carybdeid linked to the syndrome, at approximately eight to ten days after the full moon.<sup>51</sup> Similar reports of lunar cycles coinciding with cubozoans that have the potential to produce Irukandji syndrome have been recorded from Puerto Rico, Kiribati, and around the Gilbert Islands but the syndrome has not yet been recorded from these regions.<sup>87–89</sup>

In Australia, Irukandji syndrome may be present throughout the year except for July and August.<sup>4,8,21,34,36,39,45,46,76,90,91</sup> Peak times appear to be from December to February on the east coast of Australia, and January to May in the Northern Territory. Some bimodality to envenomings is evident, including on the west coast with various meteorological conditions linked to these occurrences.<sup>2,8,13,36,37,44,46,78,91,92</sup> Maximum incidences have been reported as the last and first two weeks of each year, often with multiple stings occurring over only a few days.<sup>4,13,17</sup> However, this may reflect increased beach usage by swimmers at these times.<sup>4,17</sup> Numbers of cases may also vary between seasons within locations, some years experiencing large numbers of envenomings while in others no cases may be recorded.<sup>7,17,21,46</sup> These variations in sting incidence may also reflect the ecology of the envenoming animals and their propensity for different areas at different times.<sup>5</sup> With so little known about the ecology and life history of these animals, this remains speculative at best.

### Venom components

Research into the venom components of cubozoans responsible for the syndrome have been hampered by the relatively low numbers of animals collected and the low yields of venom acquired from these animals compared to that of the larger, multi-tentacled chirodroids.<sup>93</sup> Research conducted into extracted venom has shown a large number of different proteins. As many as 60 proteins were present in the venom extracted from nematocysts on mature bells of animals (SDS-PAGE gel analysis), and at least 45 different

proteins in the venom extracted from tentacular nematocysts, with proteins ranging in size from 25–250 kDa in size, the majority being less than 100 kDa.<sup>69</sup> There are also distinct differences in venom protein profiles between mature and immature specimens as well as venom extracted from bell nematocysts as compared to tentacles.<sup>69</sup> The large number of proteins found in *C. barnesi* venom is far greater than previous studies into the components of cubozoan venom, which saw only three major protein bands present.<sup>86</sup>

### Laboratory studies

Laboratory studies into the components of Irukandji venom have predominantly revolved around the cardiac responses of extracted venom on both whole and isolated vertebrate models including on pigs, guinea pigs and rats.<sup>43,49,65,70,71,86</sup> Initial studies on the effects of *C. barnesi* venom have shown that serum levels of endogenous adrenaline increase as well as heart rate and blood pressure, with widening pulse pressure and a positive inotropic effect when injected into rats.<sup>49</sup> Similarly, studies utilising crude blended whole specimens of *C. barnesi* injected into mechanically ventilated pigs saw a 200- and 100-fold increase in serum noradrenaline and adrenaline respectively, with sustained tachycardia and systemic and pulmonary hypertension.<sup>43,65</sup> The effect of the venom may not only be causing the release of catecholamines but may also cause direct vasoconstriction.<sup>65</sup>

Crude venom extracts on isolated rat and guinea pig right atria caused tachycardia in the presence of atropine.<sup>65</sup> However, this effect was almost abolished in an *in vivo* pig model by the prophylactic addition of tetrodotoxin and restricted to peripheral post-ganglionic sympathetic sites and possibly the splanchnic nerve innervations and the adrenal medulla. This suggests that this venom extract functions as a neural sodium channel activator.<sup>65</sup> However, as crude venom extract and not pure extracted venom was used in these studies, and as subsequent research has found toxic components in tentacle extract devoid of nematocyst material, as well as cardiac responses to this same material, these results must be viewed with some reservation.<sup>65,70,71</sup>

Subsequent laboratory studies have utilised a refined venom extraction technique.<sup>69,94</sup> These investigations showed some comparable cardiac effects, including severe pressor responses from venom of *Carukia barnesi* and *Alatina nr mordens* (approximately 3–5 times less potent than that of *C. barnesi*), supporting the theory of a venom-induced catecholamine release after intravenous venom administration.<sup>70,71</sup> Interestingly, pressor responses do not appear to be dose-dependent, suggesting that the venom may be inducing a release of catecholamine into the circulation and not actually contain a direct vasopressor itself.<sup>70,71</sup>

In one of these studies, the administration of prazosin (an  $\alpha$ -1 adrenoceptor antagonist) in envenomed test

animals both reduced the venom-induced pressor response and inhibited the tachycardia, supporting the hypothesis that this is an indirect rather than a direct effect on the peripheral vasculature, and also not a direct  $\alpha$ -adrenergic effect.<sup>71,95</sup> Conversely, cardiovascular collapse in envenomed animal models does appear to be dose related, indicating the toxins may also be acting directly on the myocardium.<sup>71</sup> Salivation and urination in envenomed animals is also seen, which suggests parasympathetic stimulation resulting again from the venom-induced catecholaminaemia.<sup>70,71</sup>

### Climate change and human interaction

Studies of jellyfish abundance and frequency are under-researched; however, the few studies that do exist seem to implicate an increase in jellyfish numbers over time.<sup>96</sup> Various potential factors for this have been cited, from anthropocentric practices such as over fishing and pollution, to climate change and ocean acidification.<sup>96-98</sup> Climate models combining factors of increased ocean temperatures have led researchers to surmise that jellyfish numbers as a whole will increase over the next 100 years.<sup>96</sup> Additional to oceanic conditions are the reports of seasonal expansions and blooms of gelatinous species, possibly because of increased global temperatures, and introduction into new areas through changing ocean currents and human activity.<sup>99,100</sup> What is abundantly clear is that when it comes to jellyfish trends worldwide, more information is needed on the life cycles and ecology of these animals.<sup>100</sup>

### Conclusions

Irukandji syndrome has historically been considered a problem for the waters of northern Queensland; however, a literature search has revealed that its reach extends much further than originally thought. Whether this increased global reporting is owing to heightened awareness, reflects changing ocean conditions or is indicative of the increased number of people utilizing the oceans remains unclear. The possibility of this syndrome becoming a more widely distributed phenomenon adds weight to the need for further understanding and this can no longer be perceived as simply an Australian problem but, rather, a global phenomenon. The Irukandji syndrome needs further research and a clearer definition both in terms of the specific species and their toxins causing it and its geographic and temporal distribution.

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# Case report

## A forensic diving medicine examination of a highly publicised scuba diving fatality

Carl Edmonds

### Abstract

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A high-profile diving death occurred in 2003 at the site of the wreck of the *SS Yongala* off the Queensland coast. The victim's buddy, her husband, was accused of her murder and found guilty of manslaughter in an Australian court. A detailed analysis of all the evidence concerning this fatality suggests alternative medical reasons for her death. The value of decompression computers in determining the diving details and of CT scans in clarifying autopsy findings is demonstrated. The victim was medically, physically and psychologically unfit to undertake the fatal dive. She was inexperienced and inadequately supervised. She was over-weighted and exposed for the first time to difficult currents. The analysis of the dive demonstrates how important it is to consider the interaction of all factors and to not make deductions from individual items of information. It also highlights the importance of early liaison between expert divers, technicians, diving clinicians and pathologists, if inappropriate conclusions are to be avoided.

### Key words

Scuba diving, scuba accidents, diving deaths, legal and insurance, autopsy, buddies, case reports

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### Introduction

In October 2003, a diving fatality occurred at the site of the wreck of the *SS Yongala* off the Queensland coast, when a young woman, Tina Watson, died on her honeymoon. A police investigation extending over a nine-year period described a modus operandi for her alleged murder; at a 2007 coroner's inquest, on national television, in many news media stories, in a book and at a USA courthouse in 2012.<sup>1-4</sup> The victim's diving buddy, her husband, Gabe Watson, was charged with capital murder in both Australia and the USA. He had arranged a diving trip to the *SS Yongala*, where, on the eleventh day of their marriage, he allegedly killed his wife, a novice diver, in the following scenario. The motive was claimed to be financial (insurance claim, assets).

Gabe Watson was alleged to have used the ploy of a malfunctioning computer to abort the dive and separate himself and Tina from the other divers. They then joined another group for the second dive attempt. They left the descent line at about 12 metres' sea water (msw) (as did everyone else), but swam ahead of the others allegedly so that he could turn off her air supply without being noticed. After she had died or lost consciousness, he caught her in a bear-hug and turned the air supply back on. Despite his being an experienced diver with rescue qualifications, he let her sink to the bottom as he made his way leisurely to the surface. Thus, she died of asphyxia (obstruction of the air supply, suffocation) and Gabe was charged with murder. He spent 18 months in jail in Australia after a plea bargain to the lesser charge of manslaughter. A comprehensive assessment of the

legal aspects of the case is made elsewhere.<sup>4</sup> In Birmingham, Alabama, the judge dismissed the charge without requiring a defence, on the grounds that the prosecution evidence was based on conjecture and speculation.

This presentation deals with the facts of the dive, based entirely on information in the public domain – the sworn witness statements and video interrogations supplied to and by the police investigators, the coroner's inquiry, analysis by the dive computer (DC) experts, the autopsy results and equipment examination by the police divers. An analysis and interpretation of the data are presented in the discussion section.

### Diving experience

Gabe Watson qualified as a diver in 1998. He had made about 56 dives, mostly in still water (pool, quarry, etc.) and had little genuine open-water experience other than two wreck dives and a couple of drift dives in Cozumel, Mexico. He did a rescue course some four years before the *Yongala* dive, and this included one supervised rescue of a neutrally buoyant buddy in a still-water quarry.

Tina Watson was encouraged by her then fiancée to undertake scuba diving in 2003. She was also trained in a pool and the still-water quarry, with purpose-built dive platforms. She panicked at a shallow depth and required rescue despite the relatively innocuous conditions. A dive coordinator described her as the most ill-prepared diver he had ever seen. Other descriptions such as “*hysterical*” and “*shaking*” were

used. She possibly had made 11 dives, although only eight were recorded on her DC. The maximum water depth ever reached was 9 metres' water, with an average maximum depth of 6 metres and average dive duration of 13 minutes.

### The dive

The dive, as described by Gabe Watson, Dr Stanley Stutz, Wade Singleton and other divers (validated by DC profiles from Gabe, Tina and Wade's computers), was as follows. Soon after 1000 h on 22 October 2003, the Watsons were transported on a tender to a descent line to start a dive on the wreck of the *SS Yongala*. The Watsons were last of the group to enter the water, but soon aborted their dive after a descent to 1 metre' sea water (msw), when Gabe's DC gave an alarm signal (beeps) indicating a problem with the air supply. They ascended, returned to the dive vessel and replaced the battery in the transmitter of his DC. After about 15 minutes, they had their scuba tanks topped up and the DC was working. Tina wore a small 3 mm wetsuit and carried weights of 9 kg.

Lou Johnston, who was a moderately experienced diver, an instructor and now a deckhand, had dived the area that morning. In her diary, she described the conditions and currents underwater as savage, an extremely strong current that required her to kick and breathe as hard as she could to reach the descent line. She also observed the Watsons after their first short shallow dip as they looked exhausted, "*out of breath and panicked... I was quite concerned*".

At about 1030 h the Watsons commenced to dive in a group of six divers. This time, the Watsons descended first. With Tina in the lead, she and Gabe descended slowly, hand over hand, at about 3 metres per minute, to about 12 msw. The others followed a minute later. At about 12 msw, like all the other divers and 3–4 minutes into the dive, the Watsons left the line and commenced to swim or drift along the top of the wreck, with the current. They dropped another 3–4 metres to 16 msw during the fifth minute. Gabe was not sure how far they had come, but he could barely see the people on the descent line and could not see the ascent line at all. Tina indicated to Gabe with her thumb that she wanted to return to the descent line. He stated that he was also concerned and agreed to return to the line and, thus, the safety of the dive boat.

They turned around and started swimming back to the descent line. They got some way back when it was evident that Tina was in distress, and not coping with the current. She appeared fearful, was swimming slowly and was overweighted. They were hand-in-hand, Gabe towing her below and behind him. He claimed to be swimming and breathing very hard. He indicated to her to inflate her BC, but her brief attempt at this was ineffectual and Gabe stated he was unsure whether the main problem was with her or her equipment. Tina then stopped swimming. Towards the end of the fifth

minute, trying to get back to the line and not making much headway, he was pulling her by the top of her BC and was close to her when her waving hand displaced his facemask and regulator. He then let her go, backed away to re-adjust his mask, clearing it by exhaling air through his nose, and replacing the regulator with his second or 'octopus' regulator. Later he was to observe that the mouthpiece had become detached and lost from the primary regulator.

During the time that he was replacing mask and regulator, she sank and floated away from him. He swam down about 3 metres and attempted to reach her again (probably the event clearly seen and described by Dr Stutz, who was descending down the line in the next group of divers). Gabe Watson decided to ascend to obtain assistance, as his previous, exhausting attempts to get Tina back to the line had failed. At an estimated distance of 9 metres or so from the descent line, he allegedly swam hard at a 45 degree angle to that line. When he reached it he attempted to enlist the aid of two Asian divers, but quickly realised that communication with them was not effective. He then rapidly ascended up the line, surfaced and attracted the attention of the boat crew. The ascent, as interpreted from his DC, was just over 2 minutes (later described by the police as "*a pedestrian rate*").

Meanwhile, Tina had sunk to the sea floor, about 10 metres from the wreck. No evidence of respirations was observed from the fifth minute onwards (Gabe, Stutz and Singleton). Singleton, one of the dive instructors in the group previously following Gabe and Tina, recognised the emergency and swam fast to reach Tina. She had her regulator and mask in place, her BC not inflated and there were no signs of life. On the seabed, he purged air into her from her regulator and repeated this during their rapid ascent; achieved by ditching his weights and inflating his BC. Blood was seen coming from her mouth on surfacing. Two divers, assisted and supervised by other divers who were also emergency ward physicians, conducted CPR for 40 minutes. Large quantities of froth exuded from her mouth, but there were no other signs of life. Tina was pronounced dead at 1127 h.

### Equipment tests

There were no abnormalities detected by the police in the laboratory or field tests of Tina's scuba equipment, except for a minimal and insignificant increase in allowable carbon dioxide level in the tank air. Gabe's tank pressure on completion of the dive was 156 bar. Tina's tank pressure at the end of the dive was 149 bar. The small buoyancy compensator (BC) she wore would have had a total lift capacity of about 9 kg, as described in the Alabama court proceedings and based on the manufacturer's claims.

The dive computers used by Gabe (Oceanic Datatrans Plus), Tina (Oceanic Versa) and Singleton (Ultra DC) were tested by the police (in conjunction with the Townsville Hospital Hyperbaric Medicine Unit) and Chris Coxon, Queensland

Workplace, Health and Safety. Later testing was performed by Adam Lindsay White, service manager for Oceanic, Australia. As there are factually incorrect statements regarding decompression and, more specifically, the DCs in the police evidence, only the tests and analyses by Coxon and White are employed here. All DCs measured accurately the depths, durations and ascent rates of the dives.

The description of an alarm being triggered, as described by Gabe but refuted by the police, was supported by the Oceanic expert. There were 54 dives recorded on Gabe's DC. This last dive was to a maximum of 16.5 msw with a descent for the first 5 minutes and an ascent for the last 2 minutes (Figure 1). Unfortunately only 3 msw depth increments and whole minute intervals were able to be downloaded, producing a much "smoothed out" dive profile without the ability to detect smaller variations in depth or duration. At the 6 msw mark Gabe was ascending at 18–27 m min<sup>-1</sup> and his maximum recordable ascent rate was 27–36 m min<sup>-1</sup>. The air consumption, (indicating the rate of air being consumed, not the total air consumed) showed 7 out of a maximum 8 bars at one stage and recorded a "maximum breathing rate".

The Oceanic Versa used by Tina was even less informative. It did not allow downloading of any detailed dive information except for maximum depths and durations. The last dive was to 27 msw for 10 minutes. The ascent rate was 5/5 bars and flashing "too fast". Two of her previous dives also indicated "too fast". The Ultra DC used by Singleton showed a descent at 1031 h, a maximum depth of 27.6 msw and duration of

9 minutes. The ascent rate alarm was activated after 8.5 minutes of the dive.

### Autopsy

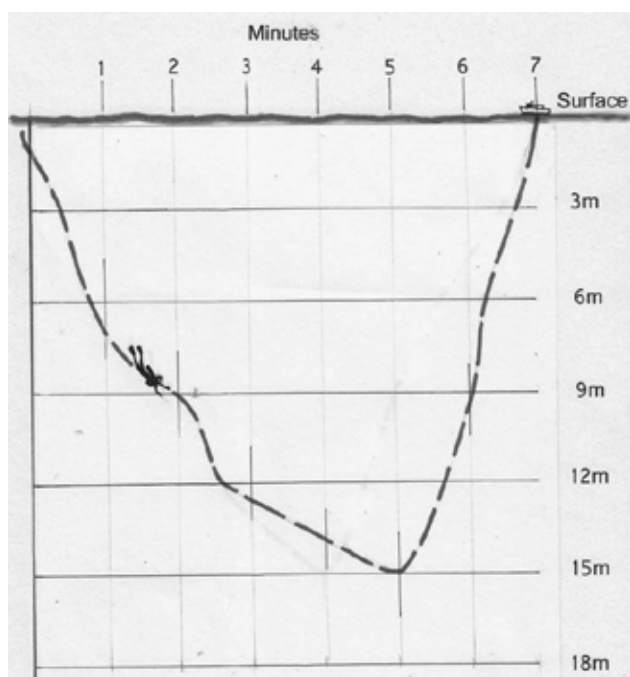
Following preservation of the body in a refrigerated morgue, post mortem CT scans taken approximately 24 hours after death showed extensive air embolism in both arterial and venous systems. This was interpreted to have occurred when there was still an active vascular circulation. It was also observed in the intra-cerebral arteries, including the Circle of Willis, but not in the cerebral veins. Gas was observed in the cervical tissues; however, neck trauma was induced during the attempted resuscitation and so may have contributed to this. There was excessive gastrointestinal gas distension and bilateral pneumothoracies. Scans also revealed mucosal thickening and polypoid opacities in the sphenoidal and other sinuses.

The lungs were oedematous (right 630 g, left 530 g), with froth in the airways and areas of congestion. Pulmonary histology showed pseudo-emphysematous areas and some haemorrhages in the alveolar spaces. There were no abnormalities of the cardiac or cerebral tissues, except for intra-vascular gas. Analysis of the extraneous gas in the body (heart, arterial system, pneumothorax, bowel, etc.) was not performed.

The cause of death was given by the forensic pathologist as drowning. The pathologist adhered to this diagnosis throughout the various proceedings, despite attempts to have it re-categorised as asphyxia.

**Figure 1**

A diagrammatic representation of the dive profile from Gabe Watson's dive computer



### Discussion

#### FITNESS TO DIVE

Tina Watson's medical history showed that she had suffered from repeated bouts of symptomatic supraventricular tachycardia and was shown to have a mild myxomatous degeneration of the mitral valve as well as the arrhythmia. Radiofrequency ablation of an aberrant conduction pathway was undertaken in 2001. She had one possible episode of tachycardia post treatment, but, in general, her cardiac status was much improved.

A specialist cardiologist without training or experience in diving medicine stated under oath that this procedure was "usually curative". When asked if the disorders described, or the treatment administered, would be likely to increase the likelihood of arrhythmias under the exceptional conditions possible with scuba diving, the cardiologist replied "not necessarily", and believed that Tina was fit to dive. By contrast, a reputable Australian diving physician stated that the possibility of a cardiac arrhythmia as a cause of Tina's death could not be excluded.

Whether Tina Watson was fit to dive from a cardiac aspect would be questionable despite the cardiologist's expressed opinion. My assessment is that she was permanently medically unfit because of the many aggravating factors leading to arrhythmias in diving, the fact that she had at least one scarred and potentially irritant focus from the surgery, and the high incidence of cardiac deaths from diving. This remains conjecture. What seems less debatable is that she was not a physically competent swimmer according to her friends, and not psychologically suited to scuba diving, based on her history and the observations of others. This would be especially so under strenuous conditions. Consensus of opinion is that, whether medically fit to dive or not, she was too inexperienced to undertake the *Yongala* dive.

## ENVIRONMENT

### *Current speed*

This is relevant to a number of key issues: why the Watsons failed to regain the line, the failure of Gabe's rescue attempt, and his rate of ascent, which the police interpreted as suspicious. It also casts doubt on the relevance of the attempted re-enactments, which did not reflect this aspect of the environmental conditions at the time of the fatality. In general, for a neutrally buoyant non-expert diver 0.5 knots or less is a comfortable swim against a mild current, 0.6–1 knot is a moderate current but problematic, whilst 1 knot is a strong current, tolerable only for short distances. Inexperience, unfitness and anxiety will aggravate the problems. Drifting with the current is easy, but swimming against it is hard – causing greater anxiety and increased air consumption. Of the divers that morning, 15 out of 19 stated that the currents were moderate to severe, as did the police documentation of the incident. Other indicators supported this assessment. Divers were horizontal on the line and when they let the line go, it took strong swimming to re-attach.

### *Depth*

With increasing depth there are greater problems with anxiety in inexperienced divers and greater buoyancy problems for divers who are overweighted. Tina Watson had previously only dived to a maximum depth of 9 metres.

## BUOYANCY AND AIR CONSUMPTION

### *Tina's negative buoyancy*

With a small 3 mm wetsuit and carrying 9 kg of weights, Tina was negatively buoyant, unless countered by inflation of her small BC. She was wearing more than twice the weight theoretically needed and twice the amount used by the other female divers on that dive. She was not seen to inflate her BC once immersed, and it was never subsequently seen to be inflated. Allowing 1 kg for a full tank, she was at least 6

kg over-weighted on the surface and more at depth. Using excessive weights is common in novice or anxious divers, to assist in descent. Her over-weighting was verified by subsequent events but would not have been a major problem until she let go of the rope at 12 metres to swim. Failure to inflate her BC is not surprising. Many novice divers do not pay adequate attention to buoyancy and do not appreciate the length of time necessary to inflate a BC at depth.

### *Air consumption*

Calculation of Tina's air consumption (surface value) indicates almost 600 litres. Allowing for an initial usage and some loss, this equates to a respiratory minute volume of about 100 L min<sup>-1</sup>. Corrected for her depth exposure, this is about 50 L min<sup>-1</sup>, an exceptional air consumption for a small female. Anxiety-induced hyperventilation and exertion may explain most of this. It would be impossible to explain if the air supply had been turned off for 2 of the 5.5 minutes of the dive. Gabe's air consumption was also very high, over 500 litres (surface value) and about 40 L min<sup>-1</sup>, corrected for his depth exposure. As Gabe did use his BC throughout, more accurate figures are harder to determine, but it is still a large value and would require anxiety and/or considerable exertion to explain it. In both cases, the relatively innocuous first 3 to 4 minutes of descent down the line, requiring small minute volumes, makes the air consumption in the latter part of the dive even more impressive.

## THE FIFTH MINUTE

The descent in the first 3 to 4 minutes appears to have been uneventful. Both divers were over-weighted and so they would have just let themselves down slowly, attached to the line. The use of a line overcomes the effect of both the current and the over-weighting. Once they let go of the line, these factors come into play. During this fifth minute, four negative, inter-related factors had a bearing on Tina Watson's dive:

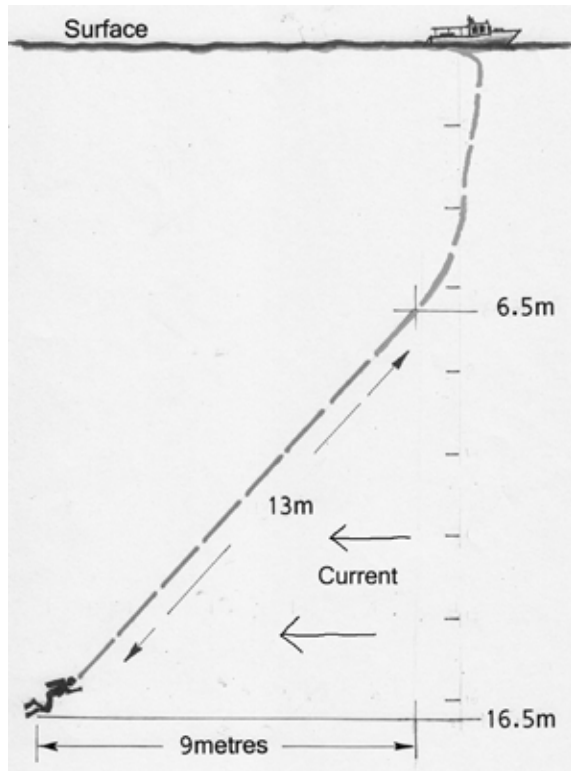
- Inexperience (at depth and against currents, swimming);
- Anxiety and panic;
- Hyperventilation, increasing resistance to breathing (over-breathing the regulator) and thereby aggravating the panic;
- Negative buoyancy, worse with depth.

During this period, Gabe Watson, who had regained neutral buoyancy, had three factors to overcome, increasing his work load:

- Tina was over-weighted (estimated at > 6 kg); this would reduce their swimming speed while he was towing her;
- She was positioned more vertically than horizontally, because of the over-weighting, thus greatly increasing the effect of drag;
- Swimming against a moderate/strong current.

**Figure 2**

A diagrammatic representation of Gabe Watson's projected deep ascent from 16.5 to 6.5 msw, swimming at a 45 degree angle against the current, then his shallow ascent direct to the surface up the 'descent' line



#### THE FIFTH TO SEVENTH MINUTE: GABE'S ASCENT

Gabe claimed a hurried and energetic dash to get help for Tina. His claims were inconsistent with the police interpretation but, because of the limitations of the DC, the ascent time could be variously interpreted as less than or greater than 2 minutes. At a depth of at least 16 msw, and a distance of 9 metres from the line, Gabe ascended at a 45 degree angle. This means that he covered a distance of approx 13 metres before he reached the line. He still had 6.7 metres to ascend up the line. Thus there are two parts to his ascent (Figure 2).

##### *Shallow phase (6.7 metres to the surface)*

Once he reached the line, Gabe could pull himself up with his hands, free of any effect from the current. The DC showed a very rapid ascent over these final 6 metres. At 18 msw min<sup>-1</sup>, it would take 20 sec. At 36 msw min<sup>-1</sup> it would take 10 sec. The actual time was probably somewhere in between. That still leaves about 2 minutes for the deep phase.

##### *Deep phase (from at least 16 to 6.7 metres' depth)*

The duration of the deep phase was approximately 2 minutes. Consider the two extremes of moderate and strong currents.

If we consider a strong current, then at a speed of 1.2 knots, this is 37 m min<sup>-1</sup>. He would have to swim the equivalent of 74 metres just to remain in the same place. If we consider a moderate current, then at a speed of 0.6 knots, this is 18.5 m min<sup>-1</sup>. He would have to swim the equivalent of 37 metres just to remain in the same place. To these distances, one must add the extra distance covered during ascent, i.e., 13 metres. The total equates to 87 metres (strong current) and 50 metres (moderate current). Over 2 minutes, this requires swim speeds of 43.5 m min<sup>-1</sup> and 25 m min<sup>-1</sup> respectively. Time to attempt communication with the Asian divers also needs to be factored in, making the above an underestimate.

#### *Conclusion*

These calculated swim speeds vary from fast to very fast in full scuba gear; the actual speed would likely be somewhere between. By comparison, Singleton's ascent rate, but at risk to both his and the victim's life, was about 18 m min<sup>-1</sup>, and he had extra buoyancy to assist him. Watson's critics presumably assumed that his 2+ minute ascent time was a direct, vertical swim to the surface, without consideration of the current, both of which assumptions we know to be incorrect.

#### CAUSE OF DEATH

There is little reason to question the autopsy findings of drowning and of extensive air embolism. However, some controversies do arise and warrant discussion and explanation. The gross sinus pathology, which was the focus of some confusion, usually indicates barotrauma of descent whilst unconscious but with a functioning circulation, i.e., whilst the diver is still alive.

##### *Drowning or asphyxia?*

Asphyxia was a term frequently used during the legal proceedings (and with legal connotations) by both the police and prosecution. It was used without adequate definition. In forensic circles, it usually implies suffocation, i.e., a cessation of air supply (hanging, upper respiratory tract obstruction, laryngospasm, turning off an air supply, etc). This results in a buildup of carbon dioxide and a struggle to re-establish the air supply. Loss of consciousness results from progressive hypoxia after a couple of distressing minutes, then death. At depth, this would take longer, as the available oxygen in the lungs is greater than at the surface.

Hypoxia from aspiration of water in the drowning syndromes is due to shunting of blood through non-ventilated sections of the lungs, often with increasing ventilation to reduce the carbon dioxide build-up. Struggling may be present during this process, but often it is either ineffectual or absent (termed 'silent drowning'). The duration prior to loss of consciousness depends on the degree and type of aspiration.

The pathologist adhered to his diagnosis of drowning in both the Australian and USA trials, despite attempts to have it re-categorised as asphyxia by both the police and prosecution. This was rejected by the USA court judge, who correctly adhered to the pathologist's diagnosis of drowning. The lung weights, morphology and histology were characteristic of drowning, not simple asphyxia.

#### *Post-mortem gas*

Interpretation of the presence of gas at autopsy in diving deaths is best demonstrated by CT or MRI scans of the body, but is sometimes contentious for several reasons, as follows.

- Although uncommon, death can occur from decompression sickness, with gas bubbles developing within any tissue. This is classically seen as *cutis marmoratus* in the skin, but subcutaneous tissues and organs can also be involved, as can the venous system and the right heart. The diagnostic sign is a tissue reaction or inflammation around the gas bubbles. This is not described in this case.
- Decompression artifact because of off-gassing (mainly inert gas) post-mortem, is seen when divers die underwater or in pressure chambers and are then brought to the surface. From deep and prolonged dives, it can produce extensive surgical emphysema and replace blood from vessels ('gas angiograms') and the heart. The CT scan should extend to the thighs, so that the tell-tail signs of post-mortem decompression artifact may also be seen as gas in the intra-muscular fascial layers. In this case, the brief period (5–10 minutes at an average depth of 15 msw) will produce little or no off-gassing and this would have been even more diminished by 40 minutes of oxygen-based resuscitation.
- Putrefaction (decomposition) is evident after about 24 hours if the body is not refrigerated, and produces a foul-smelling gas initially in the gastro-intestinal tract, the portal veins and liver. Both hydrogen sulphide and methane may be present.
- Drowning often results in the swallowing of air and water into the gastro-intestinal tract, explaining the tendency of near-drowning victims to vomit. The gas is mainly nitrogen and oxygen, as in air. This aetiology is relevant to this case, but incidental to the cause of death.
- Air embolism following pulmonary barotrauma. This is mainly observed in the arterial system and the left heart. Continuation of life, and circulation, including effective resuscitation efforts, may result in some air (nitrogen/oxygen) bubbles moving to the venous system, the right heart and the pulmonary filter – but arterial bubbles may persist, especially in small arteries, such as the Circle of Willis, supporting the diagnosis.
- Resuscitation itself may result in a few small venous bubbles with rare instances of arterialization of these through right-to-left cardiac shunts.

Unfortunately analysis of the extraneous gas in the body was not performed in this case.

#### AIR EMBOLISM FROM PULMONARY BAROTRAUMA

In this case, air filled the left side of the heart and there were widespread 'gas arteriograms' seen on CT scan, as well as in the venous system. Support for the diagnosis of pulmonary barotrauma included the history of rapid ascent, purging of air into the lungs during ascent, bilateral pneumothoracies, cervical surgical emphysema, gas in the arterial system and haemoptysis on surfacing.

#### RESCUE/RESUSCITATION

Nine years after Tina's death, and with no urgency to make decisions, it is clear that the ideal way to have rescued Tina, for both Gabe and Wade, would have been for them to ditch Tina's weights and ascend at a moderate speed to the surface. This ignores the problems of ditching weights if one is not cognisant of the specific equipment, and the possibility of surfacing too far from the dive boat.

Gabe did desert his wife after 5 minutes. To reach a safety line and then surface, he had to swim extremely hard against a moderate to strong current. He was unable to tow her with her negative buoyancy and the drag of her body. He was not confident of what to do if he went with her to the bottom, or if he managed to achieve an ascent away from the boats. He decided to ascend and enlist the assistance of others. His DC and his estimated air consumption validate his description of events, and his ascent rate was fully comparable to the direct ascent by Singleton. Gabe attempted to rescue Tina by getting her to the descent line. If he had succeeded in this, it is at least possible that she could have been surfaced and resuscitated from a near-drowning episode. Letting her sink increased the likelihood of drowning.

Singleton took Tina rapidly to the surface and inadvertently caused the pulmonary barotrauma, from the rapid ascent and the positive inspiratory pressures generated by purging air into her lungs from the regulator. The subsequent extensive air embolism guaranteed resuscitation would be impossible without a recompression chamber. Both Gabe and Wade did their best to rescue Tina; neither succeeded.

#### Conclusions

Tina Watson suffered the two most common causes of death in young scuba divers, drowning and air embolism from pulmonary barotrauma. She had most of the contributing causes for these. She was medically, physically and psychologically unsuited for the dive she undertook. She was inexperienced, doing the deepest dive she had ever attempted, her first dive in open water and against currents she had never encountered previously. She was overweighted and without adequate supervision. She panicked,

was probably exhausted and over-breathed her regulator, aspirated water, became hypoxic, lost consciousness and finally drowned. This was complicated by bursting her lungs during a rapid emergency ascent. The death was a tragic, but preventable accident.

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## Conflict of interest

In June, 2011, Dr Edmonds was asked by the authors of *The Honeymoon Dive* to analyse the evidence for their explanations

of this diving death. He was supplied with all the police documentation (including original witness statements, subsequent video interviews, police investigations and reports), forensic reports and the Australian inquest proceedings. The ABC documentary *Unfathomable, parts 1 and 2*, were also made available.

Following his assessment, the attorneys for the defence of Gabe Watson requested the court that Dr Edmonds be summoned to the court proceedings in Birmingham, Alabama, in 2012 as an expert witness. The court approved and financed this transport, but the case was thrown out of court before he or any other defence witnesses were called, based on the absence of plausible evidence supplied by the prosecution. At no stage did Dr Edmonds communicate with the accused or the accusers in this case.

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# The world as it is

## Swedish recommendations on recreational diving and diabetes mellitus

Johan Jendle, Peter Adolfsson and Hans Örnhagen

### Abstract

(Swedish recommendations on recreational diving and diabetes mellitus. Jendle J, Adolfsson P, Örnhagen H. *Diving and Hyperbaric Medicine*. 2012;42(4):231-233.)

Divers from many countries travel to explore various diving sites worldwide. In 2005, the Divers Alert Network (DAN) wrote guidelines for recreational diving and diabetes mellitus, but there is no up-to-date consensus or adoption of international guidelines on diabetes and diving. There are also large differences between the regulations in different countries. This is potentially both a medical and an insurance problem for a diver with diabetes. We present the current Swedish recommendations for recreational divers with Type 1 diabetes mellitus.

### Key words

Diabetes, recreational diving, fitness to dive, safety, safety memorandum, disability

### Introduction

In Sweden, recreational scuba diving has been permitted since 1998 for individuals with type 1 diabetes mellitus (DM1) under certain conditions. According to the Swedish Hyperbaric Medical Society's policy on diabetes mellitus from 1998, recently revised in 2011, it is possible for well-controlled and well-informed individuals with DM1, or people with type 2 diabetes (DM2), on either insulin or combinations of oral hypoglycaemic agents (OHAs) to be accepted for recreational diving.<sup>1</sup>

An important part of the acceptance of these recommendations is a consensus between the responsible specialist in diabetology, the diving physician and the diver. The following aspects need to be met:

- Acceptable glycaemic control HbA1c 52–73 mmol mol<sup>-1</sup> (5–8.8% National Glycohemoglobin Standardization Program), without any long-term diabetic complications. Mild diabetic retinopathy is accepted.
- No episode of severe hypoglycaemia should occur during the last year and no report of hypoglycaemic unawareness.
- The diver should have good knowledge of how to manage their diabetes, and how to adjust insulin doses and the amount of carbohydrates prior to physical activity.
- Regular self-monitoring of blood glucose (SMBG) should be done at least 4–6 times daily during the days of diving and the week prior to diving.
- Continuous glucose monitoring (CGM) should be performed on an annual basis.

The risk for an individual with diabetes during diving is

linked to the risk of hypoglycaemia while in water. The symptoms of hypoglycaemia could mimic those seen from other conditions during a dive, e.g., fatigue, shivering and reduced cognitive function due to hypothermia. Moreover, in case of decompression illness, the picture becomes even more difficult.<sup>2</sup> It is easy to misjudge the symptoms and this could lead to unnecessary air transportation and recompression treatment when the correct treatment would instead be to add carbohydrates or administer glucagon. An untreated hypoglycaemic episode during the dive might increase the risk for the person with diabetes as well as the diving buddy. Severe hypoglycaemia during diving could lead to drowning. Taking into account the facts above, it is important to minimize the risk of hypoglycaemia when allowing people with diabetes to dive. The most important advice is to prevent hypoglycaemia. It is also important to know how to treat low glucose levels during a dive since a rapid ascent is not always possible.

### Preventing hypoglycaemia

Hypoglycaemia is defined as a plasma glucose level below 4 mmol L<sup>-1</sup>.<sup>3</sup> The prevalence of hypoglycaemia during diving can be reduced by systematic measurement of glucose levels using home glucometers.<sup>4</sup> Prior to diving the glucose levels should be checked more frequently. Strive for a stable glucose level to minimize hypoglycaemic events and to reduce the number of hyperglycaemic events the week before diving. Pronounced and repeated hypoglycaemic events have been shown to have an impact on the hormonal counter regulation, reducing the elevation of glucagon, cortisol, growth hormone, adrenaline and noradrenaline.<sup>5</sup> Thus the hormonal response to a hypoglycaemic event during diving or to the physical activity itself might be impaired. Structured frequent glucose monitoring shows the level of

glucose and gives a rough overview of the trend. A declining trend of glucose the hour prior to the dive indicates a higher risk of hypoglycaemia during the dive and the dive should then be postponed. In order to modify the glucose trend at a slightly earlier stage, giving a more stable or increasing glucose value, the diver could add carbohydrates. The last measurement, 10 min before the dive, shall always be at the same level or higher than the previous (30 min before Dive 1).

The recommended structured glucose monitoring series in association with diving includes measurement of plasma glucose 60, 30 and 10 min prior to diving. This visualises the glucose trend. Aim for a stable glucose level between 7–12 mmol L<sup>-1</sup> 10 min prior to the dive and avoid a falling trend. Assess plasma glucose immediately post dive. This visualises the glucose trend during diving.

The timing of meals is very important. A meal should take place 1.5 to 2 hours prior to all dives. With this approach the insulin levels will be decreasing when the dive starts and this will lower the risk of hypoglycaemia during the dive. The insulin dose prior to a meal sometimes needs to be reduced aiming at a stable glucose level of 7–12 mmol L<sup>-1</sup> prior to diving. The intake of additional carbohydrates, 15–20 g per 70 kg body weight, just before diving further increases the safety.

Field studies, have shown that glucose levels in divers with DM1 decrease by about 1.7 mmol L<sup>-1</sup> during a 60-min dive to 18 metres' depth.<sup>6–8</sup> All dives should be logged in a personal logbook with data on carbohydrate intake, insulin dose, and glucose levels prior to and after the dive, together with information about the type of dive (depth, duration, level of physical work, etc). This log can be used later to refine future planning in relation to diving.

**Figure 1**

The L-signal, where the index finger and thumb forms the letter L is used to call the attention of the diabetic diver's buddy when the diver experiences symptoms of possible hypoglycaemia



### Hypoglycaemia – how to inform your buddy

It is very important to practise signalling of hypoglycaemia. The 'L-signal', with the index finger and thumb forming the letter L is used to alert the diving buddy (Figure 1). If the signal is given, the diver, with their instructor and/or diving buddy, should start ascending to the surface. Depending on the depth and length of the dive, the decision will be to go to either a safety stop or the surface. The individual with diabetes should ingest carbohydrates (as carbohydrate gel or glucose/fructose solution) before even starting the ascent. These formulations should always be kept in pockets of the BCD during all dives. We recommend that both the diver with diabetes and their diving buddy carry carbohydrate gel or glucose/fructose solution in their BCD. Divers with diabetes should practise ingesting gels underwater in controlled conditions. Following an underwater hypoglycaemic event treated with ingestion of carbohydrates, the dive should always be aborted following normal decompression routines.

### Insulin pumps – how to manage during diving

Individuals on subcutaneous insulin infusion pumps should remove the pump shortly before the start of the dive. There is a risk of malfunction or permanent damage of the pump if used during diving. Most insulin pumps on the market are water-resistant but are not approved for use at increased pressure. A reduction of the basal insulin dose (temporary basal reduction) is recommended 1–2 hours prior to diving. This lower amount of insulin before and during the dive reduces the risk of hypoglycaemia. The insulin pump should be reconnected as soon as possible post dive.

### Conclusions

We are aware that diving, even in the absence of diabetes, is a potentially dangerous activity with three to four fatalities in Sweden occurring every year. However, we feel convinced that if the recommendations given are followed, the diabetes as such will not contribute to fatalities during diving.

### Diving safety<sup>9,10</sup>

- Recommended maximum diving depth, is 20–25 metres allowing direct ascent.
- Diver with diabetes should dive with a buddy without diabetes.
- Diver with diabetes shall inform their divemaster/dive instructor/buddy about the limitations and special conditions that apply to diving with diabetes.

### Hypoglycaemia (glucose level < 4 mmol L<sup>-1</sup>)<sup>3</sup>

- If hypoglycaemia is suspected, the diver should be instructed to take glucose gel and be brought on board or ashore.
- Glucose level should be measured immediately diving is completed.
- If hypoglycaemia is confirmed, ingest carbohydrates

(20 g) to a fully awake individual.

- If unconscious, give an injection of 1 mg of glucagon (intramuscular).
- Call for emergency help.

#### Contra-indications to diving in DM divers<sup>9,10</sup>

- serious hypoglycaemic event during the last year;
- hypoglycaemic unawareness;
- repeated episodes of inpatient care;
- physical or psychological conditions that might interfere with diving;
- known diabetic complication except mild diabetic retinopathy.

#### For further background information, the following websites are recommended:

<[www.diversalertnetwork.org](http://www.diversalertnetwork.org)>  
<[www.ukdiving.co.uk](http://www.ukdiving.co.uk)>  
<[www.spums.org.au](http://www.spums.org.au)>

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This article was originally published as Jendle J, Adolfsson P, Attvall S, Örnhagen H. Dykning vid diabetes möjligt men inte riskfritt. *Läkartidningen*. 2011;44;2230-1. It is reproduced in English translation with kind permission.

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## British Sub-Aqua Club (BSAC) diving incidents report 2011

Compiled by Brian Cummings, Diving Incidents Advisor

<[http://www.bsac.com/core/core\\_picker/download.asp?id=22364&filetitle=Diving+Incident+Report+2011](http://www.bsac.com/core/core_picker/download.asp?id=22364&filetitle=Diving+Incident+Report+2011)>

### Summary of the 2011 report prepared by Colin Wilson

The BSAC have collected and collated accounts of diving incidents from their members for over 30 years, with published reports being available on their website from 1980.<sup>1,2</sup> Over the years, the quality of these has matured as they have striven for accuracy and completeness. This has allowed the club to identify common failings and learn lessons. They have directed their training towards these identified areas to improve safety. Changes in diving practice over the years have in some instances created new and different issues and problems.

This report covers incidents in the United Kingdom (UK) with a small section on overseas reports from their members only. Summaries of BSAC reports (2005 to 2010) have been presented previously in this journal with the sources of data and their methods of collection discussed.<sup>3-5</sup> In this report, there were 375 UK incidents which is in line with the average for the last few years.

There were 103 reports of decompression illness (DCI). Although one of the biggest categories, this continues a downward trend over the last eight years. However, reports in the additional category of 'diver injury/illness' were up by 29 from 2010 to 84 and no doubt included a number of cases of DCI but, because of their source, these have not been specified. Training has recently been directed towards buoyancy control, the effectiveness of which is seen with the lowest number of reports for some time of only 48.

The monthly variation mirrors the increased activity in the northern hemisphere summer. In relation to depth, there are fewer incidents, six, occurring deeper than 50 metres' sea water (msw), though there were two deaths in this range. The Coastguard were involved in 205 (55%) of incidents, fewer than in previous years, but the Royal National Lifeboat Institute (RNLI) services were called upon on more occasions (118 incidents), assisting disabled boats, searching for missing divers and recovering divers with unspecified illnesses and DCI. Incidents involving the use of helicopters for searching for missing divers and transporting those with DCI were fewer this year at 96.

### Fatalities

With only 11 deaths reported in 2011, it does appear that the rate is continuing to fall and is below the 15.8 average for the last decade. There are usually multiple contributing factors involved in these incidents. Unlike the more accurate

analysis of Australian diving fatalities, there currently is insufficient information available in this report to be clear as to the exact chains of events and specific root causes.<sup>6</sup>

The analysis of the facts shows:

- One diver suffered a serious medical condition leading to death.
- In four cases, a "medical event" underwater seems likely.
- Six cases involved separation of some kind:
  - three separated during the dive either deliberately or accidental;
  - two separated during the ascent;
  - in one case, it remains unclear.
- Six cases involved diving in a group of three or more divers. In a buddy pair it is obvious when separation occurs, but this is less so with multiple divers.
- Two cases were diving deeper than 50 msw, one at 55 msw and the other at 61 msw.
- Two incidents involved divers running out of gas:
  - one on ascent;
  - one a cave diver, diving in a threesome.
- Two cases involved rapid ascents:
  - one with a drysuit problem;
  - one as a result of other problems.
- One case was that of a cave diver.

Technical diving is over-represented within these cases, with one diver diving with a rebreather on a shallow try dive and three cases where trimix was used. The average age of these fatalities is 54 years, continuing the disproportionate trend where age is a factor. Eight divers (out of 11 fatalities) were over 50 years old, whereas only 16% of BSAC divers are in this age group and the average age of BSAC divers is 38 years. Of these eight divers, four were thought to have had a medically related problem that led to their death.

### From the fatalities section:

#### Case 1

*"An experienced diver was taking part in a rebreather try dive at an inland site; he had had no previous experience with this equipment. Competence skills were conducted at 6 m [depth] and the group moved down to 18 m. The diver was seen coughing into the loop and he then began to ascend. His buddy went with him and attempted to control the ascent. At the surface, the diver complained that it was hard to breathe; he was told to switch to open circuit and they swam back to the shore. He was helped from the water but then lost consciousness. CPR was started. The diver was*

airlifted to hospital by an air ambulance helicopter but was declared deceased on arrival at hospital.”

### Case 2

“Three divers entered the water just before slack [water] for a dive on a wreck in 62 m of water. The three divers were all using trimix (30% helium) as a bottom gas and had planned 18 min bottom time and total dive time of 60 min. During the descent, one diver had problems with sinus pain but it cleared and he continued. On approaching the bottom of the shotline, the diver who had experienced the sinus pain overtook the diver who was then in the lead and dropped off the shotline onto the wreck. The third diver in the group also passed the diver in the lead and was waving his unlit torch. The lead diver passed him his spare torch and the third diver continued his descent to the wreck dropping off the shotline in the opposite direction to the other diver. The diver who had been in the lead then joined the diver with the sinus problem and both made their way along the wreck towards the third diver. As they moved along they could see a light but it was not moving and they found the torch previously passed to the third diver switched on but lodged in the top of the wreck. One of the other divers picked up the torch and clipped it onto his harness and, looking around, saw the third diver 4 m away and 2 m above him in an upright position and not making any rapid movements or appearing to panic. This was the last that the divers saw of the third diver. The surface cover RHIB [rigid hulled inflatable boat] was approaching the shot buoy in preparation to deploy another pair of divers when they saw a delayed SMB arrive on the surface about 10 min after the three had started their dive. Shortly after this, the third diver was seen to surface rapidly feet first with a fully inflated suit and fall back onto his back.

The divers who were about to dive were immediately advised of an emergency and stood down whilst the boat was motored towards the surfaced diver. As they approached, the diver was lying still, had a blue grey colour and was unresponsive. A Mayday call was made whilst the diver was de-kitted, recovered from the water and laid down inside the RHIB. The oxygen kit was prepared and it was found that the diver was not breathing so CPR was commenced. The Coastguard tasked a helicopter to respond and a Royal Navy warship responded and approached closely before launching an RHIB and lowering a stretcher. The diver was winched onto the warship and subsequently airlifted from the deck of the warship by helicopter to hospital. The diver did not recover. The diver had been using independent twin cylinders and these were found to still contain 130 bar and 160 of gas respectively.”

### Decompression illness (DCI)

In 2011, there were 103 incidents reported, involving 107 cases. This number is very similar to that of 2010 and is close to the lowest for the last 15 years. Where possible to identify, the major features leading to DCI were:

- 31 repetitive diving;
- 28 rapid ascents;
- 27 were diving deeper than 30 msw;
- 17 missed decompression stops.

Some cases involved more than one risk factor. This list is much the same as in previous years except for more cases diving deeper than 30 msw. It is again felt that a number of the ‘diver injury/illness’ reports probably relate to DCI, though the rate of reporting mirrors that of previous years.

### From the DCI section:

#### Case 3

“Clyde Coastguard was alerted to a diver suffering from suspected DCI following a dive to 27 msw, the diver had been shell fishing and had a collection bag attached to his person, the clip broke causing the diver to make an uncontrolled ascent to the surface. The symptoms of DCI manifested whilst the diver was making his way home. On reaching home, the diver was arrested by the police for an unrelated matter. Whilst in police custody, the diver was seen by a police doctor; he contacted Aberdeen Hospital who requested the diver be transported to Millport chamber for treatment.” [Coastguard report]

#### Case 4

“Two divers conducted a dive to a maximum depth of 31 msw for a duration of 26 min. After reaching their planned maximum depth the divers began working their way back up the reef. At a depth of around 22 msw one of the divers indicated that she had 50 bar remaining in her cylinder. The dive leader signalled that they should ascend, and deployed his delayed SMB. During the ascent, the pair experienced a current pushing them up the reef and, despite dumping air from their suits, they ascended to the surface faster than they should have done. The cover boat was in close proximity and the dive leader signalled that they should re-descend with a view to conducting a safety stop. The divers descended to a depth of 12 msw but the dive leader had not reeled in the loose line from his delayed SMB and this tangled in the propeller of the RHIB. The coxswain lifted the engine to untangle it and in doing so the divers were again pulled to the surface. The divers were recovered to the boat and the dive leader’s dive computer was signalling SOS, whilst his buddy’s computer did not show any warning. Both divers were placed on oxygen, the boat returned to the shore where a local chamber was contacted for advice and both divers were subsequently transported to the chamber for assessment. The dive leader showed no signs of DCI. His buddy showed signs of DCI and was treated with a 4 hour 40 min recompression treatment with a further 2 hour treatment the next day.”

It is heartening to see that the number of fatalities and the incidents of DCI appear to be continuing to fall, though avoidable errors still occur. The training efforts in buoyancy

control have seen a dramatic fall in these reports over recent years. The lessons from previous reports are being learned. The efforts of Brian Cumming and the BSAC team in producing these reports are again commended and they should be digested by all divers, diver educators and diving physicians.

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## Key words

Recreational diving, accidents, diving deaths, decompression illness, abstracts

## Errata

### Gulve et al – Erratum

In the paper Gulve MN, Gulve ND, Shinde R, Kolhe SJ. The effect of environmental pressure changes on the retentive strength of cements for orthodontic bands. *Diving and Hyperbaric Medicine.* 2012;42(2):78-81, an error in the quoted pressures appears on pages 78, 79 and 81. The equivalent pressure in kilopascals for 30 metres' sea water is quoted as 304 kPa, which is the gauge pressure used not the absolute pressure at which the experiments were conducted. This should read 405 kPa (absolute pressure).

### Ivkovic et al – Erratum

In the paper Ivkovic D, Markovic M, Todorovic BS, Balestra C, Marroni A, Zarkovic M. Effect of a single pool dive on pulmonary function in asthmatic and non-asthmatic divers. *Diving and Hyperbaric Medicine.* 2012;42(2):72-77, on p. 74 there are references in the third paragraph of the results section to Figure 2 and Figure 3. These should have been deleted from the text as the figures were not used in the final version of the paper, the data being presented in Table 3.

### The Editor's offering

In the editorial for the September issue, *Diving Hyper Med.* 2012;42:125, the paper by Rossignol et al (Rossignol DA, Rossignol LW, Smith S, Schneider C, Logerquist S, Usman A, et al. Hyperbaric treatment for children with autism: a multicenter, randomized, double-blind, controlled trial. *BMC Pediatrics.* 2009;9:21. doi:10.1186/1471-2431-9-21) was incorrectly described as a Canadian study when, in fact, it was a multicentre study based in the USA.

The database of randomised controlled trials in hyperbaric medicine maintained by Michael Bennett and his colleagues at the Prince of Wales Hospital Diving and Hyperbaric Medicine Unit, Sydney is now at:

<<http://hboevidence.unsw.wikispaces.net/>>

Assistance from interested physicians in preparing critical appraisals is welcomed.  
Contact Assoc. Prof. Michael Bennett: <[M.Bennett@unsw.edu.au](mailto:M.Bennett@unsw.edu.au)>

# Cochrane corner

## Hyperbaric oxygen therapy for treating chronic wounds

Kranke P, Bennett MH, Martyn-St James M, Schnabel A, Debus SE

Chronic wounds, often associated with diabetes, arterial or venous disease, are common and have a high impact on the wellbeing of those affected. Hyperbaric oxygen therapy (HBOT) is a treatment designed to increase the supply of oxygen to wounds that are not responding to other measures to treat them. HBOT involves people breathing pure oxygen in a specially designed chamber (such as that used for deep sea divers suffering pressure problems after resurfacing).

This review update of randomised trials found that HBOT seems to improve the chance of healing diabetes-related foot ulcers and may reduce the number of major amputations in people with diabetes who have chronic foot ulcers. In addition this therapy may reduce the size of wounds caused by disease to the veins of the leg, but the review found no evidence to confirm or refute any effect on other wounds caused by lack of blood supply through the arteries or pressure ulcers.

### Background

Chronic wounds are common and present a health problem with significant effect on quality of life. Various pathologies may cause tissue breakdown, including poor blood supply resulting in inadequate oxygenation of the wound bed. Hyperbaric oxygen therapy (HBOT) has been suggested to improve oxygen supply to wounds and therefore improve their healing.

### Objectives

To assess the benefits and harms of adjunctive HBOT for treating chronic ulcers of the lower limb.

### Search strategy

For this first update we searched the Cochrane Wounds Group Specialised Register (searched 12 January 2012); the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library 2011, Issue 4); Ovid MEDLINE (1950 to January Week 1 2012); Ovid MEDLINE (In-Process & Other Non-Indexed Citations, 11 July 2012); Ovid EMBASE (1980 to 2012 Week 01); and EBSCO CINAHL (1982 to 6 January 2012).

### Selection criteria

Randomised controlled trials (RCTs) comparing the effect on chronic wound healing of therapeutic regimens which include HBOT with those that exclude HBOT (with or without sham therapy).

### Data collection and analysis

Three review authors independently evaluated the risk of bias of the relevant trials using the Cochrane methodology and extracted the data from the included trials. We resolved any disagreement by discussion.

### Main results

We included nine trials (471 participants). Eight trials (455 participants) enrolled people with a diabetic foot ulcer: pooled data of three trials with 140 participants showed an increase in the rate of ulcer healing (risk ratio (RR) 5.20, 95% confidence interval (CI) 1.25 to 21.66;  $P = 0.02$ ) with HBOT at six weeks but this benefit was not evident at longer-term follow-up at one year. There was no statistically significant difference in major amputation rate (pooled data of five trials with 312 participants, RR 0.36, 95% CI 0.11 to 1.18). One trial (16 participants) considered venous ulcers and reported data at six weeks (wound size reduction) and 18 weeks (wound size reduction and number of ulcers healed) and suggested a significant benefit of HBOT in terms of reduction in ulcer area only at six weeks (mean difference 33.00%, 95% CI 18.97 to 47.03,  $P < 0.00001$ ). We did not identify any trials that considered arterial and pressure ulcers.

### Authors' conclusions

In people with foot ulcers due to diabetes, HBOT significantly improved the ulcers healed in the short term but not the long term and the trials had various flaws in design and/or reporting that means we are not confident in the results. More trials are needed to properly evaluate HBOT in people with chronic wounds; these trials must be adequately powered and designed to minimise all kinds of bias.

**This review is published as a Cochrane Review in the Cochrane Database of Systematic Reviews: Kranke P, Bennett MH, Martyn-St James M, Schnabel A, Debus SE. Hyperbaric oxygen therapy for chronic wounds. Cochrane Database of Systematic Reviews. 2012, Issue 4. Art. No.: CD004123. DOI: 10.1002/14651858.CD004123.pub3. Cochrane Reviews are regularly updated as new evidence emerges and in response to comments and criticisms, and the Cochrane Database of Systematic Reviews should be consulted for the most recent version of the Review.**

*Assessed as up to date: 12 January 2012*

### Key words

Hyperbaric oxygen, hyperbaric oxygen therapy, wounds, diabetes, outcome, Cochrane library, abstracts

# Critical appraisal

## Postoperative hyperbaric oxygen reduced neurological deficit, brain oedema and abnormal brain density on C/T imaging following resection of meningiomas with associated brain oedema

### Clinical bottom line:

- Hyperbaric oxygen therapy (HBOT) reduced the incidence of neurological deficit at six months after resection.
- HBOT reduced the measured volume of oedematous brain at 15 days postoperatively and of the volume of encephalomalacia at six months.

**Citation:** Tang X, Yin X, Zhang T, Peng H. The effect of hyperbaric oxygen therapy on clinical outcomes of patients after resection of meningiomas with conspicuous peritumoral brain edema. *Undersea Hyperb Med.* 2011;38:109-15.

**Lead author's name and e-mail:** Xiaoping Tang <Tangex1971@gmail.com>

**Three-part question:** For patients with meningiomas associated with significant brain oedema, does postoperative HBOT result in improved clinical outcome?

**Search terms:** Meningioma, brain oedema, Karnofsky score

**The study:** Non-blinded, concealed, randomised controlled trial; intention to treat unclear.

**The study patients:** Adult patients with resectable supratentorial meningiomas where significant brain oedema is shown preoperatively on CT or MRI.

**Control group:** ( $n = 116$ , 116 analysed) Standard operative and postoperative care with resection, dehydration, anti-epileptic drugs, antibiotics and symptom relief.

**Hyperbaric group:** ( $n = 116$ , 116 analysed) As above, plus postoperative HBOT at 203 kPa for 20 minutes daily to a

total of 20 sessions.

**The evidence:** See Tables 1 and 2.

### Comments:

- Unusual method of randomisation, but probably effective and with allocation concealment.
- There was no description of power or sample-size calculations.
- No information given on the numbers of patients who did not complete the HBOT course, who suffered complications or on the numbers who were assessed in first 15 days.
- Karnofsky score at 15 days was reported as significantly different between groups in the paper, but not so with our calculations for this appraisal. This score is assigned in units of 10 from 0 (dead) to 100 (perfect health). It is not clear that comparing the means is an appropriate statistical approach.
- These interesting findings would need to be replicated before HBOT could be established as routine. More information is required on any complications of therapy. Ideally, future trials should be blinded to treatment approach and could consider pre-operative treatment included in a third arm.

**Appraised by:** Michael Bennett

**E-mail:** <m.bennett@unsw.edu.au>

### Key words

Hyperbaric oxygen therapy, hyperbaric oxygen, central nervous system, brain injury, cancer, critical appraisal

**Table 1**

Proportion of patients with identifiable neurological deficit at 6 months post-op; NNT – number needed to treat

	Control <i>n</i> (%)	HBOT <i>n</i> (%)	Absolute risk reduction (%)	NNT
Patients with neurological deficit or epilepsy	28 (24)	15 (13)	11	9
95% confidence interval			1 to 21	5 to 76

**Table 2**

Changes in mean (SD) outcomes for functional performance scores and imaging-determined volumes; 95% CI – 95% confidence interval; \*Karnofsky Performance Score ranges from 0 (dead) to 100 (perfect health); \*\*between groups difference  $P < 0.05$

Outcome	Control	HBOT	95% CI
Karnofsky Performance Score* at 15 days post-op	88.4 (15.0)	95.4 (15.6)	-53.8 to 67.8
Volume of oedematous brain at 15 days post-op (cm <sup>3</sup> )**	47.1 (6.4)	34.6 (5.2)	3.7 to 21.3
Volume of brain with encephalomalacia at 6 months post-op (cm <sup>3</sup> )**	13.9 (3.7)	9.0 (2.3)	2.4 to 7.4



# Continuing professional development

## CME activity 2012/4

### A potpourri of short-answer questions

Anonymous, edited Suzy Szekely

#### Accreditation statement

#### Intended audience

The intended audience consists of all physicians subscribing to *Diving and Hyperbaric Medicine* (DHM), including anaesthetists and other specialists, who are members of the Australia and New Zealand College of Anaesthetists (ANZCA) Diving and Hyperbaric Medicine Special Interest Group (DHM SIG). However, all subscribers to DHM may apply to their respective CPD programme coordinator or specialty college for approval of participation. This activity, published in association with DHM, is accredited by the ANZCA Continuing Professional Development Programme for members of the ANZCA DHM SIG under Learning Projects: Category 2 / Level 2: 2 credits per hour.

#### Objectives

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

#### Faculty disclosure

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

#### Do I have to pay?

All activities are free to subscribers.

#### Background reading

Practitioners are referred to the following background references and reading.

- 1 Wong R, Walker M. Diagnostic dilemmas in inner ear decompression sickness. *SPUMS J.* 2004;34:5-10.
- 2 Leverment J, Wolfers D, Kertesz T. Isolated inner ear decompression illness following a nitrogen/oxygen dive: the difficulty in differentiating inner ear decompression illness and inner ear barotrauma. *SPUMS J.* 2003;33:2-5.
- 3 Millar IL, Moulden PG. Compressed breathing air – the potential for evil from within. *Diving Hyperb Med.* 2008;38:145-51.
- 4 Mathieu D. Contraindications to hyperbaric oxygen therapy. In: Neuman TS, Thom SR, editors. *Physiology and medicine of hyperbaric oxygen therapy.* Philadelphia: Saunders; 2008, editors. p. 587-96.
- 5 Torp KD, Carraway MS, Ott MC, Stolp BW, Moon RE, Piantadosi CA, Freiberger JJ. Safe administration of

hyperbaric oxygen after bleomycin: a case series of 15 patients. *Undersea Hyperb Med.* 2012;39:873-9.

- 6 Jacoby I. Clostridial myositis, necrotizing fasciitis and zygomycotic infections. In: Neuman TS, Thom SR, editors. *Physiology and medicine of hyperbaric oxygen therapy.* Philadelphia: Saunders; 2008. p. 397-408.

#### How to answer the questions

Please answer all questions in short answer format, i.e., brief paragraphs or lists.

Answers should be posted by e-mail to the nominated CPD coordinator.

For ANZCA DHM SIG members, this will be Suzy Szekely.

**E-mail:** <Suzy.Szekely@health.sa.gov.au>

For EUBS members for this CPD issue this will be Peter Müller.

**E-mail:** <peter.mueller@eubs.org>

On submission of your answers, you will receive a brief model answer for each question. A correct response rate of 80% or more is required to successfully complete this activity. Each task will expire within 24 months of its publication to ensure that additional, more recent data have not superceded the activity.

#### Key words

Inner ear barotrauma, inner ear decompression sickness, exogenous poison, clinical toxicology, pharmacology, necrotising infections

*Question 1. Compare and contrast the diagnosis of inner ear barotrauma and inner ear decompression sickness.*

*Question 2. a) What medical problems could occur in a scuba diver breathing from a cylinder of contaminated gas? b) How would you investigate a comment from the chamber attendant that the air smelt "foul"?*

*Question 3. Briefly discuss four drugs that may interact with hyperbaric oxygen and result in an adverse outcome.*

*Question 4. a) Compare and contrast clostridial myonecrosis and necrotising fasciitis.*

*b) By what mechanisms may hyperbaric oxygen therapy be of benefit in managing anaerobic infections?*



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## Minutes of the meeting of the Executive Committee of EUBS, (ExCom) Belgrade, 13 September 2012

**Opened:** 1230 h

### **Present:**

P Germonpré (PG), C Balestra (CB), J Schmutz (JS), A Möllerlökken (AM), F Sharp (FS), JM Pontier (JP), P Wooding (PW), P Bryson (PB), P Müller (PM)

Invited: M Sedlar, Serbia, JJ Brandt Corstius (JJ), SHF, M Kemmerer, Germany

### **1. Minutes of previous meeting 2011:**

Accepted by e-mail and published on the website and in *Diving and Hyperbaric Medicine* (DHM) 2011;41:242-4. No further comment today.

### **2. Secretary General's report 2012:**

An overview is given by M Sedlar, Secretary General of the EUBS 2012 Meeting.

(preliminary) There were 255 registrants (245 + 10 exhibiting companies) from all five continents, representing 36 countries; 144 (+10) were members of EUBS / 11 UHMS/ 5 SPUMS; 31 were students or nurses; approx. 20 on-site; 54 non-members; 10 exhibiting companies.

There were 57 oral presentations, 34 posters, 3 invited lectures, and 1 workshop.

There are extra copies of the Book of Abstracts and Posters. Most of them will be sent to the EUBS Library (managed by Arvid Hope from NUTEC). An electronic copy should be sent to ExCom and also to the DHM European Editor.

ExCom congratulates the organizers for a well run and very hospitable meeting.

EUBS workshop: 101 participants, lively, interesting discussion.

Key points: difficulties in conducting research; visiting speakers interested and positive, need to carry on the work; plan studies carefully, get outsiders in.

A report of the Workshop will be created for publication in DHM – Ruth Stephenson ‘volunteered’ to do this work.

Next year, a (similar?) workshop/discussion/liaison session will be organized, coordinated by PB.

### **3. Update on EUBS 2013 (RÉUNION 2013):**

Presented by JJ Brandt Corstius (Scott Haldane Foundation) representing the main organizing committee.

The declaration of intention (joint document to guide the collaboration between the three societies and the host society ARESUB) has been approved via e-mail, and also been approved by the SPUMS and SAUHMA committees.

There will be satellite events from ECHM, DAN (Europe/

USA?). The satellite conferences will be timed separately from the Tri-Continental Meeting.

Information on the RÉUNION 2013 meeting will be given at the Conference during a 10 minutes presentation by JJ. Information will all be assembled on the dedicated website: <www.reunion2013.org>. The domain “eubs2013.org” will be linked through to that site.

Invited speakers should be chosen. All ExCom (EUBS, SPUMS, SAUHMA) should now produce names and a short justification as to why (s)he should be an invited speaker for Réunion.

### **4. Future meetings:**

2014: Meeting will take place in Wiesbaden, Germany, on 24–27 September. This will be combined with the triennial meeting of GTUEM. A presentation is given by PM and Michael Kemmerer (Wiesbaden, VDD President). Secretary General will be Peter Müller (Vice President GTUEM). Approved by ExCom.

2015: An official proposal was approved (2011 ExCom) from Amsterdam (AMC – Albert Van den Brink & Rob Van Hulst). Final dates are: 19–22 August 2015. This EUBS Meeting will be concurrent with “SAIL2015”, an international ‘rally’ of big sailing ships, which might attract more participants to our meeting.

2016: An official letter has been received from Croatia (Nadan Petri). Approved by ExCom. Secretary General to be officially appointed two years before the Meeting.

### **5. Travel grant:**

Travel Grant Committee: JM Pontier (EUBS ExCom), M Sedlar, A Marroni and T Jovanovic (local scientific committee). There has been only one application for travel grant (reminder: maximum amount 3 times 800 Euros): **V Papadopolou**, R Eckersley, M Tang. *Decompression modelling: a projection procedure for dissolved phase tracking simulations* (PP-38).

The grant is conditional on the submission of a paper of the presentation for consideration of publication in DHM. Although publication cannot be guaranteed (indeed thus far, all such submissions have been rejected for publication), the editors of DHM will assist in every way they can. Acceptance for publication in DHM is not a prerequisite for the award of a travel grant. Last year’s grantee has fulfilled this obligation and has been paid their grant.

### **6. Zetterström and Musimu Awards Committee:**

Committee Members: J Schmutz, P Müller (EUBS ExCom), C Balestra (for the local scientific committee). Posters are evaluated on a scale assessing relevance to the field of diving or hyperbaric medicine, methodology and visual presentation.

The selected posters were:

Zetterström Award: **T Jovanovic**, P Brkic, D Ninkovic. *The effectiveness of hyperbaric oxygenation in diabetes mellitus type II heterogenic patients* (PP-18)

Musimu Award (offered by the Belgian Society for Diving and Hyperbaric Medicine): **S Theunissen**, N Sponsiello, F Tillmans, et al. *Oxidative stress in breath-hold divers after successive dives* (PP-35)

The registration to the next EUBS will be paid by EUBS if the final paper is submitted to DHM for consideration within 12 months.

## 7. Ballots:

145 votes out of 233 members (62%) were received (up from 46% last year and 35% the year before). This shows that the internet-based voting system is generally well accepted as easy and quick. We expect that the number of voters will increase gradually. The same problem – low response rates – has occurred also with postal ballot; PW should check the e-mails of members, and there is a constant need to remind members to update their data for correct e-mail addresses.

Vice-President: two candidates; J Kot, JE Blatteau. J Kot is elected.

Member-at-Large: five candidates; SL Blogg, P Lafère, I Eftedal, A vanden Brink, R Stephenson. SL Blogg is elected.

Next year's election will need candidates for Member-at-Large. ExCom members are tasked to identify suitable candidates.

Member-at-Large A. Möllerlökken is leaving the ExCom; expression of thanks for excellent service and pleasant collaboration.

Past-President N Bitterman is leaving ExCom after 12 years of faithful duty; she will be missed.

### **New composition of 2012–2013 EUBS ExCom:**

President: C Balestra

Vice President: J Kot

Immediate Past President: P Germonpre

Past President: AO Brubakk

Member-at-Large 2010: JM Pontier

Member-at-Large 2011: F Sharp

Member-at-Large 2012: SL Blogg

Membership Secretary – Treasurer: P Wooding

Honorary Secretary: J Schmutz

EUBS Liaison Officer: P Bryson

DHM, European Editor: P Müller

Webmaster: P Germonpré

## 8. Diving and Hyperbaric Medicine Journal (PM):

The Annual Report of the Editor, Mike Davis, is discussed.

The Impact Factor of our Journal has gone up to 0.68. This is probably the result of a better visibility on the web, as all volumes are now searchable in PubMed Central back to 2008. As the definition of the Impact Factor is “*the number of published papers divided by the number of citations*”, this will probably rise as articles from DHM are easily ‘google-able’, and the number of citations will probably increase.

Observed drop in submissions? This needs more attention.

CB proposes to make a template for EndNote available on the DHM website – to be followed up. Invited speakers should write a DHM report.

A presentation will be given at AGM by PM (10 min).

The question was raised about the future of the Editorial Office once the current Editor retires – although this is not an issue now, as there is no indication that Mike Davis would want or need to quit this job. M Davis proposes to stay on for a new three-year contract (till 2015). Approved by ExCom.

E-versions of the Journal are published on the website, for members only. For next year, the paper version will be preserved. We will investigate the printing and mailing costs if it can be done at the same quality, but cheaper, in Europe. Approved by ExCom.

There have been inquiries from non-members of EUBS/SPUMS to receive DHM. The topic has been discussed by PG with the SPUMS President and no solution was found to make sure the societies' memberships do not suffer. One idea could be to ask the same amount of money for journal subscription only. Subscription to the Journal would then automatically give access to the members-only section to the website(s), depending on the geographical location of the subscriber (to be defined) as a sort of ‘e-supplement’ and a reduced registration fee to the ASM. The Journal could thus be promoted outwith the societies, and their memberships would increase. This would probably incite some non-members to get involved more. On the other hand, the number of ‘inactive’ members will also increase. This proposition will officially be put forward to the SPUMS Committee. Approved by ExCom.

Cost of the Journal: a budget estimate was sent by M Bennett in February 2012 and a more detailed journal budget balance on 18 July 2012. The production costs will stay roughly the same in 2012, bar fluctuations in the Euro conversion to AUD. A revised cost to be produced by end-2012 based on budget. The bank account of DHM is completely separate from SPUMS, and transfers in and out will be traceable. Any profit will be kept as a ‘reserve fund’ in the DHM account. Approved by ExCom.

A new DHM Treasurer has been proposed by SPUMS, Peter Smith, who is different from the SPUMS Treasurer (Shirley Bowen). The need for having a ‘neutral’ treasurer must be discussed, but this will involve much administration as DHM is not a separate organization, and cannot ‘own’ a bank account. Therefore, the DHM bank account is ‘owned’ by SPUMS, and this can be accepted, provided transactions are fully transparent. Approved by ExCom.

DHM is still listed as “*the Journal of SPUMS*” in Medline – this has been brought to the attention of the DHM Editor and will be taken up with the SPUMS President by the EUBS President. Approved by ExCom.

## 9. Website (PG):

There have been no major changes to the website, which is kept up to date by PG and PW (for the membership

database).

People are increasingly using electronic payment, PayPal is working well now. Some countries are not 'allowed' by the PayPal system (e.g., Egypt) so we will keep the possibility for members to pay cash at the Meeting. Approved by ExCom.

Proposal from PB to use website as tool to distribute 'lessons learnt' from successful or failed research. To be followed up.

#### 10. Membership:

Some new corporate members were 'enrolled'. Effort needed to increase. PG will circulate an e-mail summarizing the benefits of CM to ExCom Members. Membership is stable, even slightly increasing.

In order to increase further the quality of our EUBS membership services an increase of the membership Fee may be needed (last increase was in 2007–2008). It is proposed to have an annual evaluation and increase the fee slightly, rather than do a big increase every 5 years. Will be proposed to GA. Approved by ExCom.

Combined membership SPUMS/EUBS:

History: A member asked if he could receive a reduced fee and not receive the journal twice. This matter has been discussed before and there is still no definite answer to this. One proposal for a global solution could be that all EUBS members would get a login onto the members-only section of the SPUMS website and vice-versa? This has to be discussed further and will be put forward to the SPUMS Committee.

Evolution: further discussion with the SPUMS President – agreement that for a small nominal fee (20 Euro, 25 AUD) members will get access to the 'member's-only' section of the other society. We need to determine how the membership application process and website should be modified in order to make this possible. PG to check with SPUMS Committee whether this has been accepted by them. Approved by ExCom.

#### 11. Financial matters (PW):

The financial report (prepared by PW) is accepted.

Mrs Anna Stilman from DDRC has audited the books of EUBS and found them to be in order. They will be available for a short time on the website in the members-only section.

The sponsorship for EUBS 2012 by the US Office of Naval Research (to be used for invited speakers, travel grants and abstract book) has been paid. PG will again apply for a new ONRG grant for RÉUNION 2013. Approved by ExCom.

Decisions from last year on percentage on exhibition fees (10–20%) and registration fee have not yet been implemented. First year of application will be 2014.

Proposal to buy laptop for PW by next year: approved by ExCom.

Increase in monthly fee for PW (has not changed in 10 years): no immediate objection. To be decided during next year's ExCom depending on the finances.

#### 12. Any other business:

The 08–09 November Eilat Meeting (retirement of Y Grossman) will be announced at AGM and a link will be placed on our website. Approved by ExCom.

The possibility of creating a Facebook page or Closed Group is discussed. AM and FS will investigate and propose how EUBS can be given increased visibility through these new media. Approved by ExCom.

A proposition was received from the Italian Society for Diving and Hyperbaric Medicine (SIMSI), they consider combining their membership with EUBS membership. Approved by ExCom.

Arvid Hope, the 'keeper' of the official EUBS library, has now retired. The Society needs to find out what will happen to the Library. PG to contact AH. Solutions in case NUI is not able to do this anymore need to be explored. Rubicon Foundation is suggested, however, PM points out that the GTUeM database already has electronic copies of all previous EUBS proceedings and that these are available free of charge to all EUBS members.

PG proposes to create a monthly e-mail newsletter to all EUBS members. Will be proposed to AGM. Approved by ExCom.

PB proposes to expand the Liaison Committee by at least one person. He will identify a suitable person. Since this can be done by ExCom according to the Constitution, PB is asked to proceed. Approved by ExCom.

List of European research organizations to be produced by PB for inclusion on the research pages of the website.

**Closed:** 1505 h

*J Schmutz, Honorary Secretary*

#### Key words

Meetings, medical society

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The  
Diving and Hyperbaric Medicine  
journal website at  
<[www.dhmjournal.com](http://www.dhmjournal.com)>  
is currently under reconstruction

## Minutes of EUBS General Assembly, Belgrade, 14 September 2012

**Opened:** 1701 h

### 1. Welcome:

The President Peter Germonpré (PG) welcomes all the participants. He states that this will be the end of his three-year term as President of EUBS. The next President will be Costantino Balestra.

### 2. Minutes GA 2011 in Gdansk:

The minutes of the General Assembly 2011 are accepted.

### 3. Status of the 2012 Annual Scientific Meeting:

PG presents some figures for the current meeting, provided by M Sedlar of the local organizing committee: 255 persons attended the meeting, which includes the 9th ECHM consensus conference and the EUBS workshop on Research in Hyperbaric Medicine (101 participants). Looking into the details, 154 were members of EUBS, 11 of UHMS and 5 of SPUMS. There were also 31 students/nurses, 54 non-members, 10 exhibiting companies and separate sponsors ONRG, CHM and Oxyheal. There were 57 oral presentations, 34 posters, 3 invited lectures. The proportion of EUBS members attending has increased. The scientific content was excellent. The President congratulates Mariana and her staff who are warmly applauded. The Workshop on 'Research in Hyperbaric Medicine', which was held for the first time at an annual meeting, had to be organized outside of the normal time for programming reasons. It was organized by the Liaison Officer, P Bryson. It is planned to repeat it because the feedback from the participants was excellent. On request of PG, F Lind accepted to assist P Bryson. He proposed the topic of radiation cystitis. Many RCTs having been launched in Scandinavia, it would be a good idea to show what has been in these trials and to open them up as parallel studies in order to increase the numbers of treated patients. The presence of three societies would be a good opportunity. This will be finalised after further consultation.

The ExCom has asked Ruth Stevenson to write a report of this first workshop for submission to the Journal.

### 4. Awards and grants:

EUBS Travel Grant is intended to motivate young researchers to attend and publish their research by financing their travel and expense costs to our meeting. We had one application this year. The Travel Grant Committee consisted of: JM Pontier (EUBS ExCom), M Sedlar, A Marroni and T Jovanovic (local scientific committee). Awardee is V Papadopoulou for her paper on decompression modelling. The grant will be awarded once she has submitted her paper to DHM.

Zetterström award: The jury was J Schmutz, P Mueller (EUBS ExCom), C Balestra (for the local scientific committee). Posters are evaluated on a scale assessing

relevance to the field of diving or hyperbaric medicine, methodology and visual presentation. The award was given to T Jovanovic, P Brkic and D Ninkovic for their work entitled: *The effectiveness of hyperbaric oxygenation in diabetes mellitus Type II heterogenic patients*. The paper was rewarded because this was the first report, to our knowledge, to investigate if there is a correlation between the therapeutic response to HBOT in diabetic foot ulcers and pre-existing chromosomal damage. Here again, the attribution of the prize is linked to a submission to DHM.

In 2011, EUBS adopted a new award in honour of Patrick Musimu for the best scientific contribution on breath-hold diving. This prize is submitted on the same conditions as the Zetterström award and is sponsored by the Belgian Society for Diving and Hyperbaric Medicine. The winner was: S Theunissen for her work entitled: *Oxidative stress in breath-hold divers after successive dives*.

### 5. EUBS publications (journal and website):

The Assembly is reminded that *Diving & Hyperbaric Medicine* (DHM) is sent out to members in paper copy, and that a PDF version is available for 6 months on the members-only section of the EUBS website.

P Müller presents to the EUBS members the situation of DHM reported by the Editor, M Davis. M Davis has now been Editor for 10 years. The former *SPUMS Journal* was changed to DHM in 2006. The former newsletter of EUBS was changed to *European Journal of Underwater and Hyperbaric Medicine*. Both journals were joined in 2008. Both societies lost a few members on this occasion. P Müller emphasizes the necessity for the members to submit more articles to keep the Journal successful.

2008 was a major step forward when DHM became indexed by Thompson Reuters ISI Web of Knowledge. This allowed the attribution of an Impact Factor (IF). In 2011, DHM achieved Medline indexation. The National Library of Medicine has now accepted abstracts for PubMed from DHM back to 2008. Indexation has brought an increase in the number of papers submitted. Some papers have been accepted and some rejected. Australia still has the majority of papers, but now UK, Sweden and other European countries are increasing their submission numbers. The majority of papers still deal with diving medicine. The proportion of original papers has increased from 30% to 60%, which is very encouraging. The IF is almost 0.7. The circulation of DHM has dropped from about 1000 to 860 copies and EUBS lost 20% and SPUMS 30% of their membership over 2009 through 2011. This, combined with the affects of inflation over time, has led to an increase in the cost to individual members for the journal, as about 40% of these are fixed costs, irrespective of the print numbers. The Editorial Board is looking for one more academic clinician preferably with a background in Emergency Medicine.

Comment from PG: the fall in EUBS membership is due to the fact that EUBS has been, over the last couple of years, more efficient in tracing non-payers; this means the

Journal has not been sent any more to 'ghost members'. This is confirmed by P Müller.

Website: The web page discussion forum is basically inactive. The ExCom has decided to investigate new ways of activating this interesting tool. PG, the webmaster, will send a monthly e-mail newsletter to inform all EUBS members of changes in the web page. The Assembly accepts this idea by a large majority. A Möllerlökken agreed to investigate a possible presentation of the Society's webpage on Facebook.

#### 6. Financial report:

The financial report was prepared by our membership secretary, Patricia Wooding and projected to the GA. The audit was made by Anna Stillman from DDRC in Plymouth, who is thanked by ExCom for her voluntary efforts.

The financial report is accepted by the General Assembly and will be accessible for a limited time on the Society website (members-only section). We have a rather good balance and are slowly recovering from the bad years; however, major expenses, grants, awards, invited speakers, recurrent journal costs still have to be paid. A small amount of money will be dedicated to a reserve fund. Every member can follow his financial status by looking at his 'payment history' in the members only section of the website.

There is an ongoing discussion about a possible combined membership of EUBS and SPUMS. Up to now it is not possible to have access to both web pages if you have not paid the membership fee of both societies. One possible option could be to pay an extra fee of 25 Euros to have access to both web pages; this will be further discussed with the SPUMS Committee.

Comment from the floor: people could be tempted to go to the cheaper society in order to have the Journal. PG states that the fees are comparable. SPUMS is a little higher but offers more services, like accreditation, courses, etc. EUBS membership fees have not changed over the last four years. ExCom proposes to be allowed to increase the membership fee each year, according to increasing economic cost of living. The GA rejects the automatic indexing of the membership fee. As an alternative, ExCom will evaluate each year the appropriateness of the amount asked as membership fee, and request permission of the GA prior to raising the fee. This is accepted by the GA. It is suggested that members could 'opt out' of receiving the paper version of the DHM Journal, and thus reduce the costs. PG explains that this would not decrease the costs substantially, because of the fixed start-up and printing costs. It would only raise the per copy price for the other members. DHM also needs a certain number of hard copies to be produced in order to keep its index. This topic will be discussed further with SPUMS. ExCom will investigate if it would be possible to obtain cheaper printing and mailing costs in Europe.

#### 7. Votes and elections:

The number of members who have voted has steadily increased since the introduction of e-voting. However 46% of the members still did not vote. One reason could be spam filters, another that they were not convinced by any of the candidatures. For this reason, ExCom will add the possibility of abstention in the ballot. Our system protects the anonymity of voters and who they voted for, but does allow us to identify who did not vote. In order to improve the voting process, the ExCom proposes to the floor to send to the non-voters an e-mail asking the reason for this. Accepted by GA.

Comment from the floor: Allow voting till the last day preceding the general assembly, people who forgot could still vote. A reminder could be given during the opening ceremony. PG will check if the by-laws allow it.

Noemi Bitterman has finished her 12-year term on the ExCom and A Möllerlökken his three-year term as a Member-at-Large. They are applauded by the floor.

Vice-President: J Kot was elected from the two candidates. Member-at-Large: SL Blogg was elected from the five candidates. The new Executive Committee 2012–2013 is presented to the GA.

#### 8. Next meetings:

The next meeting, in 2013, will be historic because three societies from three different continents will join for the first time to hold a common meeting: SPUMS, SAUHMA and EUBS. It will be held on Réunion from 23–28 September 2013. More information on: <[www.reunion2013.org](http://www.reunion2013.org)>. A short presentation is shown by JJ Brandt Corstius, representing the main organizing committee.

Dates and locations of the next Annual Meetings:

2014 Wiesbaden

2015 Amsterdam

2016 Croatia

2017 an application from Israel has been received.

#### 9. Miscellaneous:

P Bryson has done a good job as Liaison Officer and ExCom proposes to prolong his mandate. The Liaison Committee will be expanded in view of the meeting on Réunion. Accepted by the membership.

There was no other business from the floor.

**Closed:** 1804 h

*J Schmutz, Honorary Secretary*

#### Key words

Meetings, medical society



For the first time ever, the European Underwater and Baromedical Society, the South Pacific Underwater Medicine Society and the Southern African Underwater and Hyperbaric Medical Association will hold a joint scientific meeting.

We invite you to attend a full week of science, scuba and social interaction on the exotic French island of Réunion in the Indian Ocean. The conference will be hosted by the Association Réunionnaise de Médecine Subaquatique et Hyperbare in the picturesque coastal village of St Gilles les Bains, where a range of hotel packages will be available to suit all styles and budgets. There will be possibilities for diving, whale watching, island excursions; we invite you to extend your stay before or after the meeting and to bring your family.

The meeting format will be a meld from all three societies, including discussion and workshop sessions, keynote lectures, free papers, a scientific poster session/display and industry exhibition.

#### Programme:

22 September	ECHM Workshop: <i>Diagnosis and treatment of mild decompression sickness</i>
23 September	ARESUB meeting
23–28 September	Tri-Continental Scientific Meeting on Diving and Hyperbaric Medicine
28 September	SPUMS, EUBS, SAUHMA General Assemblies
29 September	International DAN Diver's Day

#### Call for Abstracts:

Abstracts for oral and poster presentations should be submitted electronically to: <[www.reunion2013.org](http://www.reunion2013.org)>  
The Organizing Committee intends to publish all accepted abstracts in a conference proceedings and encourages speakers to submit full papers for consideration in *Diving and Hyperbaric Medicine*.

#### Preliminary timetable:

20 December 2012:	Open for registration via the website
1 April 2013:	Deadline for submission of abstracts
1 April 2013:	End of early-bird registration period
12 July 2013:	Notification of accepted abstracts

Language: The official language for the Tri-Continental Scientific Meeting, the ECHM Workshop and the International DAN Diver's Day will be English. The language for the ARESUB meeting will be French.

Full information on registration and abstract submission format may be found on the website:

<[www.reunion2013.org](http://www.reunion2013.org)>

All enquiries: <[info@reunion2013.org](mailto:info@reunion2013.org)>





# SPUMS Notices and news

## SPUMS Diploma in Diving and Hyperbaric Medicine (updated October 2012)

### 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:

- The candidate must be medically qualified, and be a current financial member of the Society.
- The candidate must supply evidence of satisfactory completion of an examined two-week full-time course in Diving and Hyperbaric Medicine at an approved facility. The list of approved facilities providing two-week courses may be found on the SPUMS website.
- 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.
- The candidate must submit a written proposal for research in a relevant area of underwater or hyperbaric medicine, in a standard format, for approval *before* commencing their research project.
- The candidate must produce, to the satisfaction of the Academic Board, a written report on the approved research project, in the form of a scientific paper suitable for publication. Accompanying this written report should be a request to be considered for the SPUMS Diploma and supporting documentation for 1–4 above.

In the absence of documentation otherwise, it will be assumed that the paper is submitted for publication in *Diving and Hyperbaric Medicine*. As such, the structure of the paper needs to broadly comply with the 'Instructions to Authors' – full version, published in *Diving and Hyperbaric Medicine* 2010;40(2):1102.

The paper may be submitted to journals other than *Diving and Hyperbaric Medicine*; however, even if published in another journal, the completed paper must be submitted to the Education Officer for assessment as a diploma paper. If the paper has been accepted for publication or published in another journal, then evidence of this should be provided.

The diploma paper will be assessed, and changes may be requested, before it is regarded to be of the standard required for award of the Diploma. Once completed to the reviewers' satisfaction, papers not already submitted to, or accepted by, other journals should be forwarded to the Editor of *Diving and Hyperbaric Medicine* for consideration. At this point the Diploma will be awarded, provided all other requirements are satisfied. Diploma projects submitted to *Diving and Hyperbaric Medicine* for consideration of publication will be subject to the Journal's own peer review process.

### Additional information – prospective approval of projects is required

The candidate must contact the Education Officer in writing (e-mail is acceptable) to advise of their intended candidacy, and to discuss the proposed subject matter of their research. A written research proposal must be submitted before commencing the research project.

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

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

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

The Academic Board reserves the right to modify any of these requirements from time to time. As of October 2012, the SPUMS Academic Board consists of:

Associate Professor David Smart, Education Officer;  
Associate Professor Simon Mitchell;  
Associate Professor (retired) Mike Davis.

### All enquiries and applications should be sent to:

Associate Professor David Smart  
GPO Box 463, Hobart, Tasmania 7001  
E-mail: <[david.smart@dhhs.tas.gov.au](mailto:david.smart@dhhs.tas.gov.au)>

### Key words

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

## Executive summary of the minutes of the SPUMS Executive Committee teleconference held on 01 April 2012

**Opened:** 1605 h

**Present:**

M Bennett, K Richardson, J Lehm, D Smart, P Smith, G Williams, A Fock, G Hawkins

**Apologies:**

M Davis, C Acott

An unedited copy of the Minutes is available on request to the Secretary: <secretary@spums.org.au>

### 1. Minutes of previous meeting:

An executive summary of the Minutes from the Executive Committee Meeting held at Prince of Wales Hospital in November 2011 was circulated and accepted and was published in *Diving Hyperb Med.* 2012;42(2):114-6.

### 2. Matters arising:

- 2.1 C Meehan has completed the first diving medical on an individual with type I diabetes in anticipation of a specialised training course that will commence shortly in Cairns.
- 2.2 There has been no further progress on the position paper re epilepsy and diving.

### 3. Annual Scientific Meetings:

- 3.1 ASM 2012
  - 3.1.1 C Meehan reports there are 62 registrants as of 31 March.
  - 3.1.2 M Bennett has almost finalised the academic programme.
- 3.2 ASM 2013
  - 3.2.1 KR (SPUMS), Peter Germonpré (EUBS), Jonathan Rosenthal (SAUHMA) and Jan Jaap Brandt Corstius ("JJ" Scott Haldane Foundation) will meet on Réunion Island on 16–18 April 2013 for planning and reconnaissance. The meeting will be hosted by the three societies with input from the local EUBS chapter.
  - 3.2.2 The Scott Haldane Foundation will organize logistics and provide financial structure for the meeting at no cost. A presentation package will be prepared for use at SPUMS ASM 2012.
- 3.3 ASM 2014 and beyond: No convener has been identified for 2014. Venues, including Saipan, Micronesia and Wakatobi, Indonesia, were discussed. Further discussion will be held at ASM 2012.
- 3.4 Update on Convener's Manual: C Meehan and S Lockley will combine experiences and update the Convener's Manual at the 2012 ASM in Madang.

### 4. Journal matters:

- 4.1 MD submitted a journal report for consideration;

however, as he was unable to participate in this teleconference, all journal business has been deferred to the next Executive Committee meeting.

4.2 MD is now keeping an itemised spreadsheet of incidental journal expenditure.

4.3 EBSCO has again written to the Journal requesting our participation in their search engine service. This matter will be discussed with the EUBS Executive.

### 5. Website matters:

The following items have been identified as requiring updating on the SPUMS website:

- 5.1 Post the latest edition of SPUMS Purposes and Rules and relabel drop-down menu to same.
- 5.2 Ensure every SPUMS committee member has a generic email address for publication in DHM.
- 5.3 Change the labeling and format of the SPUMS Diving Medical Examination to ensure it is easy to find and convenient to access and print.
- 5.4 Add the ANZHMG Diving and Hyperbaric Medicine Course information to the website.
- 5.5 Archive or remove out-of-date posts and information.
- 5.6 Add a disclaimer to the forums website to ensure users are aware opinions are those of the individual not the Society.
- 5.7 Provide a frequently asked questions (FAQs) page to alleviate common e-mail enquiry burden on Administrator, Secretary, President and Education Officer.
- 5.8 Establish presence for the Future ASM Steering Committee on the website.

### 6. Education Officer's report:

- 6.1 Progress on Stellenbosch University DHM Diploma alignment: DS has produced a discussion paper on this issue which he presented at the UK sports diving medicine conference. This paper will be published in *Diving and Hyperbaric Medicine* in due course.
- 6.2 RACGP Accreditation progress report: No solution to this issue has been found, further update at 2012 ASM from S Lockley.
- 6.3 ANZCA Cert DHM: ANZCA has undertaken a review of the Cert DHM and has acknowledged the role of the College in difficulties experienced with the qualification process. ANZCA has now named one individual as point of contact and is investigating the possibility of remote supervision for units that do not have an appropriate mentor. The certificate will continue but requires streamlining as it is currently cumbersome and poorly administered. This issue has been discussed at the ANZHMG SIG Committee Meeting.
- 6.4 SPUMS Diploma: DS reports there is one diploma in process. Sijak Ching is conducting an RCT on treatment of burns at a Singapore Hyperbaric Facility. His paper has yet to be submitted.

### 7. ANZHMG Representative's report:

- 7.1 RCC facility accreditation update. DS reports that Australian Standard 4774.2 needs to be revised then

used as a platform for facility accreditation, particularly because the new Safework legislation makes no provision for workers in hyperbaric facilities. It is noted that there is currently a deficiency in the accreditation process. HTNA have expressed a concern about the proliferation of non-comprehensive facilities in Australia and the safety implications of this. The UHMS model of accreditation is not compatible with Australasian practices. The accreditation process ideally will be conducted as a peer review by out-of-state colleagues as the ACHS does not understand the safety implications of our unique working environment. SPUMS and the ANZHMG should have a definitive position on this process for discussion at the HTNA meeting in Christchurch in September 2012.

7.2 Formal review of Australian Standard 4774: DS has been invited to represent the ANZHMG at this review process.

#### **8. Treasurer's report:**

8.1 Additional signatories: A proposal was made to increase the list of people authorised to operate the various SPUMS accounts. Proposed J Lehm, seconded M Bennett, unanimously accepted.

It is proposed to add G Hawkins to the signatories to the accounts with St George Bank and an authorised user of Business Banking On-Line.

8.2 There have been considerable difficulties encountered with St George Bank failing to process submitted documentation. PS is now listed as a seconding electronic signatory; however, KR will no longer be undertaking this role.

#### **9. Public Officer's report:**

9.1 AF will produce a handover guide for the next Public Officer.

9.2 It is noted that with the plans for the combined ASM in September 2013, official application must be made to the Victorian authorities for the AGM to occur past its usual date in April/May.

#### **10. Secretary's report:**

10.1 Administrator role and issues: MB reports the SPUMS Administrator Steve Goble currently bills between 60 and 100 hours per month. This time is spent primarily answering e-mail enquiries, sorting membership subscriptions and ensuring journal delivery. SG has been asked to compile a list of most frequently received enquiries. This will be used to establish a FAQs page on the SPUMS website.

10.2 Assets list: The assets list is unable to be completed until requested information is received from MB, GW, SG and JL.

#### **11. Membership matters:**

11.1 Update on membership status: GH reports membership numbers as of 01 April: 318 full, 29 associate, 10 retired, four corporate. Total membership of 361. It is noted that these figures are taken during the

period where renewals are still occurring. SG is in the process of sending renewal reminders.

11.2 Membership database: SG has commenced an update of the SPUMS membership database. Information on incorrect e-mail addresses has been requested from GH.

11.3 Request from ADHMA for electronic journal access: MB has corresponded with Tony Lee on the decision not to grant electronic access to the Journal.

11.4 Request from EUBS for global membership: Provision of access to the SPUMS website for EUBS members was approved in principle. There should be three pricing strata to ensure this: cost for the Journal alone, cost for Journal plus membership to one society, cost for Journal plus membership to both societies. Problems exist with this concept including disparity between membership dues, ensuring the applicants are current EUBS members and the possibility of falling membership numbers. This issue will be discussed further at the next Executive Committee meeting.

11.5 SPUMS representation at conferences: A position has been secured at ODEX 2013, no space is available at ANZCA 2012 but has been requested for 2013, DS proposes participating in the Emergency Medicine College's ASM.

#### **12. Other business:**

12.1 MSAC review process: MB and DS note they are still awaiting a response from the last MSAC submission.

12.2 SafeWork legislation and codes of practice: These documents have been passed into law despite numerous concerns notified via the appeals process. DS proposes to be the SPUMS point of contact to collect data on negative outcomes for divers seen to be a direct result of this legislation. A notice will be placed in the journal requesting this information be forwarded to him by email.

12.3 SPUMS relationship with HTNA: HTNA have responded with appreciation for SPUMS, offer of sponsorship for their ASM; however, no further progress has been made in establishing what form this will take.

12.4 Succession planning and elections: Nomination forms have been distributed for the coming elections at 2012 ASM for the positions of Treasurer and Executive Committee Member.

#### **13. Correspondence:**

13.1 SPUMS response to Queensland Recreational Dive and Snorkeling Industry Reference Group Report to Minister for Education and Industrial Relations November 2011: Responses have been submitted by MB on behalf of SPUMS and DS as an individual, strongly opposing the move towards use of the RSTC form instead of a formal face-to-face diving medical. If the outcome of this review process chooses the screening questionnaire approach, DS nominates himself as the point of collection for data demonstrating negative outcomes as a result.

13.2 Snap Printing Hawthorn to DHM Editor: notification was given of a change of ownership for the printing service currently responsible for producing the Journal.

There have been no problems encountered so far. There are no plans at present to change printer.

#### 14. Next meeting:

Madang Resort, Papua New Guinea, Sunday 20 May 2012, time to be confirmed.

**Closed:** 1735 h

*K Richardson, Secretary SPUMS*

#### Key words

Meetings, medical society

### Minutes of the Annual General Meeting of the Australian and New Zealand Hyperbaric Medicine Group, Thursday 23 August 2012, Chateau-on-the-Park, Christchurch, New Zealand

**Opened:** 0900 h

#### Present:

D Smart, S Mitchell, S Szekely, N Banham, C Meehan, J Orton, D Marley, M Davis, H Holland, C Odlin, G McGeogh

#### Apologies:

M Hodgson, H Ozer, B Webb, A Fock, D Wilkinson, C Sames, K Thistlewaite, J Lehm, I Millar

#### 1. Minutes of 2011 Annual General Meeting:

The Minutes from the 2011 Annual General Meeting held at the Crown Plaza Hotel, Goojee Beach, Sydney on 15 September 2011 as circulated by e-mail and published in *Diving Hyperb Med.* 2012;42(1):54-6.

Proposed S Mitchell, seconded N Banham, carried.

#### 2. Matters arising:

- 2.1 Discussed under current agenda items.
- 2.2 S Mitchell suggested that SPUMS fund ANZHMG activities such as the MSAC battle. He will raise this as an agenda item at SPUMS Executive.

#### 3. Office bearers:

- 3.1 As the MSAC review is approaching a denouement, D Smart has offered to continue in his role as Chair for his fourth and last term. Proposed S Mitchell, seconded N Banham, carried unanimously.
- 3.2 D Wilkinson is also agreeable to continue as Secretary for one more term. Proposed D Smart, seconded M Davis, carried unanimously.

#### 4. Address by Chair of ANZHMG:

- 4.1 Medicare Services Advisory Committee: D Smart

and M Bennett have been intimately involved with this process with partial success: accepted for radiation wounds but not chronic non-diabetic wounds. Funding for chronic non-healing wounds is to be withdrawn from November 2012. D Smart has written to politicians and RSL/TPI associations. He has encouraged this to be done in each state. D Smart has received an invitation to talk to TPI group (unfunded) at their National AGM in Canberra, 19 September 2012. A formal complaint has been sent to the Health Minister.

4.2 Federal Work, Health and Safety Regulations: These have been implemented despite SPUMS' objections. No mention of AS/NZS 2815 series and AS/NZS 4774.2 in the legislation. SPUMS through ANZHMG provided significant input to these regulations.

4.3 Adequate standards for professional divers: These are covered under 4.2 above.

4.4 Australian Standard for Compressed Air and Hyperbaric Facilities: AS/NZS 4774.2 is now being reviewed (sponsored by HTNA) as is AS/NZS 2299.1 (sponsored by ADAS)

#### 5. Research:

5.1 HOLLT: This is proceeding steadily and a recent interim analysis of data indicated that the difference between the two groups is greater than originally predicted and numbers have been able to be reduced from 250 to 120. Hopefully the trial will be completed towards the end of 2013.

5.2 HORTIS: Dick Clarke has announced that the HORTIS trial for radiation cystitis is closed owing to insufficient recruitment numbers. All remaining arms of the HORTIS study have been closed.

5.3 Wound study: Closed in March 2012. 12-month follow up will be complete in March 2013; to be published after this.

#### 6. Courses in diving and hyperbaric medicine:

6.1 Introductory course in diving and hyperbaric medicine, PoW, Sydney 25 February–08 March 2013; always fully subscribed; course notes to be published.

6.2 Adelaide course on again in November. Usually over-subscribed (S Szekely).

6.3 Navy course on again in November; still accessible for non-military (six positions); Joel Hissink is Course Director.

6.4 Fremantle course (3-day GP course) planned for 2013, possibly in April.

#### 7. Australia and New Zealand Standards report:

AS now works on a corporate model. Result – need money (approx. AUD16k) for a Standard to be assessed/reviewed. Now often adopt an International Standard, sometimes 'dumbing down' a pre-existing AS, e.g., AS 4005.1 is still around, but in practice not used by much of the diving industry (still a legislative requirement in QLD).

4774.2: Supported by HTNA and has commenced review.  
2299.1: Commenced review – D Smart representing SPUMS.

#### 8. *Diving and Hyperbaric Medicine Journal* (DHM):

8.1 M Davis presented his report (presented at SPUMS AGM May 2012 and published in the September issue of DHM). Medline-indexed since beginning of 2011, and abstracts from years 2008 through 2010 will also be on PubMed.

8.2 Editor to be appointed for 2013 on. M Davis has expressed the wish to be reconsidered for a further three years. D Smart congratulated him on his achievements, especially the Medline indexing.

#### 9. Facility accreditation:

Linked to AS/NZS 4774.2. The review of 4774.2 has been sponsored by HTNA. Issues regarding accreditation and training of technicians were discussed. To undertake the process requires a reference document – this will be the revised 4774.2 when completed. It will require ANZHMG input regarding medical aspects. Options for accreditation methods were addressed, e.g., adapt the UHMS system for our use. This will likely have cost implications. There is a current NZ document which may be used as a template (ACC). M Davis to send to ANZHMG for distribution. ANZHMG will look at both options, with preference to the local option.

It was agreed that:

- ANZHMG supports accreditation;
- ANZHMG to lead the accreditation process (rather than HTNA);
- ACC (NZ) local option to be explored in preference to the UHMS system;
- Input to AS/NZS 4774.2 via D Smart. This will serve as the template for accreditation.

#### 10. Clinical indicators:

Reported annually. Collated results presented at the HTNA conference in the Meeting Proceedings.

#### 11. Clinical trials:

A separate meeting to be held during this HTNA ASM.

#### 12. HTNA issues:

ANZHMG to support HTNA review of 4774.2

#### 13. Other business:

13.1 G. McGeogh explained the NZ situation re HBOT. National coordination of hyperbaric services is being considered.

13.2 J Orton discussed training of NZ hyperbaric registrars in Australia. Funding issues to be addressed.

13.3 MSAC and HBOT – role of ANZHMG. All agreed that for necessary meetings re MSAC, ANZHMG members should receive funding from SPUMS to attend the meetings. To date, D Smart has funded his own trips to Canberra. There was unanimous support that these

trips should be funded by SPUMS. To be presented to SPUMS Executive through S Mitchell.

#### 14. Next meeting:

To coincide with 2013 HTNA ASM (date to be confirmed).

**Closed:** 1200 h

*Neil Banham (in the Secretary's absence)*

#### Key words

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### Hyperbaric Technicians and Nurses Association (HTNA) SPUMS Award 2012

The SPUMS award for the best presentation by a HTNA member at the HTNA 2012 Annual Scientific Meeting, held August at The Chateau-on-the-Park, Christchurch, New Zealand was awarded to Corry Van den Broek, Senior Hyperbaric Technologist, Royal Hobart Hospital, Hobart, Tasmania, Australia.

His presentation was entitled:

*Baxter Colleague 3 CXE infusion pump – hyperbaric suitability*

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### Advertising in *Diving and Hyperbaric Medicine*

Commercial advertising is now welcomed within the pages of *Diving and Hyperbaric Medicine*. Companies and organizations within the diving, hyperbaric medicine and wound-care communities who might wish to advertise their equipment and services are welcome. The advertising policy of the parent societies – EUBS and SPUMS – appears on the journal website: <www.dhmjournal.com>.

**Details of advertising rates and formatting requirements are available on request from:**

**E-mail:** <editor@dhmjournal.com>

**Fax:** +64-(0)3-329-6810

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The



website is at

<[www.spums.org.au](http://www.spums.org.au)>

Members are encouraged to log in and to keep their personal details up to date

## Certificate in Diving and Hyperbaric Medicine of the Australian and New Zealand College of Anaesthetists

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

### Eligibility criteria are:

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

2 Completion of training courses in Diving Medicine and in Hyperbaric Medicine of at least four weeks' total duration.

For example, one of:

a ANZHMG course at Prince of Wales Hospital Sydney, **and** Royal Adelaide Hospital or HMAS Penguin diving medical officers course **OR**

b Auckland University Postgraduate Diploma in Medical Science: Diving and Hyperbaric Medicine.

### 3 EITHER:

a Completion of the Diploma of the South Pacific Underwater Medicine Society, including six months' fulltime equivalent experience in a hyperbaric unit and successful completion of a thesis or research project approved by the Assessor, SPUMS **AND**

b Completion of a further 6 months' full-time equivalent clinical experience in a hospital-based hyperbaric unit which is approved for training in Diving and Hyperbaric Medicine by the ANZCA.

**OR:**

c Completion of 12 months' full-time equivalent experience in a hospital-based hyperbaric unit which is approved for training in Diving and Hyperbaric Medicine by the ANZCA **AND**

d Completion of a formal project in accordance with ANZCA Professional Document TE11 "*Formal Project Guidelines*". The formal project must be constructed around a topic which is relevant to the practice of diving and hyperbaric medicine, and must be approved by the ANZCA Assessor prior to commencement.

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

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

**All details are available on the ANZCA website at:**

<[www.anzca.edu.au/edutaining/DHM/index.htm](http://www.anzca.edu.au/edutaining/DHM/index.htm)>

*Dr Suzy Szekely, FANZCA*

*Chair, ANZCA/ASA Special Interest Group in Diving and Hyperbaric Medicine, Australia*

*E-mail: <[Suzy.Szekely@health.sa.gov.au](mailto:Suzy.Szekely@health.sa.gov.au)>*

## The poetry doctor

### The Urinators

Traditionally divers like to sink  
Both underwater and into drink.  
A piping hot toddy to ward off cold.  
A nip of courage to become more bold.  
A pint of ale to stimulate cheer.  
A wee dram of whisky to overcome fear.

Drink and diving have been in thesis  
As a combined cause of extreme diuresis,  
For divers were called in ancient data  
The endearing name of "urinators",  
A term that is certainly not the smartest  
But better than the colloquial "artist".  
Yet this inferred barb of such low moral fibre  
Suggests they have always been heavy imbibers.

But now we are all better informed  
Our diving habits have been transformed  
From sinking odd beers between dives galore  
To now staying sober, even the night before  
And with our new found diving sobriety  
We can now dive with less diuresis anxiety.

*John Parker*

*E-mail: <[drjohnparker@hotmail.com](mailto:drjohnparker@hotmail.com)>*

*John has recently returned from the Nuba mountains in northern Sudan, where he has been working for Médecin sans Frontières.*

## International Congress on Hyperbaric Medicine (ICHM)

### ICHM Committee:

President: Jorge Pisarello, USA

Executive Director: Alessandro Marroni, Italy

Secretary: Michael Bennett, Australia

The ICHM is a worldwide organization for physicians and scientists interested in all aspects of diving and hyperbaric medicine. The organization has minimal formal structure and is entirely dedicated to hosting an international scientific congress every three years with the purpose of improving understanding among the international hyperbaric community. Over the last year, the ICHM has re-focused its attention on bringing together the professional organization around the globe. We have invited the committees of each geographically based professional medical group of whom we know to nominate a representative to join our committee. In this way, we intend that all future meetings will be closely linked with any local organizations already in place. Where possible, we will encourage organizations to hold joint scientific meetings with the assistance of the ICHM.

In essence, the ICHM is changing from an individual member-based body to one that is more concerned with fostering closer cooperation between national and regional bodies. The rationale is that there are many such geographically based bodies, but little formal co-ordination of their scientific meetings. The ICHM believes much is gained by encouraging all those interested in the science and medicine of diving and hyperbaric medicine to meet and discuss their work in a truly international forum. We are less convinced that the world needs quite so many different organizations competing for individual memberships and going their own way. In this, we have been mightily encouraged both by the recent changes in the relationship of SPUMS and the EUBS and the 'internationalisation' of education in diving and hyperbaric medicine represented by the University of Stellenbosch initiative.

To date, we are pleased to announce that we have been formally joined at the executive level by representatives from SPUMS (Mike Bennett), EUBS (Peter Germonpré), the French organization MedSubHyp (Daniel Mathieu), the South African Underwater and Hyperbaric Medicine Association (SAUHMA, Jonathan Rosenthal) and the British Hyperbaric Association (BHA, Colin Wilson). We anticipate further nominees in the near future.

### Website

Communication among the members and friends of the ICHM is through these information pages kindly offered by the Editor of this Journal, and the dedicated website at: <[www.ichm.drupalgardens.com](http://www.ichm.drupalgardens.com)>. We welcome any

comments readers may have – whether or not they are members of the ICHM. Negotiations also continue on the possibility of publishing the proceedings of each Congress under the *Diving and Hyperbaric Medicine* (DHM) banner – watch this space. Members of the ICHM who wish to publish scholarly articles are encouraged to consider submission to DHM in the future. Further information about the Congress may be obtained from the Secretary.

### The 18th International Congress on Hyperbaric Medicine: Buenos Aires, Argentina, 2014

On behalf of the Organizing Committee of the 18th International Congress of Hyperbaric Medicine, we would like to invite you to attend the next congress to be held in Argentina. Dates and details will be posted on the ICHM website as soon as they come to hand. The meeting will be held under the Presidency of Jorge Pisarello and with the (no doubt) invaluable assistance of Nina Subbotina. Rugby fans in the southern hemisphere are hoping the dates will coincide with a good game of international rugby in the new 'four-nations rugby championship'! I have my fingers crossed.

If you would like to submit a paper at the conference, or offer to assist with a workshop or other educational activity, please contact Nina at: <[ninasubbotina@gmail.com](mailto:ninasubbotina@gmail.com)>. I am sure she will be delighted to hear from you. Potential exhibitors should also get in touch if they wish to get in early.

### Address for correspondence:

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**E-mail:** <[m.bennett@unsw.edu.au](mailto:m.bennett@unsw.edu.au)>

**Website:** <[www.ichm.drupalgardens.com](http://www.ichm.drupalgardens.com)>

### Key words

Meetings, medical society

## The ANZ Hyperbaric Medicine Group Introductory Course in Diving and Hyperbaric Medicine 2013

**Dates:** 25 February–08 March

**Venue:** Prince of Wales Hospital, Sydney, Australia

Course content includes:

- History of hyperbaric oxygen
- Physics and physiology of compression
- Accepted indications of hyperbaric oxygen (including necrotising infections, acute CO poisoning, osteoradionecrosis and problem wound healing)
- Wound assessment including transcutaneous oximetry
- Visit to HMAS Penguin
- Visit to the NSW Water Police
- Marine envenomation
- Practical sessions including assessment of fitness to dive

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

### Contact for information:

Ms Gabrielle Janik, Course Administrator

**Phone:** +61-(0)2-9382-3880

**Fax:** +61-(0)2-9382-3882

**E-mail:** <Gabrielle.Janik@sesiahs.health.nsw.gov.au>

## EUBS Annual Scientific Meeting 2014 Preliminary Announcement

**Dates:** 24–27 September 2014

**Venue:** Wiesbaden, Germany

The 40th EUBS ASM will be held in conjunction with the 2014 Congress of the German Society for Diving and Hyperbaric Medicine (GTUeM). Dr Peter Müller has been appointed by both societies to serve as the Secretary General for the EUBS ASM 2014.

### For further information at this early stage see:

<www.eubs.2014.org>

**E-mail enquiries:** <peter.mueller@eubs.org>

## Royal Adelaide Hospital Hyperbaric Medicine Unit Courses 2013

### Diver Medical Technicians Courses

February/March 2013

Wk 1: 25 Feb–01 March

Wk 2: 04–8 March (Lecture week)

Wk 3: 11–15 March

July/August

Wk 1: 29 July–02 August

Wk 2: 05–09 August (lecture week)

Wk 3: 12–16 August

Refresher Course – September/October

Wk 1: 23–27 September

Wk 2: 30 September–04 October

### Medical Officers Course

Wk 1: 02–06 December

Wk 2: 09–13 December

### All enquiries to:

Lorna Mirabelli

Senior Administrative Asst/Course Administrator

Hyperbaric Medicine Unit

Level 2, Theatre Block

Royal Adelaide Hospital

North Terrace, Adelaide, SA 5000

**Phone:** +61-(0)8-08-8222-5116

**Fax:** +61-(0)8-8232-4207

**E-mail:** <Lorna.Mirabelli@health.sa.gov.au>

## ECHM Workshop 2013 Diagnosis and treatment of mild DCS

**Date:** During the tri-continental RÉUNION 2013 Conference  
September - exact date to be announced

**Timing:** Half-day meeting

**Organizer:** European Committee for Hyperbaric Medicine (ECHM)

**Organizing Committee:** Alessandro Marroni, Ramiro Cali-Corleo, Jacek Kot

**Theme:** Diagnosis and initial treatment of mild decompression sickness occurring in remote diving destinations, and its eventual management at the hyperbaric facility

### For further details:

**Website:** <www.ECHM.org>



## Scott Haldane Foundation

The Scott Haldane Foundation is dedicated to education in diving medicine, and has organized more than 100 courses over the past few years, both in the Netherlands and abroad. Below is a list of courses planned for 2013.



The new basic course (Part I plus Part II) fully complies with the current EDTC/ECHM curriculum for Level I (Diving Medical Examiner), and the different advanced courses offer a modular way to achieve Level IIa competence according to the EDTC/ECHM guidelines.

### Course details for 2013

6 and 12 April: Basic course in diving medicine Part 1 (Loosdrecht NL)

13, 19 and 20 April: Basic course in diving medicine Part 2 (AMC Amsterdam NL)

25 May–01 June: Basic course in diving medicine Part 2 (Oman)

June (dates TBA): 21st in-depth course “Challenges in diving medicine” (NL)

09–16 November: Basic course in diving medicine Part 1 (to be decided)

16–23 November: 21st in-depth course in diving medicine (to be decided)

23–30 November: 21st in-depth course in diving medicine (to be decided)

**For further information:** <[www.scotthaldane.nl](http://www.scotthaldane.nl)>

## Undersea and Hyperbaric Medical Society 46th Annual Scientific Meeting

**Dates:** 13–15 June 2013

**Venue:** Lowes Royal Pacific Resort @ Universal Studios Orlando, Florida, USA

**Phone:** +1-(0)877-533-UHMS (8467)

**E-mail:** <[lisa@uhms.org](mailto:lisa@uhms.org)>

**Website:** <[www.uhms.org](http://www.uhms.org)>

## Hyperbaric Oxygen, Karolinska

Welcome to: <<http://www.hyperbaricoxygen.se/>>.

This site, supported by the Karolinska University Hospital, Stockholm, Sweden, offers publications and free, high-quality video lectures from leading authorities and principal investigators in the field of hyperbaric medicine.

You need to register to obtain a password via e-mail. Once registered, watch the lectures online, or download them to your iPhone or computer for later viewing.

We offer video lectures from:

- The 5th Karolinska PG course in clinical hyperbaric oxygen therapy, 07 May 2009
- The European Committee for Hyperbaric Medicine “Oxygen and infection” Conference, 08–09 May 2009
- The 17th International Congress on Hyperbaric Medicine, Cape Town, 17–18 March 2011

Also available is the 2011 Stockholm County Council report: *Treatment with hyperbaric oxygen (HBO) at the Karolinska University Hospital*

### For further information contact:

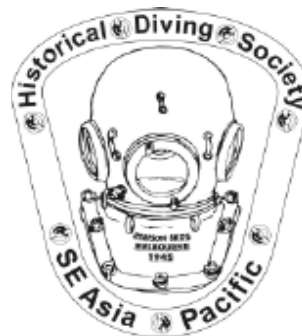
Folke Lind, MD PhD,

**E-mail:** <[folke.lind@karolinska.se](mailto:folke.lind@karolinska.se)>

**Website:** <[www.hyperbaricoxygen.se](http://www.hyperbaricoxygen.se)>

## German Society for Diving and Hyperbaric Medicine (GTUeM)

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



## DIVING HISTORICAL SOCIETY AUSTRALIA, SE ASIA

P O Box 347, Dingley Village  
Victoria, 3172, Australia

**E-mail:**  
<[deswill@dingley.net](mailto:deswill@dingley.net)>

**Website:**  
<[www.classicdiver.org](http://www.classicdiver.org)>



## DIVER EMERGENCY SERVICES PHONE NUMBERS

### AUSTRALIA

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

### SOUTHERN AFRICA

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

### NEW ZEALAND

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

### EUROPE

+39-6-4211-8685 (24-hour hotline)

### UNITED KINGDOM

+44-7740-251-635

### ASIA

+852-3611-7326 (China)  
+10-4500-9113 (Korea)  
+81-3-3812-4999 (Japan)

### USA

+1-919-684-9111

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

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### DAN Asia-Pacific DIVE ACCIDENT REPORTING PROJECT

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

Information may be sent (in confidence unless otherwise agreed) to:

DAN Research

Divers Alert Network Asia Pacific

PO Box 384, Ashburton VIC 3147, Australia

**Enquiries to:** <research@danasiapacific.org>

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### DAN Asia-Pacific NON-FATAL DIVING INCIDENTS REPORTING (NFDIR)

NFDIR is an ongoing study of diving incidents, formerly known as the Diving Incident Monitoring Study (DIMS). 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.

**The NFDIR reporting form can be accessed on line at the DAN AP website:**

<[www.danasiapacific.org/main/accident/nfdir.php](http://www.danasiapacific.org/main/accident/nfdir.php)>

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### DISCLAIMER

All opinions expressed in this publication are given in good faith and in all cases represent the views of the writer and are not necessarily representative of the policies or views of SPUMS or EUBS or the Editor.

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