Diving and Hyperbaric Medicine

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

SPUMS

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EUBS

More bubbles form after wet than dry dives

Doppler studies need more observations over a longer time

Time to treatment in neurological decompression sickness

Does diving contribute to dental alloy corrosion?

HBOT for acute retinal artery occlusion

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PURPOSES OF THE SOCIETIES

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

DIVING and HYPERBARIC MEDICINE
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The Editor's offering

How best does one test the efficacy of a decompression table or the effects of various measures, such as pre-dive exercise, on decompression risk? Doppler venous gas bubble (VGE) monitoring and ultrasonic scanning of the heart and great vessels have been used increasingly over recent decades rather than the binomial decompression sickness (DCS)/no DCS as the end point.[1] The latter is a crude outcome measure that statistically requires very large numbers of dives, and not all dive profiles in a decompression table can be tested anyway.[2] However, the links between bubble counts and the symptoms of DCS also remain imprecise. Two papers study Doppler used to assess decompression stress. Møllerløkken and his colleagues studied the differences in VGE generation in open water versus dry chamber dives and found that open-water diving, whether a long, shallow dive or a short, deep dive, generated many more bubbles than the same profile in the chamber.[3] These authors also suggest from their data that even a relatively conservative decompression model (Bühlmann) may underestimate decompression stress. Blogg and Gennser, using examples from many years of their group's ultrasound investigations, argue that some studies in the recent literature have not measured bubble formation early or often enough or for a sufficient length of time to provide comprehensive data on bubble evolution.[4]

If DCS occurs, does early recompression ensure better outcomes? There are conflicting data on time to recompression and clinical outcome. However in a recent paper, Blatteau and his colleagues reported that recompression treatment earlier than 6 hours appeared to provide a better clinical outcome, thus supporting some earlier studies.[5] Here, they report on neurological DCS in 59 military divers treated earlier than 6 hours, and found that the severity of the presenting symptoms was the most important predictor of poor recovery (a persistent finding in almost all studies), and that a delay to treatment longer than 90 minutes increased the risk to only a negligible degree.[6]

Sudden blindness from acute retinal artery occlusion (RAO) is not a generally regarded indication for hyperbaric oxygen therapy (HBOT). Nevertheless, there is a small but increasing literature of case series suggesting HBOT is better in terms of visual recovery than other current therapies or no treatment. Eggert and her colleagues offer another small case series that suggests benefit in some patients, but go further in pooling their clinical data with similar data from two other series.[7] Their analysis suggests strongly that HBOT should be considered in RAO, but there remain many questions as to patient selection and treatment modalities. Most importantly they argue the case for a multicentre database of cases to increase our knowledge in this area, since randomized controlled trials are likely to be very difficult to achieve, given the rarity of this event. A few years ago an attempt was made to set up such a database within the Australia and New Zealand, but was not followed through. Perhaps, now is the time for both societies to work together in studying the role of HBOT in this devastating event.

We have two new Editorial Board members to meet the increasing diversity of submissions. Martin Sayer, PhD, is a British marine biologist, Head of the National Facility for Scientific Diving at the Scottish Association for Marine Sciences Laboratory near Oban, Technical Advisor for the Scottish Recompression Registration Service and Editor of Underwater Technology, the International Journal of the Society for *Underwater Technology*. Martin has a strong grounding in scientific methodology and an eclectic publication record. Jane Heyworth, PhD, is Sub-Dean Health Science and Associate Professor, School of Population Health, Faculty of Medicine, Dentistry and Health Sciences at the University of Western Australia. Jane is an environmental epidemiologist with a similarly eclectic scientific and research background. We receive a sufficient number of papers with an epidemiological component that having a professional epidemiologist on the Board is important in enhancing the quality of our peer review processes. We need to increase our numbers further with another physiologist and a hyperbaric physician. Members of SPUMS and EUBS who would be interested in joining the Editorial Board are invited to submit their interest with their curriculum vitae to this office for consideration.

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Michael Davis

The cover photo of an anemone, probably *Heteractis magnifica*, and clown fishes, *Amphiprion perideraion*, was taken at Truk Lagoon by Dr Simon Mitchell.

Invited editorial

The foundations for today's future

David Elliott

This journal can flag, on its behalf, two 40th birthdays for the European Undersea Biomedical Society (EUBS); one now in 2011, and the other in 2013. Launching a new Society needed a lengthy incubation, but that gap was primarily to avoid a clash with the 1972 Underwater Physiology Symposium.

Not widely known to today's members is that the inaugural meeting of the EUBS was held on 30 September 1971 at the Royal Society of Medicine in London. Rather than presenting any scientific communications, this meeting was needed to create the Society, to confirm a formal organisation with an independent constitution and to ratify the planning and priorities for future meetings. On that occasion, our Editor, Mike Davis, was one of only some twenty founding members who were present, and it is thanks to him that a copy of the minutes of that meeting is available.[1]

At that time, I was at the US Naval Medical Research Institute for three years. In spite of being on the EUBS Executive Committee after that for nine years, until now, I had heard only oral versions of the Society's origins. Circulating stories reported some of the decisions made but omitted any formalities and all the personalities that created them. So no list of those involved was seen and some hearsay also suggested, wrongly, that this meeting had happened one year later than it did. Now, some forty years on, all has been revealed, and for this timely revelation, we thank Mike for revealing the minutes of that occasion, preserved in his meticulous archives.

A second 40th anniversary should be held in 2013. This is in recognition of the '*First Scientific Meeting of the EUBS*' which was held at the Karolinska Institutet, Stockholm in 1973.[2] Professor Carl Magnus Hesser, as the first President of the Society, gave the address of welcome and recorded that "*to get this far had required a great expenditure of time, money and effort by many individuals*". I was formally invited to attend as President of the Undersea Medical Society, and this gesture marked the beginning of the continuing liaison between these two societies.

Not many in the medical profession are familiar with an influential diving committee that had been created, also in 1973, by members of the Society of Underwater Technology. This is the EDTC (European Diving Technology Committee) which was set up to work closely with DG V, a Directorate in Luxembourg responsible for the oil industry within the CEC (The Commission of European Communities). The objectives and constitution of this were political and directed towards the formal harmonisation of diving safety and regulations across Europe's borders. Within this review, it is unique because it represents a non-scientific committee created with a 'tripartite' membership. 'Tripartite' allows three representatives to be nominated from each European nation. These were: one government, one employer and one trade union representative but, formally, no medical input. However, the nature of its business meant that each nation could then nominate one doctor to join the meetings, and several were asked to do so.

Following an inadequate medical response to a serious North Sea diving accident, the Diving Medical Advisory Committee (DMAC) was created in 1975 at the request of senior members of the international diving industry. Initially its members facilitated cross-border coordination between national sectors for medical emergencies, particularly in bad weather. Now its recommendations cover many medical aspects of diving. The DMAC guidance on decompression sickness treatment and, in particular, deep recompression in saturation diving, with a safe route back to the surface, was based on Royal Navy experience of the 1960s and this protocol remains in effective use worldwide today.

From the liaison established between EDTC and CEC's DG V, a number of symposia and workshops were held in Luxembourg and, in particular, one was the Annual Scientific Meeting of the EUBS in 1978, together with a workshop on the long-term health hazards of diving.[3] However, the regular periodic meetings of EDTC were, for the minority of medical members, not an effective use of their professional time and so, as Chairman of the EDTC in 1991, I created a separate medical subcommittee. Since then Jürg Wendling, as Chairman of EDTCmed, has continued to enhance medical input to this field.

Because of the complexity of industrial diving, DMAC's role also extended to formulating guidance related to the physiological and medical safety of hazardous procedures and environments, and to the training needed by doctors associated with diving. The Secretariat for DMAC continues to be provided by IMCA (the International Marine Contractors Association) but the members of DMAC each maintain their own 'fierce independence'. Currently IMCA advise their worldwide member-companies of the need for all doctors associated with diving to achieve and maintain their training at Level IIA.[4]

The hyperbaric speciality in Europe is recognised by the activities of the ECHM (European Committee for Hyperbaric Medicine), active from 1989 and registered in 1991, and it remains a purely medical committee. Among its many hospital-related topics, their meetings have covered the treatment of divers, predominantly recreational, who may require recompression in a clinical chamber. Related to those emergency needs, one must recognise the world-wide activities of DAN in the medical co-ordination and provision

of telephone advice and in arranging possible evacuation from remote emergencies, mostly for air-range recreational divers. Many diving contractors who employ compressed-air divers are required to provide recompression facilities on site (or have access to a treatment facility within two hours' travel time). These chambers are often used for surface-interval decompression (SurD) and are not 'medical' but, rather, are constructed and regulated as diving equipment.

The educational objectives needed to provide medical support for divers are based on the joint EDTC-ECHM guidance, originally formulated by Jordi Desola, the late Tor Nome and myself some 30 years ago. These European training requirements were implemented by DMAC for the diving industry (AODC and IMCA) worldwide, simply because many working divers move around the world frequently and dive from vessels carrying a variety of national flags. Working divers use procedures not found in recreational diving and such techniques, and their possible consequences, are reflected by the breadth and the detail of the competencies required within the medical training objectives that must be mastered by those who accept the challenging responsibility of treating them.

These training objectives have now been agreed by DMAC, EDTC and ECHM and current discussions will lead to some formal recommendations on training and periodic revision. This recent review has also generated an international awareness of the increasing similarities between some recreational diving (in particular 'tekkie' diving) and the many techniques used by working divers. Saturation diving remains almost entirely confined to commercial activities but, as some 'top-up courses' have shown, supplementary training is only a matter of a few extra days.

One never knows, when the emergency phone rings, what kind of diving has preceded it, and it is considered by many of us that those who accept the responsibility of answering the 'red phone' must know how to handle any diving emergency.

To endorse the view that all training for diving doctors should cover all diving is, in summary, simple.

- The laws of physics are the same.
- All fit divers have the same physiology.
- They are subject to the same pathologies. Indeed, even the long-term pathologies that have been described in saturation divers were each described previously among conventional air divers.
- The technical aspects of advanced recreational diving have developed to have much in common with some working procedures.
- Treatments of air-range recreational divers in the past have entered the air-saturation mode and the diving doctor must understand the options available for continued management.
- Deep mixed-gas dives of 28 days' duration needs special consideration, and their associated emergencies can happen anywhere in the world.

Those who do not agree with such comprehensive training for all on-call doctors must first define clearly the boundary of their limited ability.

So, what is it that divides divers into two major groups, recreational and working? It is not the range of diving techniques, a number of which can be found to different extents in both groups, but in every country this division is based simply on the local employment law. Unlike the laws of Nature, which are universal, national laws on diving differ. However the essence of any difference is that:

- recreational divers are responsible for their personal health and safety (but can enter into other agreements with trainers, expedition leaders, etc); they can dive when, where and how they wish, or they can, at any time, decide not to make that dive. Many recreational diving deaths appear to happen to those who dive beyond their competency.
- working divers are expected to dive when asked, where asked and are also told what to do in their dive. The health and safety assessment for each proposed dive, deep or shallow, and all aspects of its control is the ultimate responsibility of the employer. Self-employed divers are expected to follow the guidance for working divers, but national interpretations vary.

These considerations suggest that a unified medical approach to all divers is appropriate and should reflect the personal freedoms of recreational activities in contrast to the legal and hierarchical responsibilities within the work-place. All divers are exposed to hazards on every dive. Recreational and working divers assess risk on every dive and, if not avoidable, take appropriate action. Some divers may be exposed to hazards that could have delayed effects on their health, and, for working divers, this possibility needs to be considered by the examining doctor (Level I) at the time of their periodic fitness examination. Unless conducted by one who is an occupational medicine specialist, any doubts concerning the physical, chemical or biological hazards of that individual's underwater activities must be referred to an occupational medicine specialist.

So, from the 20 persons gathered in a meeting room 40 years ago, the EUBS has grown, and it continues to encourage scientific communication within our hyperbaric communities, both wet and dry. Long may this journal facilitate the continued reporting and dissemination of ideas. For those who cannot attend the meetings or workshops around the world, summaries and reports are important. Members and others should publish their scientific papers in this, their Journal, because it is now Medline-indexed.

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David Elliott, OBE, FRCP, PhD, is a Past President of EUBS and the Undersea and Hyperbaric Medical Society and a Life Member of SPUMS.

Key words
Editorials, medical society, training, standards, history, general interest

The proceedings of the inaugural meeting of the European Undersea Bio-Medical Society 1971

Held at the Royal Society of Medicine, London, at 1930 h on 30 September 1971

Surgeon Captain Rawlins RN, representing the founding members, took the chair and gave a brief introduction in which he explained the need for a group within Europe to organise scientific meetings to discuss the physiological and medical aspects of diving and underwater operations. He explained that due to legal and financial constraints, principally concerned with liability to income tax, it had been decided to recommend the formation of a separate society which it was hoped could become affiliated with the Undersea Medical Society (UMS). This change of emphasis received full discussion and the proposal was accepted unanimously. The foundation of a European society was accomplished that night on the understanding that the Executive Committee would explore the question of affiliation with the UMS at the earliest opportunity.

The proposed constitution was amended and approved line by line to produce the constitution and bylaws of the European Undersea Bio-Medical Society (1971). The President, Professor Carl Magnus Hesser of Sweden, was elected by acclamation and took the chair.

A slate of nominees for other posts on the Executive Committee was proposed, seconded and voted upon. The following officers were elected to serve on the Executive Committee with President Hesser:

Vice President	Professor KN Walder	UK
Secretary/Treasurer	Surg Cdr EEP Barnard RN	UK
Past President	Surg Capt JSP Rawlins RN	UK
Previous Past President	Dr X Fructus	France
Members-at-large	Professor JH Corriol 3 years (1974)	France
	Capt K Seemann FGN 2 years (1973)	Germany
	Dr PE Paulev 1 year (1972)	Denmark

The President gave a brief address in which he thanked those present for the honour of the Presidency and also the founding group for their efforts in bringing the Society into existence.

Dues were discussed and fixed for the year 01 January to 31 December 1972 as £5 sterling, or equivalent in other currency. Dues to be payable on the first of January each year.

A suggestion was made that student membership should be considered. This motion was accepted and will be considered by the executive Committee.

The question of affiliation was next discussed. Captain Rawlins undertook to open discussions with the executive of the UMS during a forthcoming visit to the United States. Mr Goodfellow, the Honorary Secretary to the Society of Underwater Technology, gave a useful outline of the benefits which might be gained by affiliation with his society and also supplied information as to the difficulties and delays likely in registering with the Charities Commission and the Internal Revenue Department for tax relief.

The proposal to appoint national assistant secretaries met the initial barrier that until members of the Society had identified themselves it was difficult for each country to elect a local representative; the motion, put by Professor K W Donald, was therefore carried that in principle the idea of assistant secretaries should be approved but that the way in which they were selected or appointed should be left to the Executive Committee.

It was decided on the motion of Professor Corriol that the official language of the Society should be English, but that this would not of course debar anyone who was unable to

speak English; the general principle to be followed would be inclusive rather than exclusive, with this in mind it was decided that no definition of the boundaries of Europe would be attempted.

The date of the next meeting was left open subject to a meeting of the executive to count heads and promulgate the date and purpose of such a meeting within the framework of the Constitution and Bylaws of the Society.

The need for a permanent home for the Society was discussed. Such a home would avoid having to transfer Society funds from country to country and changing the address to which subscriptions had to be paid on electing a new Secretary/Treasurer. It was decided to leave this question in abeyance until the affiliation committee, to be appointed by the President, had had an opportunity to settle the relationship of the Society to the UMS.

Those present were asked by the President to say whether any of them would be willing to serve on any of the committees of the Society. Names of those willing were taken and a separate list of Committee Chairmen and Committee Members will be issued as soon as possible.

The President made the announcement that it was hoped to hold the first scientific meeting in 1973, possibly at the beginning of June and in Sweden. It was not intended to hold a scientific meeting in 1972 since the Underwater Physiology Symposium to be held in the Bahamas in August 1972 was an important meeting with which we would not wish to interfere.

There being no further business to discuss, the meeting adjourned at 2200.

The following were present at the Inaugural Meeting:

Chairman: Capt J S P Rawlins

President and Chairman: Professor Carl Magnus Hesser
Surgeon Commander EEP Barnard RN
Captain RC Bornmann MC USN
Mr Clothier
Professor JH Corriol
Dr M Davis
Professor KW Donald
Dr R Edwards
Dr L Fagraeus
Mr Goodfellow
Surg Lt Cdr R de G Hanson RN
Surg Cdr RJ Lambert
Cdr Larsen MC USN
Cdr J Smith-Sivertsen RNN
Surg Commodore L Troell R SwN
Professor DN Walder
Surg Cdr JM Young RN

EEP Barnard, Secretary

Key words
Medical society, meetings, history, general interest

The Presidents' pages

Peter Germonpré, President, EUBS

This has definitely not been a good year. We are now nearing the 500th day of Belgium having no government. After endless discussions, mediations and (halfhearted) negotiations, without getting any closer to some sort of agreement, the country ploughs on with a demissionary government. Not only does this make us the laughing stock of many countries, it wastes money and opportunity. Explaining the background and reasons for this political disaster would take more pages than the whole of this issue of DHM. Let us summarise by noting that the Flemish (the Dutch-speaking northern part) feel that the Walloons (French-speaking, southern part) are less productive, less efficient and not willing to change this attitude, thereby taking advantage of the wealthy and industrious Flemish. The Walloons, on the other hand, live in fear that the Flemish want to break the country apart and establish an independent Flanders. They agree there is a difference in productivity, but point to the recent (60 years or so) past, where the Walloons were holding most of the industry; they insist that the current situation may be temporary, and want to maintain the solidarity that has been baked into our country's constitution...Perception is what makes the difference.

This has definitely not been a good year. Our planet has already had more than its share of nature disasters – too many to name them all. The earthquakes in New Zealand and Japan, volcanic eruptions, flooding, droughts, all bringing with them a high human and material toll, have literally shaken our globe much more than we have ever witnessed. Even if scientific analysis suggests this may be part of a cyclical climatic change (at a rate we have, with our limited knowledge, not experienced before), many believe that these events are a direct consequence of human influence on earth's atmosphere, and that we are on the verge of doomsday. How we evaluate the data will determine the course of action we will take: adaptation or pointless squabbling over each other's contributions...Perception…

This has definitely not been a good year. Over the last three months, I lost four friends in diving accidents. Three of them were very experienced divers, one a novice. What makes their deaths so tragic is that, with hindsight, all were preventable if only they had had a different perception of their own situation. All agree that diving is a sport that carries some danger; however, how one evaluates these risks is highly individual, and objectivity sometimes seems very far away. No matter how much we promote diving safety, no matter how we strive to point out the insidious nature of diving risk factors, in the end, perception is what will keep people taking risks they should not take. Those that stay behind must cope with the pain and the grief in their own ways. Mourning takes on different forms, and must be respected in its individuality...Perception…

As I write this, 2011 is little more than halfway through. By the time you read this, more disasters may have happened. Many good things will have been achieved as well. How we judge the final balance of this year will depend largely on how we perceived each event. Let us not make the mistake of letting perception fool objectivity.

Key words
Medical society, meetings

The

website is at
<www.eubs.org>
Members are encouraged to log in

Mike Bennett, President, SPUMS

For the third time I come before you at an AGM to deliver the annual President's report. I start by congratulating Sarah Lockley on organising a great meeting in trying circumstances. A high-quality programme has served as a fitting tribute to this, our 40th Annual Scientific Meeting. Both from the reception they have received and the lively social interactions that have followed, I know that our three guest speakers this year have been very popular and I thank them for all their hard work in presenting over these five days. All are old friends and members of the Society and it is a mark of the growing influence of the Society in the world of diving medicine that we can draw such high-quality material from our own ranks. Mention should also be made of the great help Sarah has had from the Committee and in particular from our Treasurer, Jan Lehm, who has manfully resisted all temptation to dispense funds without the appropriate paperwork, and Glen Hawkins who continues to be the only member of SPUMS with any real concept of how the website works. You will see during the course of this meeting that we propose to formalise the position of 'Webmaster' within the Committee from 2011 onwards. It has been a great deal of work for these three individuals, and we should recognise that formally with a round of applause. Steve Goble, ably assisted by his wife, Sue, has also been working hard to make things run smoothly both before and during this conference.

I mentioned that Sarah has dealt with trying circumstances in order to get this conference under way successfully. It is worth noting here what some of these have been, but first I need to supply some background. It has been the decision of your Committee over the last two years to take control of the ASM and break with the tradition of the past where a travel agent was appointed to organise the event from flights, to accommodation and diving services. This

initiative was largely mine and was certainly one that I have pursued passionately. Many in this room will be well aware of some of the issues raised as a consequence of the previous approach, some of which I believed, and continue to believe, were important ethical conflicts for the Society. Other considerations were the ageing demographics of our attendees and the overall cost of some of our exotically located meetings. We wanted to make the meetings more affordable and attractive to the non-diver as well as the active divers. As President, I take full responsibility for our change in policy, and, therefore, I also take responsibility for the division that has occurred within the Society as a result. It has not been universally popular, and some of those opposed to the change have voted with their feet and withdrawn from the ASM. This is deeply regretted, but perhaps inevitable. And so to why we find ourselves in Guam.

As most of you will know, our original plan was to return to one of our most popular stomping grounds, Palau. This proved quite problematic for two reasons – first, the cheap option for flights direct from Australia was withdrawn when the airline could no longer supply airworthy aeroplanes. Secondly, we were curiously unable to get the hotel in Palau to firmly commit to a room pricing offer based on their advertised rates for different standard rooms, and to allowing our attendees to book rooms on a 'first come, first served' basis. For both these reasons, Sarah and I made a decision to switch to this venue where the hotel and dive operators could not have been more helpful. And where the total cost to our members is considerably lower than it would have been with our original decision. Please talk to any member of the Committee to give your feedback on this and other decisions – we value your input enormously in our efforts to continue to provide attractive meetings.

A third consideration has been our first association with CVENT, a professional company which provides all the website functions to allow members to see details of the ASM, and to provide a single portal for booking registration, flights, accommodation and diving. This was not without considerable teething troubles, involving both financial and organisational stumbling blocks, but through which Sarah and Jan have led us admirably to a satisfactory conclusion. At this time, it is our intention to continue with this arrangement on an annual basis. It is certainly a great advance to be able to make all one's arrangements through a single portal, should you choose the options provided by SPUMS. Please note that there is no longer any suggestion that in order to be registered at the ASM, and to take part in all organised social activities, one needs to arrive on any particular flight or carrier, nor do you need to stay in the conference hotel. All SPUMS' interests lie in the number of registrants for our ASM – the rest is at your discretion. We look forward with great interest to see how this develops over the next few years.

While in a positive mood, I should also congratulate all of you who have turned up for another SPUMS ASM despite the many changes over the last year or two. We are an increasingly important scientific meeting in a small field and your Committee believes the future is bright – but it is all for nothing if we cannot rely on a solid core of regular attendees who find something they are looking for among the guest speakers and presenters of new work. Similarly, the Society cannot function effectively without the members taking an active interest in this ASM, and we, the Committee, appreciate your attendance here today.

Last year I suggested in my address to the ASM that SPUMS had reached a turning point. I stick to that view still. We continue to run on a knife-edge between a steady decline and a solid future. Membership numbers have continued to trend downward during the last year, but there are some signs we are reaching a new audience among our more junior colleagues. And we have the huge benefit of the journal *Diving and Hyperbaric Medicine*, as the latest and greatest diving and hyperbaric medicine journal to be listed by Medline through the National Library of Medicine in Washington. No mean feat! We need to build on these positive developments – and we need to continue to proselytise about the benefits of SPUMS membership.

My challenge to you remains as it was last year. First, we need to hear from as many of you as possible about your ideas for the future. Be as forceful and brutally honest as you wish. You are the experts on what this Society should be providing. Second, we need each of you to sell SPUMS membership and attendance at the ASM next year to just one person.

Finally, a word of thanks to our new committee members, all of whom have answered the call and agreed to devote every waking moment to the betterment of SPUMS. You will be introduced to them all at this meeting, and while it would not be appropriate for me to name them prior to official election or appointment, they know I am very happy and grateful to have them all aboard. Together they represent the future of SPUMS and will allow others of us to slip quietly into the backwaters of history – at peace at last!

I look forward to seeing many of you at next year's ASM – the comeback performance from one of our most accomplished conference organisers and a great destination.

Key words
Medical society, meetings

Original articles

Observation of increased venous gas emboli after wet dives compared to dry dives

Andreas Møllerløkken, Toni Breskovic, Ivan Palada, Zoran Valic, Zeljko Dujic and Alf O Brubakk

Key words
Bubbles, decompression sickness, diving tables, diving research

Abstract
(Møllerløkken A, Breskovic T, Palada I, Valic Z, Dujic Z, Brubakk A. Observation of increased venous gas emboli after wet dives compared to dry dives. Diving Hyperb Med. 2011;41(3):124-8.)
Introduction: Testing of decompression procedures has been performed both in the dry and during immersion, assuming that the results can be directly compared. To test this, the aim of the present paper was to compare the number of venous gas bubbles observed following a short, deep and a shallow, long air dive performed dry in a hyperbaric chamber and following actual dives in open water.
Methods: Fourteen experienced male divers participated in the study; seven performed dry and wet dives to 24 metres' sea water (msw) for 70 minutes; seven divers performed dry and wet dives to 54 msw for 20 minutes. Decompression followed a Bühlmann decompression procedure. Immediately following the dive, pulmonary artery bubble formation was monitored for two hours. The results were graded according to the method of Eftedal and Brubakk.
Results: All divers completed the dive protocol, none of them showed any signs of decompression sickness. During the observation period, following the shallow dives, the bubbles increased from 0.1 bubbles per cm^2 after the dry dive to 1.4 bubbles per cm^2 after the wet dive. Following the deep dives, the bubbles increased from 0.1 bubbles per cm^2 in the dry dive to 2.4 bubbles per cm^2 in the wet dive. Both results are highly significant ($P = 0.0001$ or less).
Conclusions: The study has shown that diving in water produces significantly more gas bubble formation than dry diving. The number of venous gas bubbles observed after decompression in water according to a rather conservative procedure, indicates that accepted standard decompression procedures nevertheless induce considerable decompression stress. We suggest that decompression procedures should aim at keeping venous bubble formation as low as possible.

Introduction

Testing of decompression tables is often done with the binominal end-point of decompression sickness (DCS) or no-DCS. This binominal, DCS/no-DCS, outcome is dependent on the clinical judgment of the investigator performing the medical investigation after test dives, and the signs and symptoms reported by the diver. It is commonly accepted that the primary cause of DCS is gas bubbles in blood and tissues. Such bubbles can be measured using ultrasound. Ultrasound, both Doppler and imaging, has been proven valid for indicating the risk of DCS after dives, and is also commonly used to indicate the level of stress that the diver has been exposed to.[1,2] The use of ultrasound is also attractive because it allows the number of dives needed to validate a procedure to be markedly reduced when using detection of venous gas emboli (VGE) as the end-point.[3]

The aim of the present study was to compare the number of VGE detected following a short, deep air dive and a shallow, long air dive in the same individuals in two different environments. All dives were performed by recreational divers and both profiles were tested both in a dry hyperbaric chamber and in open water. The decompression procedure tested was a Bühlmann diving algorithm, which, because of its long decompression obligations, has been considered one of the more conservative decompression algorithms.[4]

Methods

STUDY POPULATION

All experimental procedures were conducted in accordance with the Declaration of Helsinki, and were approved by the Ethics Committee of the Split School of Medicine, Croatia. All procedures and potential risks were explained to the participants in detail and they all gave written informed consent before the experiments. None of the divers participated in any other diving activity for a minimum of seven days before the start of the experiment.

A total of 14 experienced, male recreational divers were randomly divided into two groups ($n = 7$ in each). All had a valid medical certificate for diving and were clear of all symptoms of acute illness. Two of the divers were smokers (10 and 15 cigarettes per day), but all lung function values were within normal ranges (Table 1).

Table 1
Overview of the physiological characteristics of the divers; FVC - forced vital capacity; FEV_1 - forced expiratory volume in 1 sec

	Median	Range
Age (years)	34.1	26–46
BMI (kg m^{-2})	26.7	23.8–32.6
FVC (% predicted)	115.1	102.2–139.2
FEV_1 (% predicted)	106.3	88.5–127.8
FEV_1/FVC ratio (% predicted)	96.5	78.9–109.2

DIVING PROTOCOLS

Two different dive protocols were compared in this study. One deep, short dive (54 metres' sea water (msw) with 20 min bottom time) and one shallow, long dive (24 msw for 70 min bottom time). Compression rates were 10 msw min^{-1}, and decompression rates 9 msw min^{-1}. The decompression profile for the deep dive consisted of one stop for 1 min at 12 msw for 1 min, 5 min at 9 msw, 9 min at 6 msw and 27 min at 3 msw before ascent to the surface. In the shallow, long dive, the decompression consisted of a decompression stop at 6 msw for 22 min followed by a stop at 3 msw for 46 min before reaching the surface.

Both profiles were tested first in a dry hyperbaric chamber and then under field conditions (wet dives). During the chamber trials, the divers were seated resting at room temperature (approximately 20°C), performing no exercise. During the field trials, conducted in Split, Croatia, the divers were equipped with personal 7 mm neoprene wet suits, the water temperature being 16–18°C. Each diver was supplied with a dive computer (Galileo™, UWATEC, Switzerland) for verification of the dive profiles and monitoring of heart rate (HR). No exercise was performed during the bottom and decompression phases apart from any swimming needed to stay in position. No noticeable currents were recorded. Each diver performed two dives, one week apart. Seven divers completed matched dry- and open-water shallow dives and seven others completed matched dry- and open-water deep profiles. The sequence of the dives was the same under both dive conditions.

POST-DIVE MONITORING AND BUBBLE ANALYSIS

Observations for VGE commenced within 5 minutes following hyperbaric chamber exposures, while after the field dives, the divers were transported to the on-shore diving facility by boat, and it took approximately 15 min to begin VGE monitoring. The divers were placed in the supine position and a phase-array ultrasonic probe (1.5–3.3 MHz) was positioned to obtain a clear view of all four chamber sof the heart. The transducer was connected to a Vivid 3 Expert ultrasonic scanner (GE, Milwaukee, USA). The same, experienced cardiologists performed all echocardiographic investigations. Monitoring was performed every 20 min after reaching the surface for a total period of 2 hours, giving six recordings for each diver after each dive. Bubbles were observed in the pulmonary artery and the right ventricle as high intensity echoes. The cardiac images were recorded on S-VHS videotape for 60 seconds at rest and after two coughs. The bubbles were graded using the method described by Eftedal and Brubakk.[5] This grading system has been used extensively in several animal species as well as in man. The grading system uses the following definition:

0 – no bubbles;
1 – occasional bubbles;
2 – at least one bubble per 4th heart cycle;
3 – at least one bubble per cycle;
4 – continuous bubbling, at least one bubble cm^{-2} in all frames;
5 – "*white-out*", individual bubbles cannot be seen.

High-quality images were obtained in all subjects. The data were saved on tape and digitized on a personal computer (ATI Multimedia Center, ATI Technologies, USA). After grading, the values were transferred to a linear scale (bubbles per cm^2) as described previously.[6] The number of bubbles was determined at the end of each of the measurement points, and an average bubble number for the whole observation period was obtained. The divers were carefully monitored and asked about any symptoms of decompression sickness (DCS) by a diving medical specialist.

STATISTICAL ANALYSIS

Data are presented as median (range) and mean ± standard deviation (SD). Inter-dive comparisons of bubble grade were done with Mann-Whitney U tests. Differences in bubble grade, expressed as bubbles per cm^2, and HR between dry dives and in-water dives were compared using a Student t-test for unpaired samples. Statistical significance was set at $P < 0.05$. All analyses were done using Statistica 7.0 software (Statsoft Inc., Tulsa, USA).

Table 2
Changes in the amount of VGE during deep and shallow dives; * – $P = 0.0001$

	54 msw/20 min		24 msw/70 min	
	Dry dive	**In-water dive**	**Dry dive**	**In-water dive**
Median bubble grade (range)	0.0 (0–3)	3.0 (0–4)	0.0 (0–3)	2.0 (0–4)
Mean bubbles per cm^{-2} (SD)	0.1 (0.3)	2.4 (2.6)*	0.1 (0.3)	1.4 (2.0)*

Table 3
Comparison of the different decompression tables (in minutes) for the shallow-long dive (24 msw/70 min); total decompression time does not include swimming time between stops

Depth (msw)	Bühlmann	US Navy	Norwegian	DCIEM
6	22	-	5	7
3	47	23	20	30
Total decompression (min)	69	23	25	37

Table 4
Comparison of the different decompression tables (in minutes) for the deep-short dive (54 msw/20 min); total decompression time does not include swimming time between stops

Depth (msw)	Bühlmann	US Navy	Norwegian	DCIEM
12	2	-	-	6
9	5	1	5	6
6	9	5	10	8
3	27	17	15	25
Total decompression (min)	43	23	30	45

Results

All subjects completed both the wet and dry protocols without any symptoms or signs of DCS. Bubbles were observed in the right heart only (Table 2). The mean bubble number over the whole observation period increased from 0.1 bubbles per cm^2 after dry dives to 1.4 bubbles per cm^2 after wet dives on the shallow profile and from 0.1 to 2.4 bubbles per cm^2 on the deep profile ($P = 0.0001$ and $P < 0.0001$ respectively).

During the bottom phase of the in-water dives, the divers were instructed not to do any strenuous exercise, as is supported by HR data. The mean HR during the bottom phase was similar during the 24/70 dive (91.2 ± 15.6 beats per minute, bpm) and the 54/20 dive (93.6 ± 13.6 bpm) ($P = 0.8$). Heart rates from the dry chamber dives were not recorded.

The decompression obligation in the shallow, long dive is largest following the Bühlmann decompression table, compared to other tables (Table 3). For the short, deep dive, the Bühlmann decompression table gave almost the same obligations as the DCIEM table (Table 4).

Discussion

In this study, the number of VGE detected was used as an indicator of decompression stress after two different dive profiles tested in both a dry hyperbaric chamber and in open-water conditions. None of the dry dives led to large numbers of VGE being detected in any of the divers. However, when performing the same dives in water, the number of VGE increased dramatically. Despite this increase in decompression stress related to the amount of VGE, none of the divers developed any symptoms or signs of DCS.

There are obviously considerable haemodynamic differences between sitting in a dry hyperbaric chamber and swimming in water. At present, we have no good explanation as to why these differences should lead to differences in bubble formation. Even using wet-suits, divers in water will probably be colder during both the bottom and the decompression phase of the dives than divers resting at room temperature. In fact, an increase in bubble scores has been observed in warm conditions compared to cold conditions.[7] It was suggested that cold-induced peripheral vasoconstriction reduced inert gas uptake and hence the number of bubbles. A study which measured both DCS as an endpoint and VGE suggested beneficial effects of warm conditions during decompression (enhanced off-gassing from tissues) compared with deleterious effects of warm conditions during the bottom time (enhanced on-gassing during deepest part of the dive).[8] We did not monitor the core or skin temperatures of our divers, which is a clear weakness of this study. Regardless of temperature differences, we were surprised that immersion resulted in such a significant increase in the numbers of VGE following the dive.

In the development of the DCIEM air tables, schedules with >50% incidence of Kisman Masurel (KM) grading system grade 2 bubbles or higher were rejected.[9] In relation to the findings in the present study, the in-water schedules would both have been rejected. Initial experiments prior to the testing of the two dive profiles, together with the knowledge that Bühlmann procedures have apparently been used safely for many years, convinced us that the procedures we tested were safe to test on humans. The Bühlmann diving algorithm is recognised as one of the more conservative decompression algorithms. As can be seen in Tables 3 and 4, there are large differences between different decompression tables regarding these two specific dives. The first dive in the dry hyperbaric chamber supported this view. When the same procedure was tested in water in the same divers,

considerably higher bubble grades were observed. The present study points in the same direction as a previous study by Weathersby et al.[10]

The traditional endpoint for testing of decompression procedures has been the occurrence of DCS, based on the assumption that procedures that give no symptoms of DCS will have no effect upon the health of the individual. This outcome is dependent on the clinician performing the clinical investigation, as well as the symptoms reported and signs elicited from the diver. A challenge using VGE as a stress indicator after dives is that there is a large individual variability; the same dive can result in many bubbles or none at all, and the response to bubbles may also differ. At an Undersea and Hyperbaric Medicine Society 1989 workshop, the validation of decompression procedures was discussed in detail.[11] The workshop concluded that validation should primarily involve extensive, dedicated laboratory testing before putting the procedures into the field for "*operational evaluation*". By using ultrasound to detect VGE after decompression, the extent of the laboratory testing will be dramatically reduced compared to testing with the binominal endpoint DCS or no-DCS. Data from Sawatzky suggests that the absence of detectable bubbles is a good indicator of decompression safety.[1] In recent years, ultrasonic imaging systems have become more available and have been shown to be well suited to the detection of VGE.[12] While the ultrasonic Doppler method requires extensive training, both with regards to the monitoring itself and to the interpretation of the Doppler signals, the use of ultrasound imaging techniques requires less training and it has been demonstrated that the bubble grades from the different detection methods can be directly compared at rest.[6,12,13]

Recently, a reduction in ventricular and arterial endothelial function has been observed in divers when they returned to the surface.[14,15] This subclinical, asymptomatic alteration in cardiovascular function lasted up to three days after a single air dive, but was partially reversible with pre-dive antioxidant administration (vitamins C and E).[16] Thus, although high in this study, bubble scores after diving at the limits of the Bühlmann table do not appear to be predictive of DCS; their effects on cardiovascular and biochemical function should be studied in more detail to find the adverse effects of VGE. Such studies should also include the fitness level of the divers, as this has been reported to be negatively correlated with bubble formation after a dive.[17]

Hennessy and Hempleman postulated in their model for estimating risk in dives that $p\sqrt{t}$ (where p is absolute pressure in bar and t is time in minutes) can be used for evaluating dive stress.[18] The success of this model was demonstrated by Shields, who pointed out the inadequacy of existing tables to provide sufficient decompression as the pressure-duration exposure increases.[19] In North Sea professional divers, the incidence of DCS from air dives increased sharply above a $p\sqrt{t}$ value of 25.[20] That has led to a depth/duration limitation of nitrogen/oxygen dives to less than these levels for all professional dives in the United Kingdom.[19]

In the present study, the dives had a $p\sqrt{t}$ of 28.6 (54/20) and 28.8 (24/70) respectively. Despite the fact that both dive profiles in this study were above a $p\sqrt{t}$ 25 value, and generated a fair amount of VGE when conducted in water, no DCS occurred. This observation suggests that one should look for other possible test criteria than DCS/no-DCS when analysing a decompression schedule. However, these observations are based on a very small data set.

In Tables 3 and 4, the decompression requirements of four commonly used decompression tables are compared. The results from the present study would seem to indicate that the decompression requirements of most tables may be inadequate and could expose divers to considerable decompression stress in the extreme depth/duration ranges studied here. VGE is a practical way to evaluate decompression procedures, given the sometimes difficult clinical diagnosis of DCS, and we would suggest that less than grade III in 80% of a representative group of divers would be a useful set of criteria to distinguish acceptable dives from stressful dives.

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Risk factors and clinical outcome in military divers with neurological decompression sickness: influence of time to recompression

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Key words
Military diving, decompression sickness, hyperbaric oxygen therapy, recompression, outcome, treatment sequelae

Abstract
(Blatteau J-E, Gempp E, Constantin P, Louge P. Risk factors and clinical outcome in military divers with neurological decompression sickness: influence of time to recompression. Diving Hyperb Med. 2011;41(3):129-34.)
Background: This study was designed to examine the influence of short delay to recompression and other risk factors associated with the development of severe neurological decompression sickness (DCS) in military divers.
Methods: Fifty-nine divers with DCS treated in less than 6 hours from onset of symptoms to hyperbaric recompression were included retrospectively. Diving parameters, symptom latency and recompression delay were analysed. Clinical symptoms were evaluated for both the acute event and one month later.
Results: Median delay to hyperbaric treatment was 35 min (2–350 min). Resolution was incomplete after one month in 25.4% of divers with DCS. Multivariate analysis demonstrated that severe symptoms, classified as sensory and motor deficits or the presence of bladder dysfunction, were predictors of poor recovery with adjusted odds ratios (OR) of 4.1 (1.12 to 14.92) and 9.99 (1.5 to 66.34) respectively. There was a relationship between a longer delay to treatment and incomplete recovery, but the increased risk appeared negligible with an adjusted OR of 1.01 (1–1.02).
Conclusion: Our results suggest that neurological severity upon occurrence is the main independent risk factor associated with a poor outcome in military divers with DCS. Clinical recovery was not dramatically improved in this series when recompression treatment was performed promptly.

Introduction

Divers are at risk of decompression sickness (DCS) caused by bubbles of inert gas that may evolve in the tissues or blood due to supersaturation during decompression. Neurological signs involving the spinal cord and cerebral tissues are predominant in DCS, but the clinical symptoms may vary considerably from minimal subjective sensory abnormalities to paralysis and/or bladder dysfunction that could result in permanent disability.

Numerous, previous studies have been conducted with the aim of identifying possible determinants of outcome in neurological DCS, particularly the clinical presentation before treatment, the symptom latency after surfacing and the delay between the onset of symptoms and recompression treatment.[1–11] However, identification of preponderant factors that might prevent divers from developing severe neurological DCS remains elusive.

The question of whether time to treatment with hyperbaric oxygen (HBOT) influences the clinical outcome in DCS remains unanswered. There is conflicting evidence in the medical literature on whether DCS is more responsive to early rather than late HBOT. It is generally believed that the sooner you treat DCS, the better the outcome will be. However, numerous cases have been observed in which satisfactory outcome was achieved after many hours' delay, and, conversely, poor results were sometimes found in cases treated within the first few hours.[12,13]

In a recent study involving 279 cases of spinal cord DCS, we noted that delay to treatment with a median injury-to-recompression time of 4 h did not influence the recovery after statistical adjustment for confounding variables.[14] However, our analysis revealed that the optimal threshold value may be quoted as 6 h with less beneficial effect on outcome if HBOT was applied thereafter, thus supporting the assumption from previous works.[5,15] Preliminary results in animal studies have shown that DCS might be more responsive to recompression in the first minutes rather than after hours have elapsed. However, to date, there are no data on the potential beneficial effect for shorter delays to treatment in divers.[16]

The aim of this study was, therefore, to investigate the influence of time to treatment in French military divers with neurological DCS promptly recompressed in a hyperbaric chamber available at the diving site. We also sought to identify the role of other risk factors in clinical recovery.

Methods

PROCEDURE

We retrospectively reviewed the available clinical and diving data on 112 military divers treated for DCS in the French Navy from 1980 to 2007, including 66 cases with symptoms indicative of neurological DCS. Diving parameters such as bottom time, maximum depth, inadequate decompression with rapid ascent and repetitive dives within 12 h were

recorded. The following clinical data were also analysed: age, elapsed time between surfacing and initial signs, evolution of symptoms before recompression and time to recompression.

Two investigators reviewed the clinical data in order to ascertain the diagnosis of spinal cord or cerebral DCS, based on the presence of symptoms indicative of CNS injury (paraesthesiae, numbness, motor weakness, ataxia, visual disturbance, altered higher function or speech). Patients believed to have pulmonary barotraumas with cerebral arterial gas embolism (CAGE) were excluded. CAGE was diagnosed in the event of fast ascent or omitted decompression stops, associated with an early onset of altered consciousness, confusion, focal cortical sign or seizure after surfacing.

On the basis of the last neurological examination following all hyperbaric treatment, clinical outcome was grossly determined by the recovery status one month post-injury, i.e., full recovery or presence of residual neurological symptoms defined as persistent objective sensory, motor or urinary disorders.

First-aid normobaric oxygen was routinely administered after detection of initial symptoms. After complete clinical evaluation, all patients underwent recompression treatment with hyperbaric oxygen and standardised intravenous therapy with administration of methylprednisolone (120 mg) and aspirin (250 mg), according to our treatment protocol. Initial recompression complied with French Navy tables, mainly GERS B table, breathing 40% oxygen with 60% nitrogen at 405 kPa followed by staged decompression to surface with 60% and 100% oxygen breathing during 8 hours.[17] Additional HBOT sessions (253 kPa for 70 min), twice daily, were given until the patients fully recovered or until no further improvement could be observed after three further sessions. The study design was approved by the local ethics committee (HIA Ste-Anne Toulon).

STATISTICAL ANALYSIS

Clinical outcome was used as the dependent variable, i.e., full or incomplete recovery. Receiver operating characteristic (ROC) curves were used to find the optimal cut-off level for clinical information, i.e., the level that could discriminate between divers with sequelae and those without sequelae.[19] Univariate analysis was performed with Chi-square or Fisher's exact tests to identify significant variables ($P < 0.05$) predicting incomplete recovery. Variables with a P-value less than 0.20 were used as covariates in multivariate analysis with backward elimination logistic regression to control for potential confounders. Odds ratios (OR), adjusted OR and 95% confidence intervals (95% CI) were calculated. In a separate analysis, comparison for two variables between the injured divers with and without sequelae was performed using the Mann-Whitney U test. Calculations were done using the Sigmastat 3.0 software program (SYSTAT Inc., Richmond, CA).

Results

Fifty-nine of the 66 experienced male military divers with an average age (SD) of 31 (5.4) years were retained for analysis. Three divers with a diagnosis of CAGE and four divers with an elapsed time from onset of symptoms to hyperbaric recompression greater than 6 hours were excluded from this analysis. Of these 59 cases, 37 were classified as spinal cord and 22 as cerebral DCS. Seventeen injured divers reported isolated limb paraesthesiae, while 12 patients presented objective sensory symptoms with decreased pain perception and/or light touch skin sensation at multiple sites. The most common motor dysfunction observed initially was limb weakness, systematically associated with sensory loss ($n = 30$). Cerebral DCS involved mainly unilateral sensory and/or motor deficits of the face and arm with five cases of transient blurred vision, dysarthria, and concentration deficit or behavioural disorder.

Air was the breathing gas in 49 divers, whilst 10 subjects made dives breathing nitrox or tri-mix mixtures. Diving profiles were as follows: mean maximum depth (SD) 40 (12.5) metres' sea water (msw) and mean bottom time (SD) 16 (10.2) min. Four divers performed a provocative decompression schedule (i.e., omitted decompression) and repetitive dives were recorded in seven cases. The median time from surfacing to onset of initial symptoms was 15 min (ranging from immediate to 5 h 40 min).

The median time from onset of symptoms to hyperbaric recompression (time to recompression, TTR) was 35 min (range 2 min to 5 h 50 min). Of the 59 injured divers, 15 had incomplete resolution of neurologic symptoms after one month, all involving spinal cord lesions. Nine divers presented mild symptoms, such as residual paraesthesias or leg muscle strain on exertion, while six divers complained of severe disability, with bladder dysfunction, ataxia due to sensory myelopathy and paraparesis of varying degrees from case to case. Divers with cerebral symptoms did not exhibit sequelae after clinical evaluation and psychometric testing at discharge. The median number of additional HBOT sessions was one (range 0–40), with six patients receiving 20 treatments or more. The number of additional HBOT sessions received by the patients reflects the severity of neurological DCS, with a significant risk of a less favourable outcome when more than five treatments were required. Of the 59 cases studied, 17 were declared medically unfit for diving at discharge.

Univariate analysis revealed that the only two variables statistically predictive of a poor outcome were the severity of initial symptoms ($P = 0.017$) and bladder dysfunction ($P = 0.002$) (Table 1). Incomplete recovery was not associated with age ≥ 35 years ($P = 0.26$), depth ≥ 40 msw ($P = 0.41$),

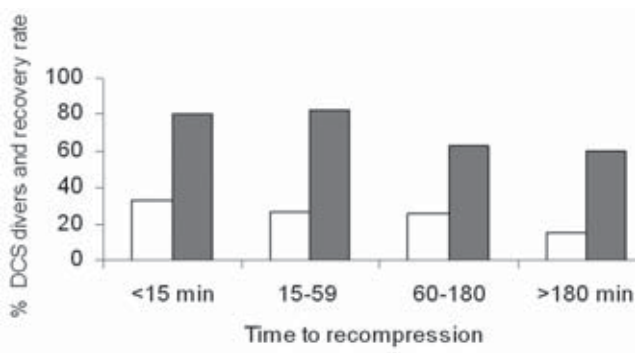
Table1
Analysis of clinical outcome in divers with neurological DCS according to diving data, clinical characteristics and treatment procedures

	Univariate analysis				Multivariate analysis	
Variable	**Full recovery**	**Sequelae**	***P***	**OR (95% CI)**	***P***	**adj OR (95% CI)**
Total (*n* = 59)	44	15				
Age (yr)			0.26	2.64 (0.7–10.1)	N/A	
< 35	37	10				
≥ 35	7	5				
Bottom time (min)			0.94	1.15 (0.35–3.7)	N/A	
< 15	25	8				
≥ 15	19	7				
Depth (msw)			0.41	1.97 (0.6–6.5)	N/A	
< 40	25	6				
≥ 40	19	9				
Repetitive dive			1	0.97 (0.17–5.42)	N/A	
no	38	13				
yes	6	2				
Controlled ascent			1	0.71 (0.07–6.9)	N/A	
no	4	1				
yes	40	14				
Delay onset of symptoms (min)			0.82	1.04 (0.32–3.37)	N/A	
< 15	21	7				
≥ 15	23	8				
Initial symptoms			0.017		0.032	4.1 (1.12–14.92)
Paraesthesia	17	0		N/A		
Sensory deficit	8	4		1		
Motor impairment	19	11		1.16 (0.28–4.76)		
Bladder dysfunction			0.002	14 (2.42–80.95)	0.017	9.99 (1.5–66.34)
no	42	9				
yes	2	6				
Delay onset of symptoms to recompression (min)			0.15	3 (0.82–10.86)	0.03	1.01 (1–1.02)
≤ 90	36	9				
> 90	8	6				
Treatment table regimen (kPa)			0.7	1.32 (0.29–5.92)	N/A	
405	37	12				
283	7	3				

bottom time ≥ 15 min (P = 0.94), repetitive dive (P = 1), rapid ascent (P = 1) or delayed onset of symptoms ≥ 15 min (P = 0.82). Multivariate analysis confirmed severity of initial symptoms and bladder dysfunction as the only independent predictors of poor outcome with adjusted OR of 4.1 (1.12 to 14.92) and 9.99 (1.5 to 66.34) respectively (Table 1).

TTR did not appear to influence the final outcome when univariate analysis was applied with a cut-off level of 90 min determined from ROC analysis (P = 0.15). However, since we observed a P value of less than 0.20, we added the variable "TTR" to the multivariate analysis (Table I). After adjustment, we noted a relationship between TTR and incomplete recovery (P = 0.03), but the increased risk appeared negligible with an adjusted OR of only 1.01 (1 to 1.02). In addition, Figure 1 illustrates the different rates of clinical recovery at one month with respect to TTR, showing

Figure 1
Effect of time to recompression on recovery status at one month post-injury in 59 subjects with neurological DCS; open bar = % subjects; solid bar = % full clinical recovery



that early treatment provided only a small portion of overall recovery.

Separate analysis showed that TTR was not significantly different in divers with full recovery (median time = 29.5 min) when compared with divers with incomplete recovery (median time = 37 min, P = 0.247). Additionally, we compared the prevalence rates of subjects presenting with sequelae who had a TTR of less than 15 min with those of a TTR of more than 15 min. Incomplete recovery was observed in 4 of 21 divers with time to treatment of less than 15 min and 11 of 38 for longer delays, but this difference was not statistically significant (P = 0.6). Among the 30 patients with 'severe' initial symptoms, the median TTR was shorter than for 'mild' cases, (23.5 versus. 60 min, not significant). Moreover, in this subgroup of 30 severe cases, no significant differences were identified after linear regression analysing TTR and presence of residual symptoms (P = 0.103).

Discussion

The prevalence of injured divers with incomplete recovery after neurological DCS is reported between 22% and 29.7% in DAN reports, including large series.[19,20] Our results are in accordance with these data, despite the difference in diving population. We found that variables usually considered as potential risk factors such as age, onset of initial symptoms, depth, repetitive dives or provocative decompression profiles, were not associated with residual deficit. On the other hand, the severity of the presenting symptoms and signs was the only predictor of a poor outcome, consistent with previous reports in other diving populations.[3,4,10] The observation that poorer outcome was associated with the need for more HBOT is consistent with previous reports underlining a linear relationship between the number of HBOT sessions and the admission clinical score.[21]

We observed that the influence of TTR on outcome was not clear and a short TTR had little additional benefit on clinical recovery. Indeed, medical evidence supporting the relative importance of TTR in DCS is controversial (Table 2), notably, if we consider that the usual delay for recompression recorded in most clinical studies is quite long with a median time ranging from 6 to 24 hours.[3,10,11] In a study of 49 cases of spinal cord DCI, it was observed that in the severely injured group, treatment within 12 h was more beneficial than after 24 h.[3] In 1,159 DCS cases of the Divers Alert Network (DAN) database from 1987–1990, long delays were associated with less successful initial decompression and a higher incidence of residual symptoms.[22] However, after logistical regression analysis this association between treatment delay and initial recompression disappeared, and the association between treatment delay and residual symptoms after three months became weak. In a study of 466 cases of "*dysbaric disorder*", analysis did not reveal any relationship between the number of hours' delay and the initial, medium and final outcome.[9]

The short time window, from symptom onset to treatment initiation has been examined in some other studies with differing outcomes. In 847 cases of DCS, a clear relationship was shown between improved outcome and earlier HBOT, including cases treated within 15 min.[2] However, pain symptoms were preponderant in this study (91.8% type 1 DCS). In a series of 50 cases of neurological DCS in military divers (a study comparable to ours), the outcome was no different in those recompressed within one hour compared to those treated thereafter.[8] In another series of 96 divers treated for neurological DCS, the delay between emerging from the water and recompression was not different in divers without sequelae (median = 185 min) when compared with divers with sequelae (median = 203 min).[23] A clinical audit conducted on 390 divers having undergone HBOT in less than six hours in Scotland concluded that the relationship between time to treatment and poor condition on discharge for severely affected cases was weak, with an insignificant increased risk of sequelae.[5] Finally, the latest surveys, on large series of divers with DCS in Scotland or in France, support the view that the optimal time to recompression should be no more than six hours.[14,15,24] A summary of the findings of these various studies is shown in Table 2.

Our study suggests that military divers presenting with less serious neurological symptoms could wait a few hours for recompression therapy with less concern for ultimate successful recovery, whereas patients with neurological symptoms showing objective sensory deficits and motor impairment should be recompressed in as short a time frame as possible. However, our data also revealed that the shortest TTR, i.e., less than 15 min, was not a guarantor of better recovery. This finding is consistent with a previous experimental study indicating that irreversible Wallerian degeneration of the central nervous system from DCS in pigs occurred within a very short period of time, despite recompression treatment as early as 10 min after surfacing.[26] We are aware that the lack of a statistically significant effect of TTR on recovery, specifically in the severely injured group, may be because the small sample size of our study decreases the ability of the analysis to detect small differences. Whether TTR acts as a gradual progression or as a step change is still unresolved and further prospective work is needed to determine the real impact of short TTR on recovery.

In conclusion, our study suggests that neurological severity at presentation is the main independent risk factor associated with a poor outcome from DCS in military divers. Our data also revealed a statistical relationship between a shorter delay before treatment and higher probability of complete resolution of symptoms, but this association does not seem to be of clinical relevance.

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Table 2
Published case series on the relationship between time to recompression treatment and clinical outcome in divers with neurological DCS; * – this significance was lost on multivariate analysis

Studies	Population	*n*	Recompression delay (h)	% recovery at discharge	*P* - value
Kizer 1982[10]	Neurological DCS	26	12–24	84%	< 0.05
			> 24	54%	
Van Hulst 1990[11]	Neurological DCS	48			
		34	< 12	77%	0.052
		14	> 24	43%	
Méliet et al 1990[8]	Neurological DCS	50			
			< 1	92%	NS
			> 2	86%	
Ball 1993[3]	Spinal cord DCS	49			
		21	< 12	73%	NS
		20	> 24	56%	
	Severe cases	24			
		9	< 12	55%	0.008
		12	> 24	18%	
Blatteau et al 2010[14]	Spinal cord DCS	279			
		197	≤ 6	73%	0.023*
		82	> 6	42.3%	OR 1.8 (1–3.3)
			Median delay (min)		
Boussuges et al 1996[23]	Neurological DCS	96			
	full recovery		185		NS
	incomplete recovery		203		
Stipp 2007[15]	Neurological DCS	343	243		< 0.05

system. The opinions and assertions contained herein are those of the authors, and are not to be construed as reflecting the views of the French Navy.

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Retinal artery occlusion: visual outcome after treatment with hyperbaric oxygen

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Key words
Retinal artery occlusion, hyperbaric oxygen therapy, outcome, case reports

Abstract
(Cope A, Eggert JV, O'Brien E. Retinal artery occlusion: visual outcome after treatment with hyperbaric oxygen. Diving Hyperb Med. 2011;41(3):135-8.)
Methods: We describe a case series of 11 patients with retinal artery occlusion treated with hyperbaric oxygen therapy (HBOT) at Intermountain Dixie Regional Medical Center between 2005 and 2009. We then combined data from our case series with data from two other case series to report on a combined total of 51 patients.
Results: Eight of our 11 patients achieved improved visual acuity. Analysis of the combined case series showed that 74% of patients treated with HBOT had improvement in visual acuity (*P* less than 0.0001) with 53% improving two lines or more on a modified Snellen value. The combined case series also showed that visual acuity improved in all time-from-occlusion to treatment categories, ranging from less than 8 hours to six days.
Conclusions: We recommend consideration of HBOT for patients who present with recent retinal artery occlusion. Hyperbaric centres treating these patients should consider forming a central registry of standardised data to prospectively study the results of therapy.

Introduction

Retinal artery occlusion (RAO) is characterised by a sudden, usually unilateral, painless loss of vision. Occlusion may result from thrombosis, embolus, arteritis or vasospasm.[1] Occlusion may not be complete. Many patients present with some light perception or visual loss in only one or two quadrants. Permanent visual loss generally occurs if the occlusion continues for more than a few hours. Prognosis depends on the level of occlusion, cilioretinal artery sparing and how quickly oxygen supply can be restored to the retina.[1] One explanation for variable visual loss is that the retina has a dual oxygen supply. The inner layers of the retina receive oxygen from the central retinal artery and the outer layers are supplied by the choroidal circulation from the posterior ciliary arteries.[2] Fifteen to 30% of eyes have a cilioretinal artery which branches off the posterior ciliary artery and enters the optic nerve disc separately from the central retinal artery, providing an alternate blood supply to the retina if the central retinal artery is occluded. It looks like a short hook at the edge of the disc. Another factor in explaining variability of loss is the amount of potentially salvageable tissue at the periphery of the ischaemic area, called the 'ischaemic penumbra'.[1]

The natural history of RAO is recannulation of the artery over a few days resulting in some spontaneous improvement of vision. Visual outcome has been reported in 244 consecutive patients seen from 1974 to 2000.[1] Of the ninety-nine patients presenting within seven days after RAO, 38% had some improvement of vision with no treatment. Many different treatments for RAO have been tried, none of which have shown significant improvement versus no treatment.[3–6] Hyperbaric oxygen therapy (HBOT) has been associated with improvement in visual acuity in retrospective studies.[7–10] HBOT can maintain oxygenation of the retina through the choroidal blood supply, decrease oedema and preserve compromised tissue adjacent to the ischaemic area.[2]

The purposes of our study were twofold. First, we reviewed patients with RAO treated with HBOT at our institution. Secondly, we combined our data with two other similar case series, making a total of 51 patients. Our two hypotheses were that HBOT resulted in improved visual acuity compared with the spontaneous improvement reported with no treatment and that improvement of visual acuity would be correlated with time from visual loss to treatment.

Methods

The hyperbaric chamber at Intermountain Dixie Regional Medical Center (DRMC) is located at an altitude of 811 metres above sea level, with a usual barometric pressure of about 101 kPa. DRMC is a regional referral centre for about 250,000 patients in small towns and rural areas. The next closest hyperbaric chamber is 193 km away and the closest centre that could provide angiography of the ophthalmic artery and instillation of thrombolytic therapy is 482 km away. This retrospective review was approved by the Intermountain Institutional Review Board.

CASE SERIES

Eleven patients with RAO were treated with HBOT at DRMC between 2005 and 2009. The referring ophthalmologist made the diagnosis and assessed visual acuity, presence of cilioretinal artery sparing and visual fields. Patients were interviewed by the treating hyperbaric physician before and after each treatment and given a hand-held standard Snellen chart to read at the recommended distance of 12 to 16 inches

from the affected eye, with the unaffected eye covered. For individuals who could not distinguish letters on the Snellen chart, (acuity worse than 20/800), visual acuity was reported as counting fingers (CF), hand motion (HM), light perception (LP), or no light perception (NLP). Time from visual loss to start of HBOT was recorded.

The medical charts in our case series were reviewed for a history of diabetes, previous eye surgery, or prescription medications for hypertension or hyperlipidaemia. The diagnosis of diabetes, high cholesterol or hypertension was based on diagnosis in the Intermountain electronic medical record or the patient taking medications for those diagnoses. HBOT was at a pressure of 243 kPa, twice daily for the first five treatments, and then daily until there was no further improvement in visual acuity. A total of 90 minutes of oxygen was given by head hood for each treatment in three 30-minute increments with a 5-minute air break in between oxygen increments.

COMBINED CASE SERIES

Two other case series in the literature were found where patients with RAO had received HBOT and the results were reported in table format with similar detail to our case series.[7,11] The data from the three case series were combined for analysis. Data for each patient in the combined case series analysis included: visual acuity, age, gender, time from onset of occlusion to beginning of treatment, number of HBOT treatments and pressures used in each treatment. Presence of cilioretinal artery sparing was unknown in the two other case series. Results reported are: percentage of patients with improved visual acuity, percentage of patients with visual acuity improved two or more increments of the modified Snellen scale and time-to-treatment versus improvement.

Visual acuity is reported in decimal values, using the table published by Holladay to convert Snellen values to decimal values.[12] Visual acuity increases by a geometric progression on a logarithmic scale. Since standard Snellen values are only listed to 20/800, Holladay calculated the values of counting fingers (CF) and hand motion (HM) by geometric progression. He gave counting fingers (CF) the Snellen value of 20/2,000, which converts to a decimal value of 0.01. Detection of hand motion (HM) was given the Snellen value of 20/20,000, which converts to a decimal value of 0.001. These values progress sequentially by a factor of 10.[12] As LP and NLP occur in consecutive order of decreasing visual acuity directly after CF and HM we arbitrarily estimated each step of decreasing visual acuity by a factor of ten. This does not presume a linear relationship. Light perception was assigned a Snellen value of 20/200,000 and a decimal value of 0.0001. NLP had a Snellen value of 20/2,000,000 and a decimal value of 0.00001. These assigned Snellen values, converted to decimal values, were used to calculate pre- and post-HBOT visual acuity for each patient included in the combined case series analysis.

STATISTICAL ANALYSIS

Statistical analysis was performed to answer two questions. Firstly, was improvement in visual acuity significantly greater than that expected by spontaneous improvement? Secondly, was improvement positively correlated with shorter time from onset of visual loss to start of HBOT?

To provide an appropriate control group allowing for the spontaneous improvement seen historically with no treatment, we used the percentage of patients improved who presented within seven days of visual loss in the report by Hayreh and Zimmerman.[1] Analysis of observed versus a 38% expected spontaneous improvement was performed using a one-tailed Z test and chi square test with a Haber correction for continuity. (Systat version 10, Systat Software Inc). A P-value of < 0.05 was accepted as significant.

Patients in the combined case series analysis were assigned to one of four time-to-treatment groups according to the time that elapsed from occlusion to the start of the first HBOT: 0 to 8 hours, 9 to 24 hours, 25 to 72 hours and more than

Table 1
Case series at DMRC; hours' delay was from onset of visual loss to start of first HBOT; chol – cholesterol

No	Sex	Age	Delay (hrs)	Diabetic	High chol	High BP	Prev. eye surgery	Treatments total #	Acuity before HBOT	Acuity after HBOT	Increments of improvement
1	M	58	9	Yes	Yes	No	No	6	0.00001	0.0001	1.0
2	F	81	6	No	Yes	No	Yes	5	0.00001	0.001	2.0
3	F	55	8	No	No	Yes	No	5	0.00001	0.001	2.0
4	M	71	72	Yes	Yes	Yes	No	5	0.00001	0.001	2.0
5	M	22	24	Yes	No	No	Yes	5	0.00001	0.4	9.0
6	M	75	18	No	Yes	Yes	No	5	0.0001	0.25	6.5
7	F	66	6	No	Yes	Yes	No	5	0.001	0.001	0.0
8	M	78	24	No	Yes	Yes	No	7	0.001	0.4	7.0
9	M	65	5	No	Yes	Yes	Yes	21	0.01	0.25	4.5
10	F	24	144	No	Yes	Yes	No	5	0.05	0.05	0.0
11	F	75	72	No	No	Yes	No	10	0.4	0.4	0.0

72 hours. Any improvement versus time-to-treatment was analysed using the MANOVA test from the Systat program. A *P*-value of < 0.05 was accepted as significant.

Results

DRMC CASE SERIES

Eleven patients were referred from their ophthalmologist for sudden, unilateral, painless loss of vision diagnosed as retinal artery occlusion. All patients received a minimum of five HBOT (Table 1). HBOT was well tolerated with no significant side effects such as barotrauma or oxygen toxicity symptoms.

Data collected on the 11 patients treated at DRMC are shown in Table 1 and the main clinical features are summarised here. Five of the patients with unilateral loss presented with NLP. One improved to LP (Patient #1). Three patients improved to HM (#2,3,4) and one to 20/50 (#5). One patient presented with LP only (#6). He improved to 20/80. Two patients presented with HM only. One did not improve (#7) and one improved to 20/50 (#8). One patient presented with CF (#9). He improved to 20/80. One patient (#10) presented with NLP in the upper half of the affected eye, but overall visual acuity of 20/400 in the eye. Visual acuity did not change after treatment, but visual fields were regained except for a small central scotoma. One patient with a patent cilioretinal artery (#11) presented with a black band across the center of the eye. Visual acuity was unchanged at 20/50, but the band was about 50% smaller in size after HBOT.

We did not see any significant trends between improvement in visual acuity and a diagnosis of diabetes, hyperlipidemia, hypertension or previous eye surgery. The data are included to facilitate future detailed case series reports.

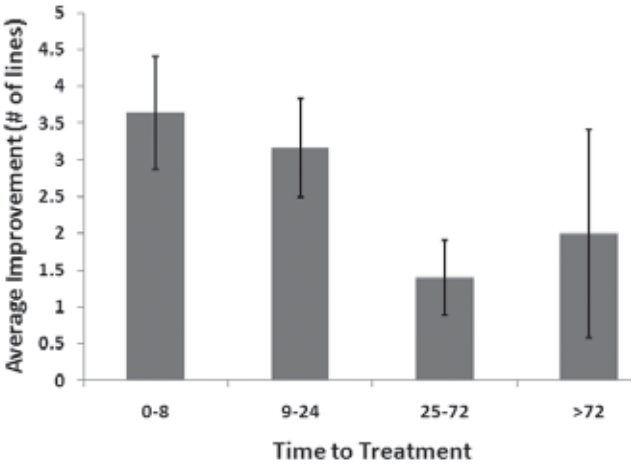
COMBINED CASE SERIES ANALYSIS

The total number of patients treated with HBOT in the combined case series is 51; 11 at DMRC, 19 and 21 respectively in the other two case series.[7,11]

Visual acuity

There was a similar distribution of initial visual acuity to those reported by Hayreh and Zimmerman: two had acuity of 20/50 to 20/100; six had acuity of 20/200 to 20/400 and 43 had vision worse than 20/400. HBOT was associated with improvement in visual acuity independent of the time-to-treatment category (t_{50} = –4.372, $P < 0.001$). Thirty-eight of the fifty-one (75%) of patients who received HBOT had any improvement in visual acuity, which is significant compared to expected spontaneous improvement of 38% (Z score = –4.19, $P < 0.001$; Chi square = 3.841, $P < 0.001$). Twenty-eight patients improved by two incremental values or better on the modified Snellen scale (Z score = –1.92, $P < 0.05$).

Figure 1
Time-to-treatment and improvement in visual acuity; error bars are 1 standard error



Time-to-treatment and improvement

Figure 1 shows the average improvement in visual acuity by time-to-treatment categories. Seventeen patients were treated within 8 hours of visual loss and 13 improved. Twenty of 25 patients treated within 9–24 hours after visual loss improved. Four of five patients treated within 25–72 hours improved and two of four patients treated between 73 and 144 hours of visual loss improved.

Discussion

The natural history of RAO is that of irreversible visual loss that traditional treatments have not been successful in regaining, though occasionally there will be spontaneous improvement in vision with no treatment. Of the 99 patients presenting within seven days after RAO reviewed by Hayreh and Zimmerman, 38% had some improvement of vision with no treatment, this being less likely the worse the presenting visual loss.[1] Of 84 patients with visual acuity of counting fingers or less, 15 had cilioretinal artery sparing, and in 10 of these, visual acuity improved spontaneously, whereas only 15 of 69 patients without cilioretinal artery sparing showed improvement.[1]

Local intra-arterial fibrinolysis does not appear to improve outcome more than conservative therapy and has been associated with 37.1% adverse reactions.[6] Treatments such as ocular massage or pharmacologic agents to reduce intra-ocular pressure have failed to improve outcome. Effectiveness of HBOT needs to be measured against spontaneous improvement observed with no treatment. We believe that comparing our combined case series of HBOT patients to the 99 patients reported by Hayreh and Zimmerman is useful and valid.[1] The improved visual acuity following HBOT was significant versus no treatment.

Analysis of our combined case series demonstrated a clear

trend towards poorer recovery if patients presented more than 24 hours following visual loss. Because of the small number of patients in the delayed treatment groups, the results were not statistically significant. Most clinicians believe that the sooner oxygen is restored to ischaemic tissue, the better the outcome. Hayreh et al cite their study in rhesus monkeys showing that RAO lasting for 240 minutes resulted in massive irreversible damage.[13] Patients may not present with complete occlusion proximal to branching of the posterior ciliary arteries and consequentially have a longer interval to irreversible damage. Butler et al cite several case studies reporting patients regaining vision with HBOT treatment delays of up to two weeks, but feel the best evidence is with a delay of less than 12 hour.[2] Hertzog et al noted HBOT was most useful when started within 8 hours of onset of visual loss.[7] Beiran treated all patients with HBOT within 8 hours of symptom onset and found 82% of HBOT patients improved versus 29.7% of no-HBOT controls.[8] Butler et al summarised selection criteria for emergent HBOT.[2] Criteria included patients who presented within 24 hours of acute painless vision loss, had visual acuity of 20/200 or worse with pinhole testing, age over 40 years and no history of recent eye surgery, trauma or "*flashes or floaters prior to visual loss*".[2] Even without an exact linear relationship, our data support those selection criteria, as visual recovery drops dramatically when patients present more than 24 hours following visual loss.

Retinal artery occlusion is an uncommon event and most hyperbaric chambers treat only a few such patients annually. A central registry for RAO would be an effective way to further broaden and strengthen therapy results. The entries should include gender, age, presence of cilioretinal artery, visual acuity before and after HBOT, time from symptom onset to treatment, number of treatments and treatment pressure. Additional data for co-morbidities such as diabetes, hyperlipidaemia, hypertension and prior eye surgery would be useful and may help predict which individuals are more likely to respond to hyperbaric oxygen therapy.

Conclusions

Eight of 11 patients treated for RAO with HBOT between 2005 and 2009 had some improvement in vision. No trends related to co-morbidities such as diabetes, hyperlipidemia, hypertension or previous eye surgery were seen. A combined case series analysis of our data with two other case series concluded that a significantly increased proportion of patients treated with HBOT had improvement in visual acuity compared to historical controls and that visual acuity improved in all time-delay categories. Chances of recovery were much less if patients presented more than 24 h after visual loss, but only nine patients presented after 24 h. We recommend consideration of HBOT for patients who present with recent RAO and hyperbaric centres treating these patients should consider forming a central registry of standardised data to prospectively study their results.

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Review article

The need for optimisation of post-dive ultrasound monitoring to properly evaluate the evolution of venous gas emboli

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Abstract
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Audio Doppler ultrasound and echocardiographic techniques are useful tools for investigating the formation of inert gas bubbles after hyperbaric exposure and can help to assess the risk of occurrence of decompression sickness. However, techniques, measurement period and regularity of measurements must be standardised for results to be comparable across research groups and to be of any benefit. There now appears to be a trend for fewer measurements to be made than recommended, which means that the onset, peak and cessation of bubbling may be overlooked and misreported. This review summarises comprehensive Doppler data collected over 15 years across many dive profiles and then assesses the effectiveness of measurements made between 30 and 60 minutes (min) post-dive (commonly measured time points made in recent studies) in characterising the evolution and peak of venous gas emboli (VGE). VGE evolution in this dive series varied enormously both intra- and inter-individually and across dive profiles. Median, rather than mean values are best reported when describing data which have a non-linear relation to the underlying number of bubbles, as are median peak grades, rather than maximum, which may reflect only one individual's data. With regard to monitoring, it is apparent that the evolution of VGE cannot be described across multiple dive profiles using measurements made at only 30 to 60 min, or even 90 min post-dive. Earlier and more prolonged measurement is recommended, while the frequency of measurements should also be increased; in doing so, the accuracy and value of studies dependent on bubble evolution will be improved.

Introduction

Audio Doppler ultrasound or echocardiographic imaging techniques are useful and practicable tools for the detection of venous gas emboli (VGE), often known as asymptomatic or 'silent' bubbles, following hyperbaric exposure. The techniques are important as they can help to assess the risk of decompression sickness (DCS) occurring. However, these techniques will only be of benefit so long as equipment, procedures and classification of the bubbles are effective, comprehensive and standardised, so that good-quality data are produced that can be compared across research groups.

In some recent decompression physiology studies, it seems that the advice given on the frequency and period over which bubble monitoring should take place, given by the pioneers of the techniques, is being ignored. For example, Nishi and co-workers proposed that for most non-saturation dives, monitoring should commence within 20 minutes (min) of surfacing, and then continue at 30 to 40 min intervals for at least two hours.[1] They also noted that "*in many studies*" only one monitoring session was conducted and hence, "*those studies were of limited value*". Despite these recommendations, it now seems commonplace to carry out studies investigating decompression risk with as few as two bubble measurements, usually between 30 and 60 minutes post-dive. Table 1 shows the dive profile type and Doppler measurement details for nine studies published between 2004 and the present.[2–10] It can be noted that, of the nine, the most commonly adopted time period for measurement was up to 60 minutes post-dive (five studies), while one measured up to 80 minutes post-dive and three to 90 minutes post-dive, all being less than the recommended 120 minutes.

In the studies summarised in Table 1 and in others, reference is often made to 'peak' or maximum bubble grades, and these data are then used to infer risk of one dive profile or intervention against another.[2,5] For these inferences to be comparable and correct, workers must be able to state, with a high level of confidence, that their reported values do indeed observe the peak of bubbling. Although researchers may have an informed idea of the period in which they would expect bubbles to occur post-dive, in reality, a wide range of inter- and intra-individual variation in the onset, peak and amount of VGE observed should always be expected, even while investigating sequential dives with the same profile and same subjects. Also, when the divers are subjected to various physiological or pharmacological interventions, unless pilot studies have been performed, it is not possible to state with any certainty when the bubbles will appear. In many cases, if measurements are not made soon after surfacing (within 30 min, though preferably 15 min), or are not continued after 60 min, then the onset and peak

Table 1
Reviewing the trend towards fewer Doppler/2D ultrasound measurements and reduced measurement periods

Study	Dive profile		Number of measurements	Time period (min post-dive)	When post-dive (min)
	Depth (msw)	Time (min)			
Dujic et al 2004[2]	18	80	Four	20–80	20, 40, 60 and 80
Berge et al 2005[3]	60	45		0–60	Discontinuously
Blatteau et al 2005[4]	30	30	Two	30–60	30 and 60
Blatteau et al 2007[5]	30	30	Three	30–90	30, 60 and 90
Blatteau et al 2008[6]	30	25	Three	20–60	20, 40 and 60
Lemaitre et al 2009[7]	Children's air dive		Three	20–60	20, 40 and 60
Pontier et al 2009[8]	30	30	Three	30–90	30, 60 and 90
Germonpré et al 2009[9]	30	30	Three	30–90	30, 60 and 90
Bosco et al 2010[10]	30	20	Two	20–50	20 and 50

of bubbling might actually be missed and the monitoring rendered inadequate, particularly in studies where a full picture of bubble evolution is necessary for the interpretation of results. In truth, many diving studies now rely solely on their bubble data, be it audio Doppler or 2D-ultrasound image data, as indices for their hypothesis. Therefore, it should follow that it is sensible to collect as much VGE data post-dive as possible, in order to present the clearest picture of the subject's response to that particular exposure and/or intervention.

In the early 1990s, the majority of Doppler monitoring made by our group and associates was carried out at relatively frequent time intervals, as the importance of regular monitoring was recognised. Measurement usually started at around 15 minutes post-dive and persisted at 15 to 30 min intervals for at least two hours or longer; for example, in the case of a saturation dive. However, given that many of the dives performed were submarine escape exposures, i.e., very rapid, deep, bounce dives with rapid compression and decompression, it soon became apparent that waiting until 15 min after surfacing would mean that the onset or peak of bubbling was quite likely to be missed. Only the tissues with very short half-times would have time to become supersaturated during an escape profile and, therefore, were likely to off-gas almost immediately after the exposure. Hence, Doppler measurements commenced as soon as possible after surfacing and were made at 5-min intervals for the first 30 min, and every 15 min thereafter for at least 120 min depending on the dive protocol and information needed, often continuing until bubble evolution had ceased. In this way, it became common practice for most post-dive monitoring, irrespective of profile, to be carried out according to this schedule whenever possible. One Doppler operator was able to attend to at least two subjects every five minutes with ease, and so there was no drawback to continuing in this way; the comprehensive information collected on the evolution of VGE in the first 30 min after surfacing for a wide variety of dives made the effort more than worthwhile.

This review presents retrospective observations on some of these data, using a number of studies that were representative of each type of dive profile, to determine the natural history of VGE evolution across all types of dives and so to indicate just how effective measurements made between 30 to 60 min post-dive are in characterising bubble evolution and peak grades.

Methods

Over the last 15 years, we have collected a large amount of post-hyperbaric exposure Doppler data from a wide variety of dive profiles, both wet and dry, using both human and animal subjects. All of the data used in the present study were taken from studies using either human or animal subjects. All human studies complied with the Declaration of Helsinki (1975) and were reviewed by a local ethics committee, while all animal work was carried out under the UK Animals (Scientific Procedures) Act (1986) and was also reviewed by a local ethics committee. The profiles include:

Simulated submarine escape exposures: usually involving a rapid compression to depth within 30 s or less, and then decompression at a rate of around 2.75 m s^{-1}. The range of depths used in studies ran from around 800 kPa (70 metres' sea water, msw) to 3,000 kPa (290 msw), with an escape from 2,500 kPa (240 msw) reported here.

Simulated saturation dives: the saturation dive reported here involved 24 h exposure to 180 kPa (8 msw).

Simulated saturation plus submarine escape exposures: these dives typically involved a 24 h, 180 kPa (8 msw) saturation exposure followed by compression to an escape depth of 2,500 kPa (240 msw) and decompression to the surface, with compression/decompression rates as for the escape profile above.

Bounce dives: of varying duration and depth that are too great in number to categorise fully here, though they may be loosely categorised into long bounce dives and short bounce

dives. (see Figures 4 to 11 for examples of the profiles used in these trials).

Post-dive Doppler measurements were made using the same pool of operators (five people) for all of these exposures, and all were trained to use the Kisman Masurel (KM) grading system; their proficiency was regularly assessed at DERA/QinetiQ Alverstoke, UK.[11] The equipment used to make the Doppler measurements were Doppler Bubble Monitors (Techno Scientific, Ontario, Canada) using a 2.5 MHz transducer probe, with measurements made in the precordial area.

The animal model used was the goat; all animal Doppler measurements were made at rest out of necessity, as the goat could not be trained reliably to perform a prescribed movement. When working with human subjects, measurements were generally taken at both rest and after movement. 'Movement' measurements are usually made to help the operator; if a dynamic movement is made using large muscles, such as those in the legs, it increases venous return and so any bubbles present are likely to arrive at the heart in a flurry that is more discernable than a trickle of bubbles, as might be heard at rest. Generally, resting measurements are used when reporting the data, but movement measurements may give a more accurate picture of the onset and cessation of bubble evolution as relatively stationary bubbles, probably located in the capillaries at the periphery of the circulation, can be dislodged by the movement.

Measurements made earlier in this 15-year period of study were generally made with the subject in an upright position, where movement measurements involved the subjects making a deep knee bend, the operators then grading the resulting sound. More recently, measurements have been made with subjects lying in the left lateral decubitus position, which means that measurements made using audio Doppler are comparable to 2D-visual ultrasonic measurements using echocardiography. In this position, movement measurements were made after the subject vigorously extended and retracted their legs from the hip three times, so essentially making knee bends, but while lying down. Also, it seems that a more reliable measurement may be made from this decubitus position than when the subjects are upright. As the heart falls slightly forward in the chest in this position, operators may find that those subjects with deep chests, on whom it is often difficult to make standing measurements upon, are easier to listen to in this position.

Most of the measurements were made at time intervals as described in the introduction, usually every 5 min for the first 30 min post-surfacing, then at 15-min intervals until at least 120 min had passed post-surfacing. In some cases monitoring continued (particularly in the case of saturation dives) every hour until bubbles ceased to be heard. Monitoring was sometimes constrained by operational limitations; for example, regular measurements could not be made at the start of the post-dive period in divers arriving back on a boat until they had returned to shore, though at least one measurement was made on the boat, as close to surfacing as possible.

Once the KM measurements were made, the resulting codes were converted into KM grades and entered into a computer spreadsheet. It must be noted that KM grades cannot be treated as numbers, as the KM scale is not an interval, but ordinal scale, producing ranked, non-parametric data. The KM scale is highly non-linear, that is, the differences between Grades 0 and I are not the same as between grades I and II, or between II and III, for example. Therefore, calculation of the mean bubble grade at a given time point is not appropriate; median values give a more conservative and statistically sound inference, particularly when using non-parametric statistics.[1] Therefore, maximum, median and minimum grades for each recorded time point across all subjects were calculated; these calculations were made separately for the resting and movement data. It is thought that using median values to report bubble evolution gives a good representation of the data for most dive profiles for comparison, with some exceptions; for example, where the median score is zero. In these cases, maximum scores may be more informative.

Care should be taken when discussing 'peak' bubble scores. In the present study, the term 'median peak' Doppler grade is used, that being the point at which the median KM grade for all subjects across the entire period over which VGE were measured, was at its highest. To use the maximum data line to describe 'peak' bubbling may be misleading, as it may represent only one individual's data.

Figures 1–11 show Doppler data from various dive profiles with maximum, median and minimum measured KM grades. All dives are dry chamber dives, unless otherwise stated. The data included are representative; they are not presented in order to be analysed statistically, but rather to illustrate the points at which the onset and cessation of VGE evolution have been observed in a number of studies.

In reporting both maximum and minimum Doppler grades across the study groups, as well as the median, these data also show that VGE evolution can vary enormously between individuals exposed to the same profile. It is also implicit that the data show the difference between dive profiles; for example, it would not be expected that bubble onset or duration would be the same following an escape and a saturation dive. Comparison of the data depicted in the plots is most usefully carried out using the line representing the median KM grades, with the maximum and minimum lines showing how large the range across subjects can often be.

KM grades in the figures that follow are referred to using Arabic rather than Roman numerals for clarity.

Figure 1
Escape dive – goats (*n* = 7) at rest; 2,500 kPa (240 msw) simulated submarine escape on air.

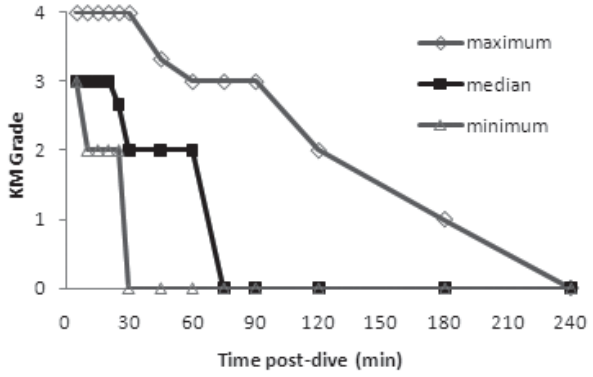


Figure 2
Saturation dive – goats (*n* = 20) at rest; 180 kPa (8 msw) saturation (24 h) on air

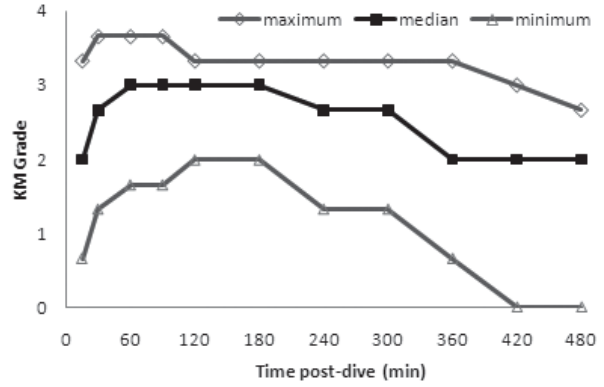
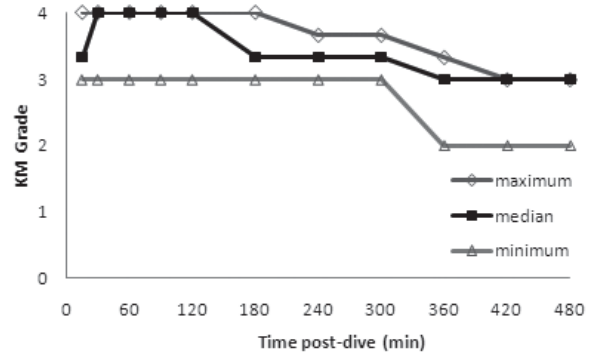


Figure 3
Saturation + Escape dive – goats (*n* = 15) at rest; 180 kPa (8 msw) saturation (24 h) plus 2,500 kPa (240 msw) simulated submarine escape dive on air



Results

SUBMARINE ESCAPE PROFILES (essentially short, deep bounce dives)

Figure 1 shows the results for a simulated submarine escape dive series on air, to and from 2,500 kPa (240 msw), involving a rapid compression to depth within 30 s or less, then decompression at a rate of around 2.75 m s^{-1}.[12] The median peak Doppler grades occurred between 5 to 20 min post-decompression and therefore would have been missed by the normal onset of monitoring at 30 min. Median grades did not return to zero until 75 min post-dive, while some outliers continued to bubble until 4 h after surfacing.

SATURATION DIVES (long, shallow dives)

Figure 2 shows the results of saturation dives to 180 kPa (8 msw) for 24 h.[12] The median peak grades occurred from 60 to 180 min, and so the onset of the peak score would just be observed within a 30 to 60 min post-dive measurement period. However, the prolongation of the median peak and the fact that median grades had still not returned to zero within 8 h post-dive would not have been noted.

SATURATION DIVES PLUS AN ESCAPE PROFILE

Figure 3 shows the results for 24 h saturation dives to 180 kPa (8 msw) followed by simulated submarine escape to and from 2,500 kPa (240 msw) (see above for profile details) on air.[12] The peak bubble grades tended to occur between 20 to 30 min post-decompression and the median peak persisted for up to 120 min. Although the onset of the median peak grades would be noted within the 30 to 60 min monitoring period, again the entire median peak period and the fact that at 8 h post-dive, the median grades had not dropped below KM III, would not have been observed. The bolstering of the median bubble grades to such a high level for such a long period (in comparison to saturation alone) reveals the additive effect of appending an escape profile onto a period of saturation.

LONG BOUNCE DIVES

For bounce dives with longer bottom times and shallower depths (around 100 min and 280 kPa (18 msw) depth for the data reported here, Figures 4 to 8), VGE would take a little longer to appear, from around 60 min. It should be noted that movement can have a considerable effect on measurement results, returning showers of measureable bubbles that would not have reached the right cardiac chamber until later if measurements were made only at rest.

Figure 4 shows the results of resting Doppler measurements made after a bounce dive to 280 kPa for 100 min on air, with a decompression stop at 3 msw for 14 min (Swedish Navy air dive tables - based on USN 56 tables).[13] Note that the maximum peak occurred at 15 min, and that the median peak would also be missed if measurements were made only between 30 and 60 min post-dive, as it was reached at 75 min and did not decline until after 105 min post-dive.

Figure 5 shows the results of the same dive as Figure 4, but the Doppler measurements were made after movement, rather than at rest. Once again, the maximum peak occurred at 15

Figure 4
Bounce dive – human subjects (*n* = 9) at rest; 280 kPa (18 msw) for 100 min on air, 3 msw for 14 min; decompression on Swedish Navy air dive tables

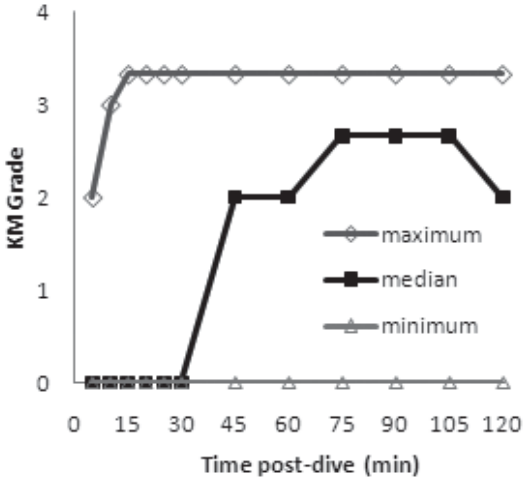


Figure 5
Bounce dive – human subjects (*n* = 9) after movement; 280 kPa (18 msw) for 100 min on air, 3 msw for 14 min; decompression on Swedish Navy air dive tables

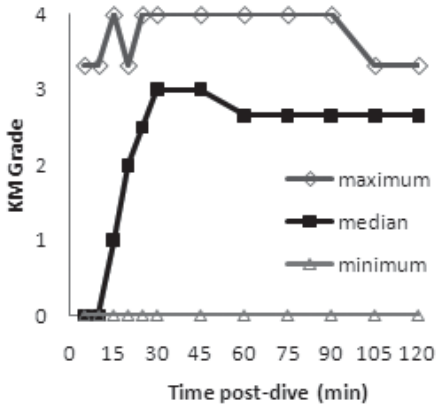


Figure 6
Bounce dive – human subjects (*n* = 8) at rest; 280 kPa (18 msw) for 100 min on air; decompression on Swedish Navy air dive tables

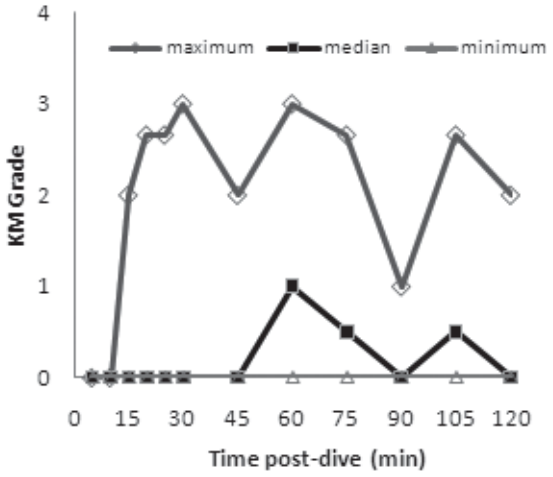


Figure 7
Bounce dive – human subjects (*n* = 10) at rest; 280 kPa (18 msw) for 100 min on air; decompression on RN Table 11 MOD.

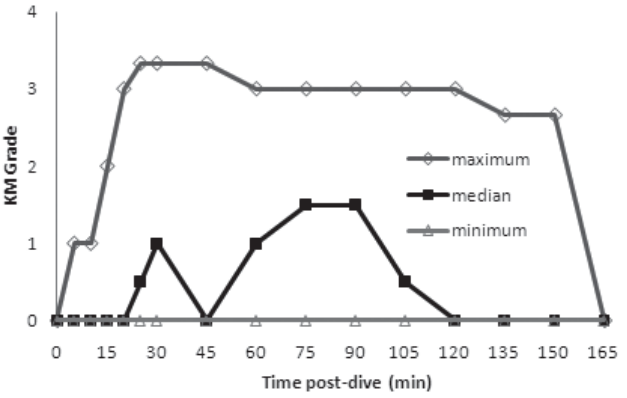
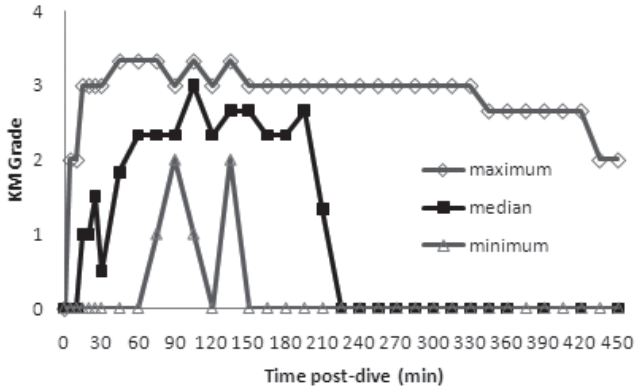


Figure 8
Bounce dive – human subjects (*n* = 10) at rest; 280 kPa (18 msw) for 100 min on air; decompression on RN Table 11 MOD



min, but movement brought the occurrence of the median peak back from 75 min (as in the resting measurements) to 30 min.

Figure 6 shows the results of another bounce dive, again to 280 kPa for 100 min on air with decompression made on the Swedish Navy air dive tables.[13] Measurements made between 30 and 60 minutes in this case would have captured both the maximum and median peak data, although bubbling continued in some subjects at a relatively high level after 60 min post-dive.

Figure 7 shows the results of a bounce dive, again to 280 kPa for 100 min or air, but with decompression on RN Table 11 MOD.[14] These data formed the control results for a trial investigating the effect of pre-dive exercise on VGE

Figure 9
Bounce dive – human subjects (*n* = 5) after movement; 700 kPa (60 msw) for 15 min on tri-mix using a semi-closed circuit rebreather in open water

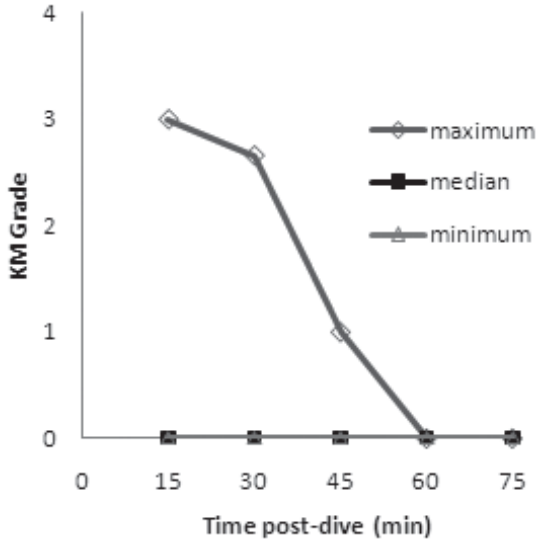


Figure 10
Bounce dive – human subjects (*n* = 3) at rest; 1,000 kPa (90 msw) for 18 min on tri-mix using a closed-circuit rebreather in open water

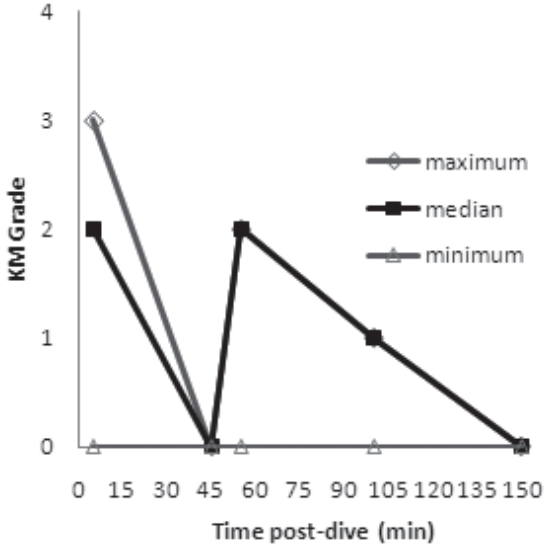
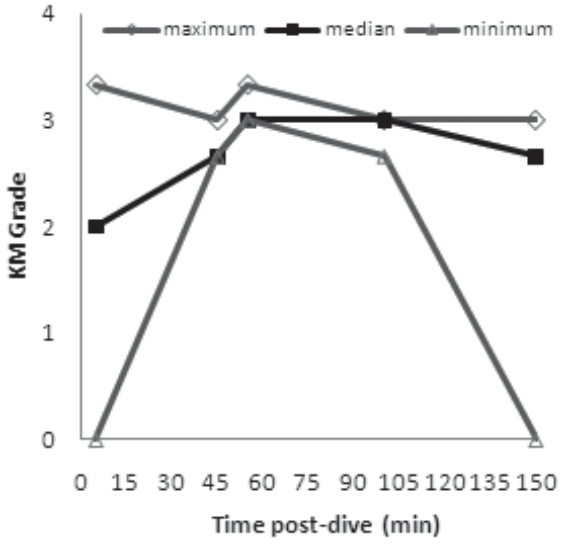


Figure 11
Bounce dive – human subjects (*n* = 3) after movement; 1,000 kPa (90 msw) for 18 min on tri-mix using a closed-circuit rebreather in open water



production. It should be noted that the maximum peak was reached at 25 min, while the median peak occurred at 75 min and did not return to zero until 120 min post-dive. All of these events would have been missed by measurements made between 30 and 60 min.

Figure 8 shows data produced after the same dive as described in Figure 7, but with exercise taken by the subjects 2 h before the dive. The median peak of bubbling was not reached until 105 min and did not return to zero until 225 min post-dive. One individual continued to produce high levels of VGE for a notable period (as described by the maximum peak data), showing the extreme of inter-individual variation. Interestingly, this subject did not produce such 'extreme' results in comparison to his peers in other sections of the trial.

SHORT BOUNCE DIVES

For bounce dives where the bottom time is short and the dive relatively deep (in the present study, between 15 and 18 min and 700 to 1000 kPa (60 to 90 msw respectively) (Figures 9 to 11), then the first appearance of VGE arrived swiftly (as soon as 5 min) after decompression.

Figure 9 shows the results of a dive to 700 kPa for 15 min on tri-mix, using a semi-closed rebreather in open water. Although the median grades did not rise above zero, two subjects out of five produced maximum peak grades of KM III- and KM III at 15 min, which then dropped to zero and KM III- respectively at 30 min. Given a larger group size, it is likely that the median peak score would rise and would therefore be missed if measurements did not start until 30 min post-dive. Measurements could not be taken before 15 min for operational reasons as the divers were busy getting out of the water and shedding their equipment. Two sequential grades of zero at 60 and 75 min meant that measurement could cease before 120 min post-dive; it is thought safe to assume that if no bubbles are heard after two sequential time points of at least 15 min apart, then audible VGE are no longer present in the circulation.

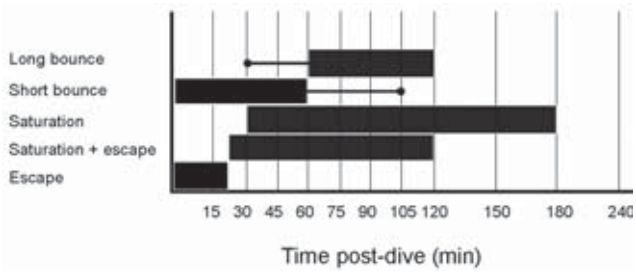
Figure 10 shows the resting Doppler results of a bounce dive made to 1,000 kPa for 18 min, again on tri-mix in open water, but using a closed-circuit rebreather. On surfacing, the divers

breathed 100% oxygen for 10 min; measurements started 5 min after this period. Note the inter-individual variation in the spread of KM scores at 5 min. Despite this, the onset of both the maximum and median peak scores would have been missed between 30 and 60 min. Fewer measurements were made following this dive than would be preferable due to operational limitations – the measurements at 5 min were made on the dive boat, then the remainder made on reaching the shore. Inactivity on the boat may have been responsible for the grades dropping to zero, then rising once more following a period of physical activity as the divers moved their equipment from the boat to shore once the second measurement had been made.

Figure 11 shows results for the same dive as detailed in Figure 10, but with measurements made after movement. Note the same inter-individual spread and that the onset of the maximum peak scores still occurred at 5 min post-dive. That movement caused VGE to circulate at 45 min, while resting measurements made at this time point revealed no detectable VGE, again indicates that both rest and movement measurements should always be made in order to determine fully whether or not bubbles are present.

Collation of these data is depicted in Figure 12, which consists of a schematic diagram illustrating the typical periods over which 'median peak' resting KM Doppler grades may occur and then persist, for the differing profiles described. 'Long bounce' dives are classified here as those of duration of 100 min at depth (Figures 4 to 8). 'Short' bounce dives are those described as being 18 min at depth or less (Figures 9 to 11). Lines with circular ends extending fore or aft of the long and short bounce bars denote the extent of the range over which bubbles can be noted if movement measurements are taken into account for the data presented in the figures for the bounce dives. No movement measurements could be included for the remaining profiles, as they were made on goats for which only resting measurements are made.

Figure 12
Schematic illustrating the typical periods over which 'median peak' resting KM Doppler grades may occur



Discussion

From these data, representing nine different studies with varying dive profiles, it can be seen that there is great variation in the time of onset, peak and disappearance of Doppler-detectable VGE across individuals and across dive profiles. It appears obvious that every dive profile cannot uniformly be characterised by monitoring VGE within a short time period of between 30 and 60 minutes, or even up to 90 minutes post-dive.

Take, for example, the data reported in Figures 7 and 8. Here, the subjects performed the same dry chamber dive, compressing to 280 kPa (18 msw) for 100 minutes, then decompressing in accordance with RN Table 11 (15 msw min^{-1} ascent rate, stopping at 6 msw for 5 minutes and 3 msw for 15 min).[14] The difference between the dive protocols was a period of exercise taken two hours before compression in one instance (Figure 8), while the other dive (Figure 7) acted as a no-exercise control. Doppler measurements made between 30 and 60 minutes would have missed the median peak KM grades after both dives. The control dive produced its median peak grades at 75 to 90 minutes, while the median peak for the dive with pre-dive exercise occurred at 105 minutes. Note that in both cases, if monitoring was carried out as recommended by Nishi et al, i.e., up to 120 min post-dive, then the peaks would be observed.[1] None of the studies listed in Table 1 would have continued monitoring long enough to find the median peak grades shown in the pre-dive exercise group. The dive profile used in this case is comparable to many used in this field of study today, as it is known to elicit VGE to varying degrees in most subjects and, therefore, can be used to test the efficacy of different interventions or prophylaxes on bubble evolution.

The measurement periods of the nine studies included in Table 1 are not too dissimilar, ranging from 20 to 90 minutes at most.[2–10] However, the dive profiles range from 280 kPa for 80 minutes, to 400 kPa for up to 30 min and 700 kPa for 45 minutes. If these profiles are compared to Figure 12, then it would seem that the median peaks for the first two should be expected between 60 and 120 minutes. The final profile of 60 msw for 45 min is more complex, as it is relatively long and deep; with regard to its comparison to Figure 12, it seems that comparable median peak grades could occur anywhere between 5 and 120 min, while monitoring actually took place between surfacing and 60 minutes.[3] This study was carried out to investigate the effect of exercise or rest before a dive on VGE evolution; the comparison of the evolution of bubbles in both groups for 60 min after surfacing would provide appropriate data for that purpose, but the cessation of monitoring would not allow the complete effect of the conditions to be observed. Given the expense, both financial and in terms of time and effort, expended on organising and running such trials, it does seem to be false economy not to continue monitoring bubble evolution for at least the recommended 120 min post-dive and, therefore, collecting a more complete, and perhaps revealing, set of data.

Given the difficulty in forecasting accurately the behaviour of VGE evolution, long intervals between measurements are

also not ideal. For example in Figures 10 and 11, Doppler monitoring was constrained by the fact that the dives had taken place in open water off a dive boat and that the primary aim of the divers was to test a closed-circuit rebreather. Doppler data collection was a secondary objective and so had to fit in around the divers getting back on the boat, attending to their equipment and getting back to base. It was only possible therefore to make five measurements, and only two of these were made in the first 45 minutes. Although it appeared that the median peak grades were recorded, the lack of measurement points between 5 and 45 min mean that we cannot say for certain that the peak was observed and the value of the data suffers because of this.

Of course, it could be argued that Doppler monitoring would have to occur continuously to be able to say definitively that the true peak had been observed. However, without the use of implanted Doppler probes, this would be completely impractical. Given the biological nature of the system in question, if the type of dive profile to be used is considered carefully and if the optimal bubble monitoring frequency and measurement period, drawn from the guidelines established here or from similar articles in the literature, is implemented, then that should allow some confidence in reporting the onset, peak and disappearance of VGE from the venous system.

Conclusion

Ultrasound monitoring of post-dive VGE needs to become more standardised across research groups in order for the data to be comparable. Both earlier and more prolonged monitoring is recommended, while the frequency of measurements should also be increased. As trials are expensive in every sense, it is logical to collect the most complete set of data possible in order to validate the results and allow accurate comparison across studies.

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Conflict of interest: none

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Technical reports

Maintenance of negative-pressure wound therapy while undergoing hyperbaric oxygen therapy

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Key words
Wounds, hyperbaric oxygen, treatment, equipment, safety

Abstract
(Chong SI, Tan MK, Liang W, Kim SJ, Soh CR. Maintenance of negative-pressure wound therapy while undergoing hyperbaric oxygen therapy. Diving Hyperb Med. 2011;41(3):147-50.)
Background: Both negative pressure wound therapy (NPWT) and hyperbaric oxygen therapy (HBOT) are useful modalities in the treatment of problem wounds. However, none of the commercially available portable negative-pressure devices have been certified safe for use in a recompression chamber. Thus, the NPWT device is removed while the patient undergoes HBOT. The purpose of this study is to demonstrate that wound negative pressure can be effectively and safely maintained during HBOT.
Patients and methods: In a small, prospective, randomised crossover trial, we used commonly available clinical materials to connect the NPWT suction tubing to the negative suction generating device in the hyperbaric chamber. Six patients each underwent one HBOT session with continuous NPWT and one HBOT session without concurrent NPWT. We assessed the patient's pain score, the amount of exudate aspirated by the NPWT during HBOT, and the appearance of the wound dressing after each session was assessed in a blinded manner.
Results: There were no differences in pain scores between the two HBOT sessions. The amount of exudate aspirated during HBOT with NPWT ranged from 5 to 12 ml. Five of the six patients had a better appearance scoring of their dressing when NPWT was maintained during HBOT ($P = 0.006$).
Conclusion: We successfully demonstrated a simple design that allows the maintenance of NPWT during HBOT without causing additional pain, and with continued extraction of exudate. The maintenance of NPWT during HBOT also allowed the dressing to be maintained undisturbed.

Introduction

Negative pressure wound therapy (NPWT) has been widely utilised to manage problem wounds. The mechanism of action lies in its ability to maintain a negative-pressure environment over the wound bed. This is achieved by creating a bio-occlusive environment connecting the wound to a negative-pressure generating device, thereby promoting angiogenesis while reducing exudation.[1]

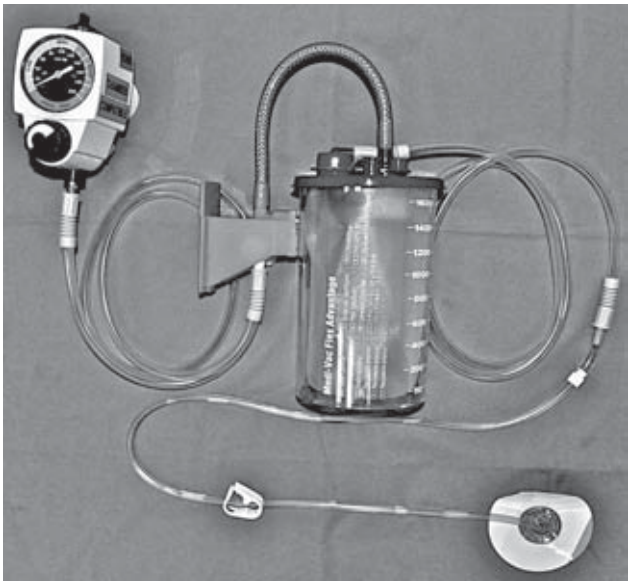
Hyperbaric oxygen therapy (HBOT) has been used as an adjunctive therapy for the management of problem wounds. These include ischaemic, diabetic and irradiated wounds, as well as compromised grafts and flaps.[2] Patients with diabetic wounds generally receive an average of 30 to 40 daily HBOT while those with necrotizing soft tissue infections generally receive an average of 3 to 10 sessions.[3-5] Some of these wounds are simultaneously dressed using NPWT. Based on their mechanism of action, there are reports that suggest the concurrent use of both treatments improves clinical outcomes in patients.[6,7]

However, none of the commercially available, portable, topical negative-pressure devices has been certified as safe for use in a recompression chamber. They contain lithium-based batteries that may be a potential fire hazard in a hyperbaric environment.[8] As a result, the NPWT system is interrupted and the device removed while the patient undergoes HBOT.

Interruption of NPWT frequently leads to pooling of exudates/blood within the wound and the loss of an intact airtight seal. This may lead to increased costs and increased discomfort by requiring the reinforcement or reapplication of the NPWT dressing system following each session. The displacement of dressing and the shearing forces generated as the fluid collects between the wound and the dressing may potentially disturb the wound bed and inhibit healing.[9] The pooling of fluids in the wound bed also theoretically increases the risks of infection and bacterial colonisation. These problems are particularly obvious for patients with large wounds with high exudation, when it is difficult to apply NPWT, such as large diabetic ulcers or wounds due to necrotizing soft tissue infections.

We aim to demonstrate that negative pressure can be effectively and safely maintained during HBOT using readily available materials, which will provide uninterrupted

Figure 1
Overview of system to maintain NPWT during HBOT; using widely available materials and components, the TRAC pad tubing is connected to a regular suction canister that is attached to a wall suction device



exudate removal and preserve the integrity of the NPWT dressing.

Materials and methods

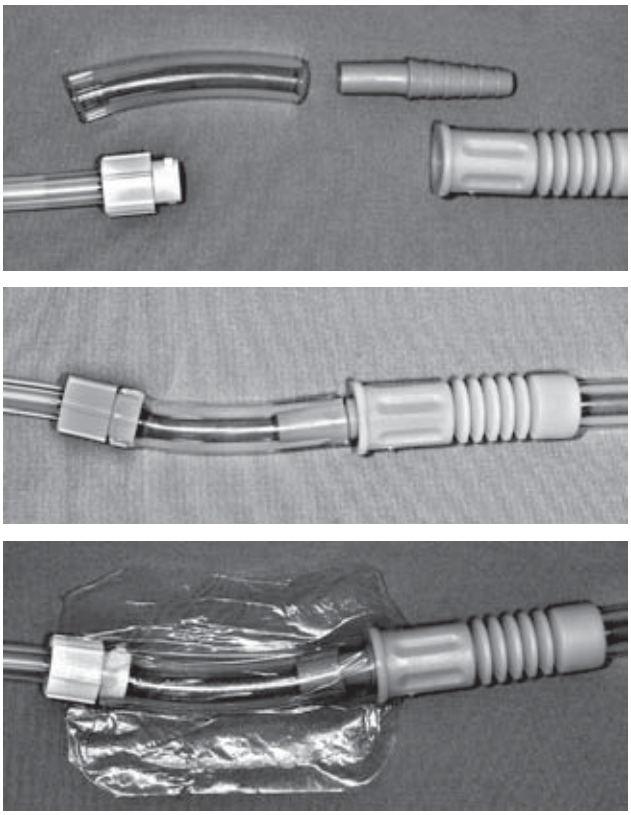
NEGATIVE-PRESSURE DEVICE FOR USE IN HBOT

Commonly available clinical materials were used to quickly and simply connect the suction tubing from the NPWT to the negative suction generating device in the hyperbaric chamber. Figure 1 shows how NPWT was maintained during HBOT. The TRAC pad tubing is connected to a regular suction canister that is attached to the wall suction device. The suction pressure which is generated by the pressure difference between the chamber and the external environment is controlled in two stages. The first stage consists of a continuous vacuum regulator unit (Ohmeda Medical, Low Vacuum model with suction range 0–200 mmHg), which allows a variable setting within predefined limits set by the chamber manufacturers (Hyperbaric Health) and the hospital Biomedical Engineering Department. The second stage consists of an adjustable pressure release valve which entrains air into this circuit to keep the pressures within an acceptable range (–50 to –400 mmHg).

The following components are assembled to form an airtight connection to the device:

- end of T.R.A.C.® Pad;
- rubber tubing with two cuts fashioned at 180^{O} apart;
- rubber connection from a naso-gastric tube;
- suction tubing.

Figure 2
Key to the setup is the connection between the TRAC pad and standard suction tubing; the TRAC pad tubing is not designed to couple with suction tubing; however, a simple modification using a short length of tubing and a connector sandwiched between two pieces of Tegaderm™ transparent dressing ensures an air-tight seal.



The key components are detailed in Figure 2. Key to the setup is the connection between the TRAC pad and a length of regular suction tubing. Unlike the other connecting parts of the setup, the TRAC pad tubing is not designed to couple with suction tubing. However, a simple modification using a short length of tubing and a connector sandwiched between two pieces of Tegaderm™ transparent dressings allows us to ensure an air-tight seal between the TRAC pad and suction tubing. For each HBOT involving the maintenance of NPWT, the attending nurse ensured that the negative pressure remained within a narrow 10 mmHg range from the target therapeutic pressure of –120 mmHg, and the pressure was recorded regularly during the treatment.

STUDY DESIGN

We conducted a small, prospective, randomised crossover trial on six patients referred for HBOT between October and December 2010. Prior to the commencement of the study, the team had tested the technique on mannequins. Ethics approval was obtained from the SingHealth IRB. Following informed consent, patients enrolled in the study. The patients' wounds were all small (< 100 cm^2) lower limb

Table 1
Demographics, wound details and exudate volumes of each patient; DM – diabetes mellitus

Age	Sex	Co-morbidities	Location of wound	Size of wound (cm)	NPWT aspiration (ml)
67	F	DM, hypertension	Post-total knee arthroplasty	8 x 4	5
50	M	DM	Right heel	5 x 8	7
43	M	DM	Right foot	8 x 6	10
56	F	DM	Right shin	4 x 7	5
61	M	DM	Left heel	8 x 8	10
56	M	DM	Left foot, post-ray amputation	9 x 7	12

wounds due to diabetes mellitus, complicated by peripheral vascular disease and poor microcirculation, and being treated with NPWT. All six patients were assessed as fit to undergo HBOT.

For one HBOT, NPWT was maintained throughout the treatment, while for the other the NPWT was discontinued during HBOT. Randomisation was performed using sealed envelopes that were opened by the principal investigator before the start of the first HBOT session. Each HBOT session consisted of 90 minutes breathing 100% 0_2 at 243 kPa. Patients were randomised to either having the NPWT interrupted or maintained for the first study HBOT session. For the second study HBOT session, the opposite intervention was instituted in the same patient.

ASSESSMENT PARAMETERS

The wound dressing was assessed by three independent assessors who were blinded as to which study arm the patient was randomised. Their grading was based on digital photographs of the NPWT dressing system taken at the end of each HBOT session to give an 'Appearance Score'. The assessments for all the treatments were made at a single sitting. The scoring system used to grade the state of the dressing was:

1 dressing intact with good seal;
2 dressing slightly soaked with some leak;
3 dressing soaked with seal leak and requiring reinforcement;
4 dressing soaked and requiring whole dressing change.

The median appearance scores between the study and control arms were analysed with the Mann-Whitney U test for significance.

The volume of exudate removed by the NPWT during the HBOT session was recorded at the end of the treatment. Pain or discomfort was assessed on a 1–10 analogue scale on three occasions during the HBOT session: at the start, one hour into and at the end. A pain score greater than seven for more than 5 minutes was a trigger for aborting the trial.

Results

Table 1 shows the demographics, wound details, pain scores and amount of exudate drained during the HBOT with NPWT. The target suction pressure of –120mmHg was achieved and maintained for all patients during the treatments. Five of the six patients had a better wound appearance score with maintenance of negative pressure than in the control arm (Z score = –2.76, P = 0.006). There was no difference in pain score between the study and control arms.

Discussion

Problem wounds can be a challenge to manage, often resulting in high costs for the patient, increased nursing demands, higher risks for complications and prolonged hospital stay. Both NPWT and HBOT have been proven to have beneficial effects in the management of problem wounds. However, the incompatibility of the negative pressure devices with a hyperbaric environment has excluded their continuous use during HBOT, with potentially disadvantageous effects on wound healing.

We have described a simple, safe technique using readily available materials, that allows the maintenance of NPWT while a patient undergoes HBOT, without causing additional pain and allowing exudate to be drained during the treatment. The maintenance of NPWT during HBOT also allows the dressing to be maintained and may potentially avoid additional nursing work such as reinforcing or changing of the dressing. However, the synergistic effects of HBOT and NPWT cannot be demonstrated by this study and further studies are required to clearly demonstrate any benefits of HBOT and continuous NPWT on non-healing wounds.

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The influence of a hyperbaric environment and increased oxygen partial pressure on the corrosion of dental alloys

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Key words
Diving, hyperbaric oxygen, nitrox, dental, teeth, hyperbaric research

Abstract
(Mehl C, Heblich F, Lenz R, Ludwig K, Kern M. The influence of a hyperbaric environment and increased oxygen partial pressure on the corrosion of dental alloys. Diving Hyperb Med. 2011;41(3):151-5.)
Objectives: The purpose of this in-vitro study was to determine whether there is a correlation between a hyperbaric environment or increased oxygen partial pressure and the corrosion of dental alloys used for dental restorations in divers.
Method and materials: Samples of three commercially available dental alloys (palladium-based, reduced-gold-content and high-gold-content) were tested in the DIN EN ISO 1562 static immersion test and the amount of dissolved ions measured by atomic absorption spectrometry. The specimens were exposed to one of the following three conditions: normobaric and normoxic conditions (PO_2 21 kPa); 608 kPa (6 bar, PO_2 127 kPa) pressurised air in a pressure chamber or 506 kPa (5 bar, PO_2 304 kPa) pressurised nitrox in a pressure chamber.
Results: None of the exposures suggested a correlation between increased ion solubility as a measure of corrosion and increased ambient pressure of the three alloys. The reduced-gold-content alloy released zinc ions at twice the weekly recommended dose. When the palladium-based alloy was exposed to a hyperbaric or hyperbaric/hyperoxic environment, ion solubility increased only slightly for gallium and silver.
Conclusions: Within the limited sample size of the current study it can be concluded that hyperbaric and/or hyperoxic conditions do not seem to be a risk for increased corrosion for any of the three tested alloys.

Introduction

Around three million Europeans are thought to be recreational scuba divers, diving to depths up to around 40 meters' sea water (msw). Additionally, there are approximately 800 professional civilian and 700 military divers registered in Germany as well as some 500 compressed-air (caisson) workers, e.g., for tunnel or bridge construction work.[1,2] Military divers, who undergo regular fitness examinations at the Naval Medical Institute in Kiel, Germany, repeatedly complain about damaged dental restorations.[2] In a study conducted over a period of nine years, the overall dental appearances of divers were constantly significantly poorer than those of submariners.[2] These findings raise the question as to whether there is a correlation between dental health and diving. As the most important property of a dental alloy is its chemical stability, its degradation might result in adverse cytotoxic reactions to the host tissue and a release of metal ions into the gingival tissue, which can lead to additional aesthetic problems such as discoloration.[3–5] Previous studies have shown that certain cements are susceptible to a loss of retention and increased microleakage when diving.[6,7]

Irrespective of a suspected decreased personal oral hygiene and oral health negligence of naval personnel, the main reason for the poorer oral condition of divers in comparison to submariners could be from stress as a result of a hyperbaric environment.[2] This may be one of several factors influencing the dental health of divers.[8] Additional potential causes might be:

- increased partial pressures of the gases used in the breathing mixture, in accordance with Dalton's law;
- changed ion composition and pH value of saliva as a result of occasional exposure of the oral cavity to sea water;
- increased evaporation and exsiccation of the oral cavity as a result of the relatively cold and dry air which is breathed, in accordance with Gay-Lussac's law.[2]

The purpose of this study was to test the null-hypotheses that exposure of dental alloys to hyperbaric pressure alone or a combination of hyperbaric and hyperoxic conditions does not lead to increased corrosion.

Methods and materials

The tests were conducted under conditions corresponding to the clinically relevant maximum levels of hyperbaric pressure (divers diving up to 50 msw) or maximum recommended levels of oxygen partial pressure (therapeutically breathing compressed oxygen in a pressure chamber at a partial pressure (PO_2) of 304 kPa).[9]

According to the procedures of DIN EN ISO 1562, 18 specimens per tested alloy were cast from a palladium-based alloy (*Reliance*, Jensen, Metzingen, Germany), a reduced-gold-content alloy (*Landmark*, Jensen) and a high-gold-content alloy (*JP-84*, Jensen), air-abraded (110 µm Al_2O_3 at 253 kPa) and polished with a 600-grit silicon carbide paper under water cooling.[10] The chemical composition of each of the three alloys is listed in Table 1. The specimens had dimensions of 32x10x1.5 mm, and were embedded

Table 1
Composition of the tested alloys expressed as % weight (see Periodic Table for symbols)

	Au	Pt	Pd	Ag	Zn	Ga	In	Others <1%
Reliance	-	-	64.4	25	8.5	2	-	Rh, Ru
Landmark	59.3	-	8	28.8	2	-	1.5	Fe, Ir
JP-84	84.5	8	5	-	-	-	2	Re, Fe

Figure 1
(Left) alloy plates fixed with slotted PE bars (Right) alloys immersed in PE-container in 26 ml saliva replacement solution

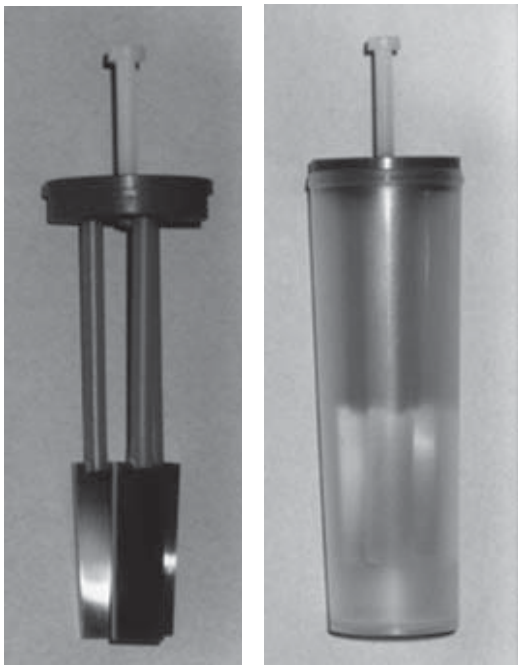
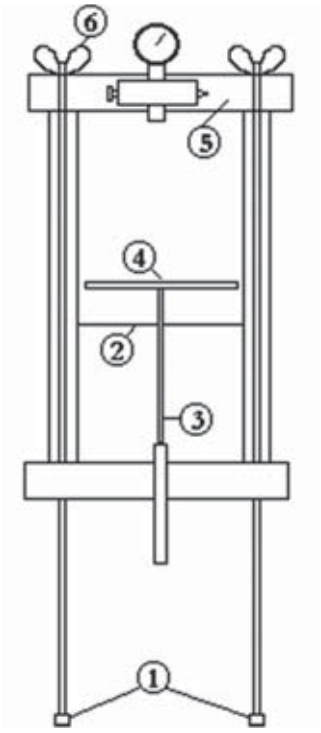


Figure 2
Pressure-chamber: 1 – rotatable feet, 2 – fluid level, 3 and 4 – height adjustable base for carrying specimens, 5 – Plexiglas lid, 6 – wing nuts



in prefabricated slots in polyethylene (PE) bars (Figure 1, left). All specimens were immersed in PE containers (27x32x9.5 mm, 30 ml, Figure 1, right) filled with 26 ml of a saliva substitute (0.1 mol L^{-1} lactic acid, 0.1 mol L^{-1} sodium chloride).[10] The lids of the PE containers were pierced with 1 mm holes to allow pressure equalization. A pressure chamber (IDE Power-test 110, International Diving Equipment, Rosenheim, Germany, Figure 2) without the specimens was put into the incubation room (TE1500*2290*80, LW1000*2000 DIN, Vießmann, Hof, Germany) three days before immersing the specimens, to allow equilibrium to 37°C. After temperature equilibrium, the specimens were stored in the pressure chamber for the static immersion test. Before and after storage, the filled PE containers were weighed to ensure constant concentration of the saliva-replacement solution. Two containers per alloy and experimental subgroup with three specimens per container (overall 18 specimens per alloy) were filled with the saliva substitute and stored as follows according to the experimental subgroups:

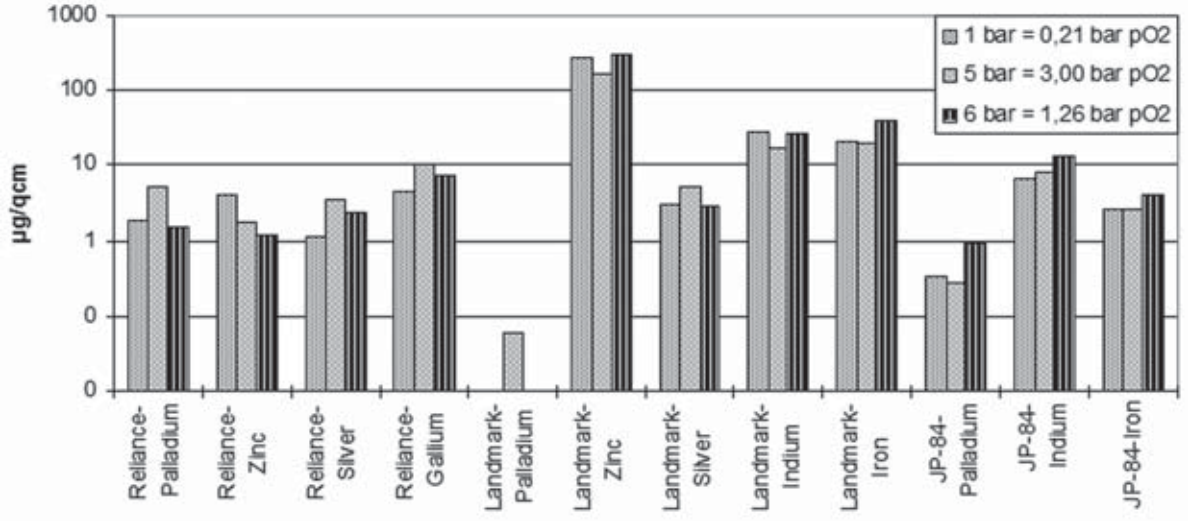
- for each of the three tested alloys, two containers with three castings each were put into an incubation room at 37°C for seven days in normobaric, normoxic conditions (control group);
- for each of the three tested alloys, two containers with three castings each were put into the pressure chamber standing in the incubation room at 37°C for seven days in air at 608 kPa, PO_2 127 kPa;
- for each of the three tested alloys, two containers with three castings each were put into a pressure chamber filled with commercially available nitrox (breathing gas mixture 60% oxygen 40% nitrogen) at 506 kPa, PO_2 304 kPa.

After completion of seven days' storage time, the concentrations of the tested ions in the saliva-replacement solution were evaluated with an atomic absorption spectrometer (Perkin-Elmer, type 1100b), a graphite tube oven (PE HGA 700) and an auto-sampler (AS-70) for palladium (Pd), gallium (Ga) and indium (In) ions. An

Table 2
Ion concentration in µg cm^{-3} of the tested solutions after storage

	Control group (normobaric air)	Hyperbaric/hyperoxic condition (506 kPa, PO_2 304 kPa)	Hyperbaric air condition (608 kPa, PO_2 127 kPa)
Palladium-based alloy			
Reliance-palladium	1.88	5.09	1.57
Reliance-zinc	3.86	1.70	1.20
Reliance-silver	1.13	3.56	2.40
Reliance-gallium	4.39	10.01	7.36
Reduced-gold-content alloy			
Landmark-palladium	0.01	0.06	0.01
Landmark-zinc	282.51	173.11	297.65
Landmark-silver	3.15	4.95	2.80
Landmark-indium	28.41	16.74	27.36
Landmark-iron	21.10	19.46	38.22
High-gold-content alloy			
JP-84-palladium	0.34	0.28	0.91
JP-84-indium	6.68	7.81	13.01
JP-84-iron	2.49	2.49	3.85

Figure 3
The concentration (µg cm^{-3}) of dissolved ions for each dental alloy shown in a logarithmic scale to eliminate the high peak of dissolved zinc ions by specimens of "*Landmark*"



atomic absorption spectrometer (Perkin-Elmer, type 5100 PC) with an auto-sampler (AS-90) was used for detection and evaluation of the concentration of zinc (Zn), iron (Fe), copper (Cu) and silver (Ag) ions. Gold (Au) and platinum (Pt) ions were not evaluated, since several studies have found minimal concentrations only of those ions after static immersion tests and other studies categorise them as inert metals.[11–14] The evaluation of the results was conducted using descriptive statistics, since three specimens were stored in one PE container, thus already resulting in a mean concentration for each alloy, leaving the sample size for each alloy and experimental group as 2 (n = 6/3 per 2 containers).

Results

The concentrations of dissolved ions of the three alloys after the seven-day period of static immersion depending on ambient pressure and oxygen partial pressure are shown in Table 2 and Figure 3. None of the three tested alloys suggested a correlation between increased ion solubility as a measure of corrosion and increased ambient pressure. When the Pd-based alloy was exposed to a hyperbaric or hyperbaric/hyperoxic environment, ion solubility increased only slightly for Ga from 4.4 µg cm^{-3} to 7.4 or 10 µg cm^{-3} and Ag from 1.1 µg cm^{-3} to 4 or 2.4 µg cm^{-3}, respectively.

Pd-ion solubility only showed an increase when subjected to a hyperbaric/hyperoxic environment. The reduced-gold-content alloy showed a high Zn release between 173 µg cm^{-3} and 298 µg cm^{-3} and to a lesser extent, but still higher than the other two alloys, a higher In and Fe release. In contrast, the high-gold-content alloy released negligable amounts of ions, with only In release slightly increasing from 6.7 µg cm^{-3} to 7.8 or 13 µg cm^{-3}. No Cu ions could be detected in the solution.

Discussion

Increasing pressure and, therefore, increasing PO_2 are two changing conditions whilst diving. The current study aimed to investigate the hypotheses of Goethe et al. that these two factors could potentially influence the corrosion of dental alloys.[2] The static immersion test is a well-established procedure to evaluate corrosion resistance of dental alloys.[10,15] It accelerates testing time by using a saliva substitute with a pH of 2.3, while the in-vivo saliva pH normal range is between 6–7.5, and using a constant temperature of 37°C, compared to a temperature of about 35°C in the mouth, which varies breath-by-breath.[16–18]

Corrosion was tested for under extreme but, for humans, tolerable conditions.[9] Using compressed air at 608 kPa represents the situation of someone diving to 50 msw. This pressure was chosen in order to test the upper end of conditions divers, particularly commercial and military ones, might normally encounter.[19] Likewise, the current study tested the highest PO_2 used in hyperbaric oxygen therapy (e.g., Boerema's scheme/TS 300-90), but which a diver would never have to experience.[8,9] The seven days of immersion represent around 300 to 600 dives, depending on the depths of the dives. Professional military divers accomplish around 5,000 dives in their lifetime. Thus, this represents a reasonable exposure time of the dental alloys.[1,20]

The corrosion of dental alloys can be measured as the sum of all dissolved ions.[21,22] Although none of the three tested alloys showed a correlation between increased ion solubility and increased ambient pressure, the Pd-based alloy showed slightly higher ion solubility for Ga and Ag when subjected to hyperbaric and/or hyperbaric/hyperoxic conditions. Pd-ion solubility only showed an increase when subjected to a hyperbaric/hyperoxic environment. With the high-gold-content alloy releasing only a minimal amount of ions as well, the ion release for these two alloys seems to be clinically negligible since the overall sum of ion release should be less than 100 µg cm^{-3}, but ideally less than 10 µg cm^{-2} in a week.[10,23]

In contrast, the reduced-gold-content alloy showed a high Zn release, more than twice the recommended limit of 100 µg cm^{-3}, independent of surrounding pressure or PO_2 conditions and regardless of a potential increase of corrosion due to salty sea water. Since even small concentrations of certain ions can cause toxicity, allergic reactions or other diseases, the additional Fe and In release of this alloy suggests its cautious use as a dental restoration material, in general.[3] With regards to the components with the highest ion release by the Pd-based alloy, Ga has shown cytotoxic effects, with soft tissue responses and cell necrosis in guinea pigs and sarcomas in rats.[24,25] When evaluating ions released in higher concentrations by the reduced-gold-content alloy, severe cytotoxic effects for Zn are known, whereas Ag was found to be intermediate in cytotoxic effects and iron the least cytotoxic element.[26–28] As Cu is known for causing inflammation, allergic reactions and cytotoxicity and with Zn being found in so-called 'Zn-free' alloys, the current study tested all experimental alloys for Cu traces and excluded contamination.[11,12]

A limitation of the current study is the small sample size of six specimens per experimental subgroup, being further diluted by the storage of three specimens in one container, thus building a mean of the ion release and only allowing a descriptive analysis of the results. Subsequent research in this particular area is desirable since the current study did not test amalgam samples. Subsequent studies should include amalgam testing, examine effects of changing ion concentrations and temperature in saliva and the effects of multiple pressure changes while diving. An additional factor to be tested should include the dilution of the saliva replacement solution with sea water and, therefore, an increased salt concentration.

Conclusions

Within the limitations of the current study with special regard to the small sample size, it can be concluded that hyperbaric and/or hyperoxic conditions do not seem to pose a risk for increased corrosion to any of the tested alloys. Because of a potential toxicity of the dissolved Zn ions released by the reduced-gold-content alloy, this particular alloy should be used with caution. The Ga release of the Pd-based alloy did not seem to be clinically important. As the high-gold-content alloy showed the lowest combined ion solubility it could be preferentially used for divers with many hours of diving, if metal alloy is the restorative material of choice.

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The world as it is

British Sub-Aqua Club (BSAC) diving incidents report 2010

Compiled by Brian Cumming, Diving Incidents Advisor

<http://www.bsac.com/core/core_picker/download.asp?id=20345&filetitle=Diving+Incident+Report+2010>

Summary of the 2010 report prepared by Colin Wilson

The BSAC has collated an annual report on diving incidents for over 20 years. This information is collected from voluntary incident reports by their membership and from a number of other sources.[1,2] Summaries for years 2005 to 2009 have been discussed previously in this journal.[3] The report primarily covers the United Kingdom (UK) incidents though there is a small overseas section of reports from BSAC members only.

There were 364 UK reports for 2010, below the 10-year average of about 400. The sources of information remain fairly consistent, giving some degree of confidence in assessing trends. As in previously discussed reports, there are limitations to the completeness of the data, though it is reasonable to accept the number of fatalities recorded as accurate. The decompression incident reports may not include patients who directly refer themselves to recompression facilities avoiding reporting by emergency services unless they submit a report themselves. There are an unchanged number of short reports from emergency agencies described as "*diver illness and injury*", the bulk of which were probable cases of decompression illness (DCI). Three-quarters of the reports occurred in the northern hemisphere summer.

There continues to be a decline in ascent incidents (strongly associated with DCI) since their peak in 2006. This supports the benefit of strong campaigning and improved training of divers to pay more attention to their buoyancy. Depth of incidents ranged from the surface to a fatality at over 60 metres' sea water (msw). In the UK, the Coastguard was involved in 235 (65%) of the diving incidents, 107 involved the Royal National Lifeboat Institute (RNLI) and helicopters dealt with 112. The RNLI are mainly tasked to assist disabled boats, search for missing divers and recover those with DCI. Helicopters also support these searches for missing divers and help to transport those with DCI to recompression facilities. This summary focuses mainly on fatalities and cases of DCI.

Fatalities

With 17 recorded fatalities there has been a small rise in recorded diving deaths above the 15.8 10-year average. There are often multiple contributing factors and these are summarised as follows:

- three died of natural causes of whom two had heart attacks. Though data are insufficient, an additional two cases probably also had heart attacks;
- ten cases involved some kind of separation:
  - four were during the ascent;
  - two cases were diving with three or more divers;
  - two had difficulties during the dive and made solo ascents, one of these was diving to over 60 msw;
  - two divers had difficulties during the dive where separation occurred;
  - one became entangled in the shot line during ascent;
  - one was thought (wrongly) by his buddy to have aborted the dive;
- two cases involved a rapid ascent with probable barotrauma;
- two cases ran out of breathing gas;
- one case was a solo snorkel diver who was spear fishing.

The method of collecting this information means that defining the specific root cause from the chain of events can be difficult, unlike the more in-depth analysis carried out on Australian diving fatalities.[4] Over the last 14 years, deaths from divers using rebreathers have been over-represented, averaging 12.2% (range 0% to 33.3%) deaths. In this report for 2010, it was pleasing to see there were none. Increasing age carries more risks to divers with eight (47%) deaths over the age of 50. The average age of fatalities is 50.5 years, compared to an aveerage diver age of 38 years in a recent BSAC survey.

From the fatalities section:

Case 1

"After a training dive to a maximum depth of 10 msw for a duration of 55 min a group of four divers surfaced without problems after completing a safety stop. The group were approximately 15 msw from shore. One of the divers indicated that he had lost his weights. The lead diver told the others to return to shore and he would recover the weights. The lead diver descended to the seabed at a depth of approximately 2 msw and located the weights approximately 5–6 msw away. He recovered the weights and swam back along the seabed until in a depth of around 1.5 msw. At this point he came across one of the other divers on the seabed. The diver failed to respond to signals and was recovered to the surface where the lead diver signalled for assistance from the others. The casualty was recovered to the shore, his equipment removed and CPR conducted for 20–30 min until an ambulance arrived. The diver did not survive."

Case 2

"After a 20-min dive to a wreck at 60 msw a diver surfaced rapidly and missed all required decompression stops. The

skipper of the boat saw the diver come out of the water "like a torpedo" and then fall back face down in the water. The diver was then seen finning to try and get back down, he then raised an arm to signal distress and then went motionless. The skipper positioned his boat beside the diver, lowered the stern lift, with himself on it, and used the boathook to pull the diver alongside. The diver grabbed the lift handle and his grip couldn't be released; this gave the skipper some difficulty in getting the diver onto the lift. The skipper cut off the diver's equipment and began CPR. The Coastguard was contacted, a rescue helicopter was scrambled and the diver airlifted to hospital but he did not recover."

Decompression incidents (DCI)

In 2010, there were 105 cases of DCI in 98 reports. Apart from 2007, this is the lowest number recorded for 14 years. Where possible to elicit, the analyses of the causal factors associated with these incidents were:

- 29 repetitive diving;
- 23 rapid ascents;
- 18 diving deeper than 30 msw;
- 15 missed decompression.

This does not include reports from the RNLI of undefined "*diver illness*" where there may have been DCI.

From the DCI section:

Case 3

"A pair of divers were ascending after an uneventful wreck dive to a maximum depth of 36 msw. At the first of three decompression stops at 9 msw one of the divers kept turning away from his buddy where he would normally have made eye contact. Afterwards it was explained that his delayed SMB line kept pulling him round. After surfacing, the diver was very quiet and said he felt dizzy. His buddy instructed him to inflate his BCD more and go to the boat first. As the boat approached, the diver drifted past the tail lift and when doing so shook his head and went face down. His buddy swam after him and turned him over and pulled him to the tail lift. At this point the diver's body had gone completely stiff which created great difficulty in recovering the diver onto the lift. The skipper of the boat and the buddy managed to get the diver onto the lift and recovered into the boat. The buddy was then recovered into the boat and given the oxygen kit by the skipper who then alerted the Coastguard. The skipper had to recover other divers who were surfacing. The buddy started to administer oxygen to the troubled diver but it became apparent that resuscitation was required and the buddy started to administer CPR. CPR was successful and the diver was airlifted to a recompression chamber where he was recompressed and, within 3 hours, was able to stand and reported feeling normal."

Case 4

"Prior to a dive, a diver felt sick due to the rough surface conditions. Once on site, he wanted to get in the water as quickly as possible in the hope he would feel better in the water. Underwater, the feeling of sickness eased slightly but the diver was not enjoying the dive. Despite his discomfort he continued with the dive because it counted towards his speciality training. At the end of the bottom time the diver deployed a delayed SMB with some difficulties which he resolved. During the ascent, at a depth of 5 msw, his computer was indicating 6 min of decompression stops. The diver was diving with nitrox 32 and should not have required stops. Due to feeling unwell he surfaced and missed decompression stops. Once back on the boat, the diver collapsed and could not feel his fingers and toes. He was placed on oxygen and airlifted for recompression treatment."

From the Technique Incidents section the following case demonstrates a near-miss situation:

Case 5

"Two pairs of divers were to dive from a boat. After the first pair of divers had entered the water the second pair began kitting up. One of the divers discovered that his side-slung decompression cylinder containing nitrox 80 was missing and a similar cylinder containing air remained in the boat. This meant that one of the first pair of divers had unknowingly taken the decompression mix on a dive to 33m. The dive manager deployed a thunderflash to recall the divers. The first pair surfaced having reached a maximum depth of 25 m. The divers were recovered to the boat and the incorrect cylinder identified. The diver confirmed that he had not breathed from it."

It is heartening to see that the incidents of DCI appear to continue to fall, though avoidable errors still occur. The lessons from previous reports appear to have been learned. Brian Cumming and the BSAC team's efforts producing these reports are again commended and should be digested by all divers, diver educators and diving physicians.

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Key words

Recreational diving, accidents, diving deaths, abstracts

Critical appraisal

Hyperbaric oxygen therapy improved pain and range of motion for patients with Ficat stage II idiopathic femoral head necrosis

Bottom line
1. Pain was significantly reduced following 20 and 30 hyperbaric oxygen treatments (HBOT).
2. The range of movement was improved following HBOT.

Citation
1. Camporesi E, Vezzani G, Bosco G, Mangar D, Bernasek T. Hyperbaric oxygen therapy in femoral head necrosis. *J Arthroplasty*. 2010;25:118-23.

Three-part question
For patients with Ficat stage II idiopathic femoral head necrosis (FHN), does the administration of hyperbaric oxygen result in any improvement in symptoms?

Search terms
Femoral head necrosis, arthroplasty

The study
Double-blinded, randomised, controlled trial with intention-to-treat.

The study patients
Adult patients with a diagnosis of idiopathic FHN (MRI-confirmed) staged at Ficat II after plain X-ray.

AIR GROUP
(n = 10; 9 analysed): Air breathing at 253 kPa, 30 sessions over six weeks for 80 minutes daily.

OXYGEN GROUP
(n = 10; 10 analysed): 100% oxygen breathing on the same schedule.

The evidence
See Tables 1 and 2

Comments:
1. The RCT was completed immediately following 30 treatments because all control patients were crossed over to receive HBOT. Cohort follow up for seven years suggests gains are maintained and no patient required joint replacement during that time.
2. Clinical significance remains unclear, but it is probable there is a true functional improvement for the HBOT group.

Appraised by: *Mike Bennett, Prince of Wales Hospital, Sydney, Wednesday, 06 July 2011*
E-mail: *<m.bennett@unsw.edu.au>*

Key words
Bone necrosis, hyperbaric oxygen therapy, outcome, critical appraisal

Table 1
Change in pain score before and after HBOT. *These values have been measured off Figure 1[1] and the standard deviations calculated from 95% confidence intervals given in that figure

Outcome	Air group mean (SD)	Oxygen group mean (SD)	Difference	95% CI
Pain (VAS 0 to 10)*	5.3 (0.6)	1.4 (0.3)	3.9	3.7–4.1

Table 2
Median (range) changes of movement and relative proportion of the load taken by the affected leg following 30 HBOT

Outcome	Air group	Oxygen group	*P*-value
Range of movement in flexion (degrees)	76 (50–120)	112 (92–120)	0.20
Range of movement in extension (degrees)	3 (0–5)	20 (15–20)	<0.001
Range of movement in abduction (degrees)	7 (0–10)	35.5 (26–45)	<0.001
Standing load taken on affected leg (% difference of good leg minus affected leg after therapy)	18 (10–42)	12 (6–22)	0.06

Book review

Hyperbaric nursing and wound care

Valerie Larson-Lohr
Co-editors: Helen Norvell, Laura Josefsen and James Wilcox

ISBN 9781930536586
Hardcover, 272 pages, full colour
Best Publishing Company
Palm Beach Gardens, FL 33410, USA
Available from: <bestpub.com>
Price: USD69.99

At 248 pages of text, this is by no means a comprehensive book on hyperbaric nursing and wound care, but appears to offer an introduction into a specialised field of practice. The author list, with 20 contributors, is more limited than in some other hyperbaric texts. All are renowned within their areas of expertise. The information in each chapter is informative and set out in a logical manner. Each chapter is divided into sub-sections with a brief chapter overview of topics covered prior to in-depth information. This is a concise book covering basic aspects of HBOT and wound care.

Chapters are individually and extensively referenced. All photos are in colour but unfortunately some clarity is lost in the small size of the pictures or the resolution used. I cannot understand why the editors/publishers would allow out-of-focus or highly pixelated photographs in a publication on wound care. For a book on wound care, most nurses would expect good quality colour photographs depicting the types of wounds being discussed, whereas there are very few photographs and those that are present are of a poor quality; this is a serious deficiency. Also, in general, the font is too small and difficult to read. In some instances, the pictures, charts and diagrams are barely readable especially in the initial chapters. It made my eyes ache!

There are some great snippets of information within the text, e.g., the table of indications and the likely linked mechanisms providing the benefit in the chapter on physiology of hyperbaric oxygen therapy, but these have the potential to get lost due to their poor presentation. Miller and Josefen's chapter on staff competencies and training is a great tool for the nurse to assess where their skill levels are at and if they are competent, by using the points as a check list. Unfortunately this chapter gets somewhat lost, buried as it is at Chapter 15.

Drs Kimbell and McKenzie's essentials of wound management chapter is concise, logical and well constructed and forms a solid platform for how wound management should progress. Unfortunately, the following chapter on modern wound dressings has a large focus on the products available but fails to mention the use of 'TIME' (tissue of wound, infection/inflammation, moisture imbalance, edge of wound) for wound management, when this has been so strongly recommended in previous publications and recognised world-wide as a logical evidence-based wound care approach.

There is little of relevance to New Zealand/Australia (and probably Europe) in the chapters on documentation and legal aspects as they are very focused on the requirements in the USA. Good documentation is a basic requirement of nursing in general and not only relevant when choosing a speciality of practice.

The previous book dedicated to hyperbaric nursing was published nine years ago and, as stated in this book, there has been much advancement in this specialised field of nursing. It has been difficult for the reviewer and her nursing colleagues to find a place for this book as it seems to be neither an introductory text for nurses entering the hyperbaric speciality nor a quality reference for those with experience in the field. There are other excellent wound care and hyperbaric nursing books published or distributed by the same company; this one fails to fill a recognisable niche.

Yvonne Denny, Charge Nurse Manager, with the assistance of the nursing staff, Hyperbaric Medicine Unit, Christchurch Hospital, New Zealand.
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Key words
Nursing, hyperbaric oxygen therapy, wounds, book reviews

Continuing professional development

CME ACTIVITY 2011/2

Acute carbon monoxide poisoning

Daniel Mathieu

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 takers' 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:

Summary of common knowledge on carbon monoxide (CO) poisoning:

1 Mathieu D, Mathieu-Nolf M, Linke JC, Favory R, Wattel F. Carbon monoxide poisoning. In: Mathieu D, editor. *Handbook on hyperbaric medicine*. Dordrecht NL: Springer; 1986. p. 239-61.

Original clinical randomised studies on hyperbaric versus normobaric oxygen in CO poisoning:

2 Raphael JC, Elkharrat D, Jars-Guincestre MC, Chastang C, Chasles V, Vercken JB, et al. Trial of normobaric and hyperbaric oxygen for acute carbon monoxide intoxication. *Lancet*. 1989;2:414-9.

3 Scheinkestel CD, Bailey M, Myles PS, Jones K, Cooper DJ, Millar IL, et al. Hyperbaric or normobaric oxygen for acute carbon monoxide poisoning: a randomised controlled clinical trial. *Med J Aust*. 1999;170:203-10.

4 Weaver LK, Hopkins RO, Chan KJ, Churchill S, Elliott CG, Clemmer TP, et al. Hyperbaric oxygen for acute carbon monoxide poisoning. *N Engl J Med*. 2002;347:1057-67.

Recent papers on CO poisoning:

5 Chang DC, Lee JT, Lo CP, Fan YM, Huang KL, Kang BH, et al. Hyperbaric oxygen ameliorates delayed neuropsychiatric syndrome of carbon monoxide poisoning. *Undersea Hyperb Med*. 2010;37:23-33.

6 Garrabou G, Inoriza JM, Moren C, Oliu G, Miro O, Marti MJ, et al. Mitochondrial injury in human acute carbon monoxide poisoning: the effect of oxygen treatment. *J Environ Sci Health C Environ Carcinog Ecotoxicol Rev*. 2011;29:2-51.

7 Kavakli HS, Erel O, Delice O, Gormez G, Isikoglu S, Tanriverdi F. Oxidative stress increases in carbon monoxide poisoning patients. *Hum Exp Toxicol*. 2011;30:160-4.

8 Annane D, Chadda K, Gajdos P, Jars-Guincestre MC, Chevret S, Raphael JC. Hyperbaric oxygen therapy for acute domestic carbon monoxide poisoning: two randomised controlled trials. *Intensive Care Med*. 2011;37:486-92.

How to answer the questions

Please answer all responses (A to E) as True or False.

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

For EUBS members for this CPD issue this will be **Dr Daniel Mathieu, E-mail:** <dmathieu@nordnet.fr>.
For ANZCA DHM SIG members, this will be **Dr Margaret Walker**, **E-mail:** < margaret.walker@dhhs.tas.gov.au>.

On submission of your answers, you will receive a set of correct answers with a brief explanation of why each response is correct or incorrect. A comprehensive reference list will be provided with this.

Successfully undertaking the activity will require a correct response rate of 80% or more. Each task will expire within 24 months of its publication to ensure that additional, more recent data has not superceded the activity.

Key words

MOPS (maintenance of professional standards), carbon monoxide, toxicicity, hyperbaric oxygen therapy

Question 1. During an exposure to a toxic atmosphere, the amount of carbon monoxide (CO) absorbed in the body depends on:

A. the CO level in the atmosphere
B. the minute ventilation
C. the carbon dioxide arterial pressure
D. the cardiac output
E. the haemoglobin level.

Question 2. Cerebral toxicity due to CO is related to several mechanisms including:

A. arterial hypoxemia
B. brain hypoxia due to a decrease in brain oxygen delivery
C. depleted neuronal energy stores due to mitochondrial respiratory chain dysfunction
D. oxidative cell injury during the re-oxygenation phase
E. immune-mediated brain injury.

Question 3. Common clinical manifestations of acute CO poisoning include:

A. loss of consciousness
B. extrapyramidal rigidity
C. convulsion
D. flaccidity in young children
E. 'gastro-enteritis-like' syndrome: headache, dizziness, vomiting and diarrhoea.

Question 4. With regard to the measurement of carboxyhaemoglobin blood levels for the diagnosis of acute CO poisoning:

A. the carboxyhaemoglobin level is the same in arterial and venous blood
B. a carboxyhaemoglobin blood level over 3% is a strong argument for the diagnosis of acute CO poisoning in a young child
C. a carboxyhaemoglobin blood level over 6% is a strong argument for the diagnosis of acute CO poisoning in a non-smoking adult
D. the diagnosis of acute CO poisoning requires a carboxyhaemoglobin blood level measured at admission in the Emergency Department of over 10%
E. in a comatose patient, diagnosis of acute CO poisoning is excluded if carboxyhaemoglobin blood level measured at admission in the Emergency Department is under 5%.

Question 5. The remaining controversy regarding hyperbaric oxygen therapy (HBOT) use instead of normobaric oxygen (NBO) in the treatment of acute CO poisoning is because:

A. there is no evidence HBOT reduces CO-induced cerebral injury in animal studies
B. long-term neurological manifestations of acute CO poisoning are so rare that randomised clinical trials targeting reduction in their frequency are not clinically useful
C. the Raphael et al study (Lancet, 1989) comparing HBOT versus NBO in CO-poisoned patients with no consciousness alteration is negative
D. in the negative Scheinkestel et al study (Med J Aust, 1999), the NBO group received an unusual normobaric oxygen protocol
E. the Weaver et al study (NEJM, 2002) has several methodological biases precluding any conclusion.

Interesting articles from the literature

1. Hyperoxia for brain injury

Associate Professor Michael Bennett has drawn attention to this review paper, which he describes as "*not a bad summary of where we are…*"

Tolias CM. Hyperoxia in the treatment of traumatic brain injury and stroke. *Transfusion Alter Transfusion Med*. 2010;11:148-55.

2. Exercise-induced pulmonary oedema

This paper addresses the current controversies that exist in the field of exercise-induced pulmonary oedema on land and with immersion and discusses its possible mechanisms and the current gaps in our knowledge.

Bates ML, Farrell ET, Eldridge MW. The curious question of exercise-induced pulmonary edema. *Pulm Med*. 2011; 361931. Epub 2011 Mar 30.

3. Diving injuries in rebreather divers

One hundred and fifty-three accidents in French military divers over 30 years are reported, with an estimated incidence rate of one event per 3,500 to 4,000 dives. Gas toxicities account for two-thirds of these, and mortality, at only three deaths, was very low.

Gempp E, Louge P, Blatteau JE, Hugon M. Descriptive epidemiology of 153 diving injuries with rebreathers among French military divers from 1979 to 2009. *Mil Med*. 201;176:446-50.

Letters to the Editor

Malignant otitis externa: experience with hyperbaric oxygen therapy

Dear Editor,

I have read with great interest the recently published series of patients treated with hyperbaric oxygen therapy (HBOT) for malignant otitis externa (MOE).[1] I agree that the treatment of this disease presents a challenge and, because of its low incidence, randomised controlled studies are impossible.

I am surprised by the high percentage of serious adverse effects of HBOT encountered in this study. The authors report that five out of 17 patients had serious adverse effects with two cases of pulmonary oedema, one hyperoxic seizure (which after careful reading turns out to be more likely a hypoglycaemic episode), one tympanic membrane perforation and one case of claustrophobia which occurred during the patient's first session. Even after discounting the case of claustrophobia, the remaining incidence of 24% is still extremely high compared to the expected incidence of side effects in this patient group. In the discussion (page 199, paragraph 2), it says "*complications such as oxygen toxic seizures and acute pulmonary oedema are directly related to high intra-arterial oxygen tensions and are well documented in the literature*". The quoted paper here (reference 14, Leach et al 1998) refers to pulmonary symptoms and subsequently pulmonary oxygen toxicity and not to acute pulmonary oedema.[2] Pulmonary oedema as a side effect purely of HBOT is extremely rare and we have not seen pulmonary oxygen toxicity in patients treated for 2 hours per day, as would be the case in MOE. Further on in the discussion (page 199, paragraph 2), the authors quote a recent review which has the wrong reference (this should be reference 21 not 18) and where they report a complication rate of 20%, whereas in the original quoted paper by Huang et al it is 1.83%.[3] Further on, the incidence of serious complications quoted in this publication by Saxby et al is 1.7% (they include pulmonary oedema, even though the original paper by Huang only talks about central nervous system toxicity), but the incidence in the original publication by Huang et al was 0.109%.[3]

At the 2010 Annual Scientific Meeting of the European Underwater and Baromedical Society, we presented a series of nine patients with MOE who received HBOT at Whipps Cross Hospital, London.[4] In our series, none of the patients experienced any severe adverse events during a similarly long treatment programme of 23 to 40 sessions. This treatment was sufficient to yield a benefit in seven of the nine patients (with benefit defined as both a significant improvement of symptoms – pain, discharge and cranial nerve palsies – and normalisation of inflammatory markers post-treatment).[4] We have similar positive results in the patient series in Plymouth (unpublished observations).

The high incidence of serious side effects reported by the authors gives me cause to wonder how patients in this retrospective study were screened for their suitability for HBOT. I am concerned that non-hyperbaric specialists reading this paper might conclude that the risk-benefit of using hyperbaric oxygen in MOE is in favour of avoiding its use, with a high risk (29%) of serious side effects and a very low benefit.

Indeed, we had problems convincing our local health authorities to fund treatment for our patients, hence a published paper talking about five out of 17 patients having serious side effects from the treatment would just reinforce their belief that HBOT is dangerous and not beneficial. Hyperbaric physicians should be careful when publishing data that could be interpreted in the wrong way by specialists unversed in hyperbaric medicine.

References

1 Saxby A, Barakate M, Kertesz T, James J, Bennett M. Malignant otitis externa: experience with hyperbaric oxygen therapy. *Diving Hyperb Med*. 2010;40:195-200.
2 Leach RM, Rees PJ, Wilmshurst P. Hyperbaric oxygen therapy. *BMJ*.1998; 317(7166):1140-3.
3 Huang KC, Hsu WH, Peng KT, Huang TJ, Hsu RW. Hyperbaric oxygen therapy in orthopedic conditions: an evaluation of safety. *J Trauma*. 2006;61:913-7.
4 Lechner M, Heywood R, Patel N, Ignatescu M. Hyperbaric oxygen therapy in malignant otitis externa. *Proceedings of the Annual Scientific Meeting of the European Underwater and Baromedical Society*; 2010. p. 52.

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Reply

We thank Dr Ignatescu for her thoughtful comments on our recent case series of malignant otitis externa (MOE).[1] Dr. Ignatescu raises some interesting and important issues, and we are pleased with the opportunity to discuss these further. We agree the incidence of serious side effects is high in this patient group, but are perhaps less surprised that this is so than Dr Ignatescu. One of the reasons we wished to do this review of our experience was our clinical impression that these generally elderly patients with many co-morbidities were indeed prone to adverse effects of their therapies and of suffering poor outcomes despite all our efforts. Dr Ignatescu quotes our numbers correctly; five of 17 patients suffered significant adverse effects and this confirmed our clinical suspicion. Whether one interprets the seizure included here as hyperoxic or hypoglycaemic is of little consequence; this patient still suffered an adverse event of therapy. Please

note also that the relevant paragraph in our report starts "*Complications that might be attributed to HBO…*" That is, we accept there is some room to argue the true cause of some of these events.

We thank Dr Ignatescu for pointing out that the reference included concerning complications does not talk specifically about pulmonary oedema.[2] The intended additional reference specific to pulmonary oedema disappeared inadvertently in the drafting stage in our attempts to shorten this report so it was an acceptable length for publication. The intended reference was Weaver and Churchill 2001.[3] There are further references available in that article to support our statement that pulmonary oedema is a well-reported complication of HBOT. To quote from Weaver's introduction: "*Pulmonary edema is a rare complication of hyperbaric oxygen therapy. Abel et al estimate the incidence of pulmonary edema associated with hyperbaric oxygen therapy at 1 in 1,000, and Riddick suggested that patients with reduced cardiac ejection fractions (EFs <40%) should not receive hyperbaric oxygen therapy because of the risk of acute pulmonary edema*". We absolutely agree that pulmonary oxygen toxicity is not a problem in patients receiving daily HBOT at the pressures used for these patients, nor did we suggest that to be the case.

Dr Ignatescu is also correct that the reference '18' in the discussion (page 199) should have been '21' and we apologise for any confusion. There should have been no reference given after the first of these two sentences. We believe, however, that Dr Ignatescu has misinterpreted the complication rates given in Huang 2006[4] as a result of mixing up quoted incidences *per treatment* and *per patient*. We agree with the figures quoted by Dr Ignatescu, but note that those we quoted are per patient, not per treatment. This is clearly given in Table 2 in Huang (48/240 or 20%) and we believe this figure is more easily interpreted by a non-expert. We had felt this was understood from the few lines above where we were talking about the proportion of patients suffering adverse events, but concede that it may have been better to emphasise this again in this passage so the reader could not possibly be confused by the two different ways of looking at the rate of complication.

We congratulate Dr Ignatescu on the success of HBOT in her group of patients at Whipps Cross Hospital and urge her to publish this is in a listed journal to add to the discoverable literature on this subject. We think the most important statement in this regard in her letter is: "*The high incidence of serious side effects reported by the authors gives me cause to wonder how patients in this retrospective study were screened for their suitability for HBOT.*" We agree – the difference in outcome probably arises from differences in our clinical decision making. We also agree with the implication that your group denied HBOT to some of the patients whom we would have accepted. Adopting a more conservative policy is indeed likely to identify those more able to tolerate HBOT; thus the Whipps Cross series has a good outcome with a low complication rate. We would argue that you may have refused patients who could have benefitted, and that our broader inclusion criteria demonstrates that only two of 17 (11.8%) could not ultimately tolerate the course of HBOT offered. Among those who did get HBOT, we perhaps contributed to improved outcomes that would not have occurred if HBOT had been withheld on safety grounds. Which of these interpretations is correct is, of course, unknowable without good comparative trials that we both agree are not possible. We simply do not know which strategy will produce the greatest net benefit.

It is possible, as Dr Ignatescu suggests, that non-hyperbaric physicians reading our study might conclude that HBOT is of little benefit in MOE. We are not clear this means we should avoid reporting our experience as is implied in the letter. We do not think it is appropriate to report our patients in the best possible light for the application of HBOT, but rather that we are honest about our experience. We have no doubt both our groups have been so, and the difference in our reported experiences contains a lot of subtle and unknown biases that have affected our outcomes. It is the primary care team physicians who must decide how they will interpret such evidence – hopefully with the guidance of specialist hyperbaric physicians who understand their literature and have appropriate experience. In this, there is no substitute for having people in our field who think deeply about what they do. We congratulate the group at Whipps Cross for being in that category.

References

1 Saxby A, Barakate M, Kertesz T, James J, Bennett M. Malignant otitis externa: experience with hyperbaric oxygen therapy. *Diving Hyperb Med*. 2010;40:195-200.

2 Leach RM, Rees PJ, Wilmshurst P. Hyperbaric oxygen therapy. *BMJ*. 1998;317(7166):1140-3.

3 Weaver LK, Churchill S. Pulmonary edema associated with hyperbaric oxygen therapy. *Chest*. 2001;120:1407-9.

4 Huang KC, Hsu WH, Peng KT, Huang TJ, Hsu RW. Hyperbaric oxygen therapy in orthopedic conditions: an evaluation of safety. *J Trauma*. 2006;61:913-7.

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Key words
Hyperbaric oxygen therapy, malignant otitis externa, ENT, clinical audit, outcome, letters (to the Editor)

Advertising guidelines for *Diving and Hyperbaric Medicine*

Dear Editor,

This letter is intended to serve as a policy document in relation to the journal *Diving and Hyperbaric Medicine*. The remarks and suggestions below have the support of both the EUBS and SPUMS.

We support the concept of advertising in the Journal and value highly the contribution that any advertisers would make to the maintenance of a high-quality scientific journal. Nevertheless, we believe there are potential advertisers who would not be acceptable to the members of both our societies. These include those designed to market unhealthy or inefficacious products. We have detailed below the categories we have agreed would fall under the description of 'unacceptable' and suggest that to advertise such products and services would be contrary to the scientific integrity of the Journal.

We also note there is a belief in both societies that, while the appearance of an advertisement in DHM does not specifically demonstrate endorsement of the service or product by the Journal or the Societies, such an endorsement may be assumed by many readers. There is a distinction in this regard between advertising in a non-scientific publication and a scientific journal.

We recognise the final decision to reject or accept an individual advertiser lies ultimately with the Editor and the Editorial Board, but these guidelines are designed to assist in decision making on this subject.

The EUBS and SPUMS Executive Committees suggest the following categories of services and products would not be acceptable:

- harmful or illegal products (such as: alcohol, tobacco, recreational drugs or any such product that is classified as illegal or harmful in Australia/New Zealand or the European Community);
- products and/or services in the field of hyperbaric and diving medicine that can be classified as 'non-justified use' by the criteria set forth by respectively SPUMS and EUBS/ECHM in their official publications;
- products or services that compromise diving safety;
- various 'alternative' forms of oxygen administration (e.g., topical HBO, mild hyperbaric therapy);
- marketing the use of 'non-approved' indications (category D, E, F in the ECHM list of indications; anything not on the SPUMS list);
- marketing in support of a product or service without a medically justifiable intent. This includes any drug or physical intervention designed to increase performance or which can potentially place patients at an unacceptable risk (such as doping products);
- products and/or services where there is no relationship to diving, diving and hyperbaric medicine, emergency, intensive care or related fields of medicine and where the same 'non-justified use' criteria apply as above;
- any product and/or service where there is a material conflict of interest with the Editor or any member of the Editorial Board. Consideration may be given to accepting an advertisement if there is a declaration of such a conflict and the Board member concerned is not involved in any decisions concerning placement, fees charged or accompanying articles.

The Editor of DHM may refer any requests for advertising to the SPUMS and EUBS Executive Committees for advice and clarification as required.

Peter Germonpré, President, EUBS
Mike Bennett, President, SPUMS

Key words
Policy, medical society, diving industry, hyperbaric medicine, letters (to the Editor)

Advertising in *Diving and Hyperbaric Medicine*

The decision was made recently to invite commercial advertising within the pages of *Diving and Hyperbaric Medicine*. Companies and organisations 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 – is set out above and appears on the journal website <www.dhmjournal.com>.

Details of advertising rates and formatting requirements for publication may be obtained on request to this office at:
E-mail: *<editor@dhmjournal.com>*
Fax: *+64-(0)3-329-6810*

Lithium batteries – intravenous infusion pumps used in hyperbaric facilities

Dear Editor,

Whilst validating the Royal Hobart Hospital hyperbaric facility's latest replacement Baxter intravenous infusion pumps (models Colleague 3 CXE and Colleague CXE), two lithium thionyl chloride batteries were discovered inside the pump. These batteries are used as a system backup when both mains power and the main battery fail. It was not obvious to us that there was a second set of batteries in the pump.

These present an occupational health and safety hazard because lithium batteries are prohibited in a hyperbaric chamber.

In order to maintain absolute safety in the hyperbaric chamber we have removed these batteries from one of the pumps in the short term to investigate if the pump will fully function satisfactorily without them. The pump has functioned normally without the batteries. We are also checking with the pump designer to determine any possible errors that might occur. Our technical staff are currently conducting detailed validation testing of pump function without the batteries and will report the outcome in a separate submission to *Diving and Hyperbaric Medicine*. We aim to replace the batteries further down the track with more hyperbaric-compatible battery type or, if there are no issues without the batteries, to remove them permanently.

We wish to draw this to everyone's attention and advise that hyperbaric units conduct a review of the infusion pumps used at their facility.

Associate Professor David Smart, Medical Co-director
Corry Van der Broek, Facility Technical Manager
Department of Diving and Hyperbaric Medicine
Royal Hobart Hospital.
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Key words
Equipment, hyperbaric facilities, safety, letters (to the Editor)

Obituary – William Brook Filer

Lt Cmdr William ("Uncle Bill") Brook Filer, MBE, GM, RN, died on 31 January 2011, aged ninety-three. Bill joined the Royal Navy in 1933 as a 15-year-old boy sailor and worked his way through the ranks to become a warrant officer after the war. He retired from the Royal Navy in 1962 with the rank of Lieutenant Commander.

His was a highly distinguished career, serving as a torpedoman, diver (at 19 years old he was one of the youngest navy divers) and in bomb and mine disposal. It was in the last-named role in North Africa that he earned the George Medal. He also learnt to fly and in 1938 became the Navy's only flier and diver. After the war, he became one of only nine divers in the RN at that time qualified for deep diving to 300 ft. In 1948, he became technical adviser on the newly-commissioned diving trials vessel *HMS Reclaim*.

His most important contribution to military and deep diving, however, was from the time he was appointed to the Admiralty Experimental Diving Unit (AEDU), where he remained until retirement from the navy, and then as the civilian officer-in-charge until the mid-1980s, overseeing many deep diving trials. He was involved in the pioneering of saturation diving, the introduction of trimix (oxygen, helium and nitrogen) and the setting of a deep diving record in 1970, when John Bevan and Peter Sharphouse spent 10 hours at a simulated depth of 1,500 ft.

Editor's note:

I first met Bill at the AEDU in 1964 when, as a second-year medical student, I was part of a scientific deep diving team from Cambridge University; then again on several visits to the AEDU through to the late 1970s. He seemed to me the epitome of the naval officer; clear and concise in his instructions, with a commanding air and a twinkle in his eye, and, amazingly, on my return visits he remembered my name and background.

EUBS European Underwater and Baromedical Society

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EUBS European Underwater and Baromedical Society

38th EUBS Annual Scientific Meeting 2012

First Announcement

Dates: 11–16 September 2012
Venue: Sava Centre, Belgrade, Serbia

11–12 September: ECHM Consensus Conference
Organisation of a clinical hyperbaric therapy centre and related health management issues
12–15 September: EUBS Annual Conference
16 September: DAN Divers Day

Hosts: The Centre for Hyperbaric Medicine and the University of Belgrade School of Medicine

For the first time the EUBS Annual Meeting will be preceded by an ECHM Consensus Conference on the organisation of a clinical hyperbaric therapy centre and related health management issues. This offers the unique opportunity to participate in two highly significant events for the European hyperbaric community.

Chairman of the Organising Committee**:** Miodrag Zaric
Executive Secretary of the Organising Committee: Alessandro Marroni

Conference main topics:

Pressure physiology and medicine
Diving physiology and medicine
Basic research in hyperbaric medicine
New frontiers of HBOT
Hyperbaric oxygenation fundamentals
Cost-benefit in HBOT
Nursing in hyperbaric medicine practice

Preliminary timetable:

February 2012: Second announcement
15 May: Deadline for submission of abstracts
15 June: Notification of accepted abstracts

Language: The official language of the conference will be English.

Contact details:

Centre for Hyperbaric Medicine
Mackov kamen 24a
11040 Belgrade
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Phone: *+381-(0)11-3670-158*
Fax: *+381-(0)11-2650-823*
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SPUMS notices and news

South Pacific Underwater Medicine Society Diploma of Diving and Hyperbaric Medicine

Requirements for candidates (updated October 2008)

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

1 The candidate must be medically qualified, and be a current financial member of the Society.
2 The candidate must supply evidence of satisfactory completion of an examined two-week full-time course in Diving and Hyperbaric Medicine at an approved facility. The list of approved facilities providing two-week courses may be found on the SPUMS website.
3 The candidate must have completed the equivalent (as determined by the Education Officer) of at least six months' full-time clinical training in an approved Hyperbaric Medicine Unit.
4 The candidate must submit a written proposal for research in a relevant area of underwater or hyperbaric medicine, in a standard format, for approval *before* commencing their research project.
5 The candidate must produce, to the satisfaction of the Academic Board, a written report on the approved research project, in the form of a scientific paper suitable for publication. Accompanying this written report should be a request to be considered for the SPUMS Diploma and supporting documentation for 1–4 above.
6 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):110-2.
7 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.
8 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 2008, 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 the Education Officer:
Associate Professor David Smart
GPO Box 463, Hobart, Tasmania 7001
E-mail: *<david.smart@dhhs.tas.gov.au>*

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

Minutes of the SPUMS Executive Committee Meeting 06 November 2010 at Prince of Wales Hospital, Sydney

Opened: 1008 h

1. Attendance:
M Bennett, S Lockley, J Lehm, G Hawkins and M Davis

2. Apologies:
G Williams, D Smart, S Squires, C Acott and V Haller

3. Minutes of previous meeting:
Minutes accepted for Executive Committee Meeting, Berjaya Resort Redang Island, Malaysia, held 23 May 2010. Proposed M Bennett, seconded G Hawkins, carried.

4. Matters arising from previous minutes:

4.1 Cathy Meehan has expressed interest as Convenor for ASM 2012. The location is to be finalised. *Complete*.

4.2 Editor's contract has been e-mailed for review by the Committee. *Complete*.

4.3 Further discussion to explore cost-effectiveness of printing DHM in Europe and distributing there versus printing with Snap Printing locally, and mailing out. Due to small-batch printing, costs go up if printed in Europe so may not be cost-effective. M Davis to continue to investigate. *Ongoing*.

4.4 Further discussed method for payment of advertising in DHM. J Lehm advised best method is for DHM Editor to send details to Treasurer who will issue invoice. *Complete*.

4.5 Discussed current issue with dive medical assessment for diabetics. No training courses yet available for diabetic divers in Australia and New Zealand. Implication is that it is still impractical to perform dive medical assessments on diabetic divers as new guidelines require specialised dive training courses and these are not yet available. Some work is being done by a group of general practitioners in the Port Douglas region, with local dive operators, but this is still in discussion phase. *Ongoing*.

4.6 Discussed changes to ISO Standards and conflict with A/NZS Diving Standards. ADAS to act as host. D Smart explained legal implications and expense involved in developing standard. *Ongoing*.

4.7 Donation to Rubicon of AUD 1,000 was agreed upon. *Complete*.

4.8 Epilepsy position paper is being drafted currently. *Ongoing*.

4.9 Discrepancy in membership and income amounts. See report as an addendum to AGM minutes, published in *Diving and Hyperbaric Medicine*. 2010;40:173. (Treasurer and President). *Complete*.

5. Annual Scientific Meetings:

5.1 ASM 2010

Final budget provided to committee by G Hawkins. An overall profit was made of AUD 5,808.24. Registrant numbers – 61 full registrants, 27 accompanying adults and six accompanying children.

5.2 ASM 2011

Discussed venue change to Hilton Guam Resort and Spa, due to airline carrier issue and problems with venue administrators. Convenor's assessment of the site presented to the Committee. Event website page was demonstrated, although not yet launched. Keynote speakers finalised. Deposits to be paid for venue (conference costs and accommodation costs).

5.3 ASM 2012

C Meehan has volunteered to convene the ASM in 2012. The venue is likely to be in Madang, PNG. This is still in the planning phase.

5.4 ASM 2013

Combined meeting with EUBS is planned. Proposal by P Germonpré (President EUBS) received via e-mail. Suggested site is La Reunion. Further discussion around cost of flights from Australia and Europe. Alternative locations were discussed including Oman and Muscat.

Action: M Bennett to respond to P Germonpré. M Davis has a contact within the Oman Navy and will investigate further also.

6. Journal matters:

6.1 Some papers are yet to be received from speakers at 2009 ASM. Advise increase charges for DHM by 10%.

Action: Secretary to send out previous budget with caveat, to the Committee (received from DHM Editor) for discussion.

6.2 Discussion around who is the Journal Publisher. Editor is concerned that it is him and questioning whether he will be covered under the SPUMS insurance for legal issues that arise.

Action: M Davis to seek advice from AMJA.

6.3 Discussed non-member subscriptions for DHM and cost.

6.4 Journal budget included additional expenses this year. Extra journals were printed and posted out due to change over of database. Proposed new budget submitted by M Davis for July 2010 to June 2011, based on actual cost from July 2009 to June 2010. Note change in budget recommended. The SPUMS administrator fee should be changed to the SPUMS administrator plus the Journal administration fees.

6.5 Revision to Editor's contract provided to committee and reviewed.

7. Website update

7.1 Diving Doctor List – Members need to be reminded to update their contact details online when they rejoin. If member does not rejoin by a deadline, then they should be removed from the list.

7.2 Suggest a disclaimer be added to the Diving Doctor List to clarify the purpose of the list. Also, we accept the accuracy of the list in terms of qualifications to perform specific dive medicals. **Action:** G Hawkins to discuss with S Goble to examine Diving Doctor List to determine

non-members (unpaid) so that an e-mail can be sent out to warn them that they will be removed from the list if their membership is not paid. This may act as stimulus for members to renew membership.

8. Education Officer's report
Has been forwarded to Secretary and reviewed here. For forwarding to Committee via e-mail.

9. Treasurer's report
9.1Apologies were given to the Treasurer on behalf of the Committee for confusion around the acceptance of the Treasurer's report. Intent was not to cause offence but to clarify discrepancy between member numbers and income that arose at the AGM. The Treasurer was not present at the meeting to clarify; however, this has since been investigated and resolved.
9.2 Membership renewal and subscription was discussed, likely this will need increasing at next AGM.
9.3 Subscription cost for corporate members was discussed. **Action:** M Davis to investigate further.

10. Secretary's report
Correspondence received from S Squires indicating his desire to resign from his position as Committee Member due to personal circumstances and difficulty attending the committee meetings due to locality change and other commitments. Peter Smith, Officer-in-Charge at the RAN Submarine Underwater Medicine Unit, has volunteered to take his position. The Committee voted unanimously to appoint P Smith into the vacant office, until the next AGM. Proposed S Lockley, seconded M Bennett, carried. Contact details for LCDR P Smith will be provided to the Committee by the Secretary.

11. Other business
DAN South Africa has forwarded an e-mail to M Bennett requesting an endorsement of a document they have developed detailing the risk assessment (including quality and safety) of remote recompression chamber facilities. G Hawkins left the room prior to the discussion after declaring a conflict of interest. M Bennett presented the e-mail to the committee. **Action:** M Bennett to draft a response to DAN South Africa to be reviewed by the Committee.

12. Correspondence
Nil

13. Next meeting
Hilton Guam Resort and Spa, Sunday 22 May, at SPUMS ASM 2011

Closed: 1335 h

Minutes of the Annual General Meeting of SPUMS held at The Hilton Hotel, Guam, on Thursday 27 May 2011

Opened: 1515 h

Present: The President and 29 voting members

Apologies: Drs G Hawkins, G Williams, M Davis, P Mueller, C Acott

1. Minutes of the 2010 AGM
Minutes of the previous meeting were published in *Diving and Hyperbaric Medicine*. 2010;40(3):169-75 and were posted on the notice board. Motion that the minutes be accepted as an accurate record.
Proposed Dr S Lockley, seconded Dr R Harris, carried.

2. Matters arising from previous minutes: Nil

3. President's report: M Bennett

4. Secretary's report: S Lockley

5. Education Officer's report: D Smart

6. Treasurer's report: J Lehm

7. Annual financial statement: J Lehm
The Auditor's report for the 2010 financial year will be available to the members on the SPUMS website The full report will be published only on the website in future.

8. Journal Editor's Report: M Davis (presented by M Bennett)

9. Subscription fees for 2011
The Executive Committee proposes a minor increase in the annual membership fee. It was proposed we notify members by e-mail around 01 November each year and then offer a substantial discount for payments within three months. It was further proposed that the new full membership fee be AUD 175, if paid on-line before 31 January and AUD 200, if paid later. Paper renewals are an extra AUD 10 and shipping DHM to an address outside Australia -New Zealand will add another AUD 10. Corporate membership fee was proposed to increase to AUD 440. Motion that the subscription fees be increased. Proposed M Bennett, seconded P Smith, carried.

10. Election of Office Bearers:
The following were elected/appointed unopposed:
Secretary: Karen Richardson (elected)
Public Officer: Andrew Fock (appointed)
Two nominations were received for the position of Executive Committee Member.
Nominee: Peter Smith
Nominee: John Orton

A ballot for this position will be organised in accordance with the constitution.

11. Appointment of the Auditor 2011:
J Lehm has recommended re-appointment of Barrett, Baxter and Bye (Medical Accountants) as Auditor. Motion that Barrett, Baxter and Bye be re-appointed as Auditor. Proposed J Lehm, seconded M Bennett, carried.

12. Business of which notice has been given:
Multiple motions regarding changes to the Purposes and Rules of the South Pacific Underwater Medicine Society. A raft of amendments was put to the meeting as detailed below. Formal consideration was preceded by an introduction and summary of the changes by M Bennett. He proposed all changes to be in the interest of good and efficient governance of the Society. No-one spoke against the aim of these proposals.

Discussion: With regard to proposal four, 22 (b), R Harris spoke to the importance of developing a system that preserves anonymity but allows prevention of fraudulent votes. M Bennett undertook to investigate and institute such a system prior to the coming election.

Proxy votes held by individuals were accepted at each vote.

Proposal one:

That the Purposes and Rules be altered to allow individuals to notify SPUMS of their wish to become members by indicating this intention through our website. To whit:

Procedure for registration of members
4. (a) Any person seeking ***any form of membership*** may apply by ***completing a membership form on the Society website and submitting this electronically to the Secretary or*** writing to SPUMS Membership, C/o Australian and New Zealand College of Anaesthetists, 630 St Kilda Road, Melbourne, Victoria 3004, Australia.
Proposed M Bennett, seconded J Lehm, carried unanimously.

Proposal two:

That the Secretary may delegate the keeping of either a hard copy or electronic database of all members to the SPUMS Administrator. To whit:

Register of members
6. The Secretary shall keep and maintain a register of members in which shall be entered the full name, address and date of entry of the name of each member and the register shall be available for inspection by members ***on request of*** the Secretary. ***The register may be maintained in an electronic or hard copy form at the discretion of the secretary. The Secretary may delegate this function to the Administrator, but the Secretary remains responsible for the integrity and accuracy of the list.***
Proposed M Bennett, seconded J Lehm, carried unanimously.

Proposal three:

That the constitution be altered to allow SPUMS to notify members of annual general and special meetings and notices of election via e-mail and website. To whit:

Notice of meetings
12. (a) The Secretary of the Association shall at least 21 days before the date fixed for the holding of any annual general meeting of the Association and at least 14 days before the date fixed for the holding of any special general meeting of the Association, cause to be sent to each member of the Association a notice ***via e-mail to*** their ***electronic*** address appearing in the register of members, ***cause to be available the same notice on the web site of the Association and, if requested by the individual member, cause the same notice to be sent*** by prepaid post stating the place, date and time of the meeting and a description of the purpose of and a summary of the business to be transacted at the meeting.
(c) A member desiring to bring any business before a meeting may give notice of that business in writing ***or via e-mail*** to the Secretary who shall include that business in the notice calling the next general meeting after receipt of the notice.

Service of notices
34. (a) A notice may be served by or on behalf of the Association to any member either personally ***or by sending it by e-mail*** to the member at his ***electronic*** address shown in the register of members, ***or, if requested, by*** post to the member at his address shown in the register of members.
(b) Where a document is properly addressed ***whether by e-mail or*** pre-paid and posted to a person as a letter, the document shall, unless the contrary is proved, be deemed to have been given to the person at the time at which the letter would have been delivered in the ordinary course of post.
Proposed M Bennett, seconded J Lehm, carried unanimously.

Proposal four:

That the constitution be altered to add a further appointed position to the SPUMS Committee – the Webmaster. This officer is to be responsible for the maintenance and content of the Association's website. To whit:

Officers of Committee
22. (a) The Committee shall consist of a President, Immediate Past President, a Secretary, a Treasurer, a Public Officer, ***a Webmaster***, the Editor of the Journal, an Education Officer, the Chairman of the Australian and New Zealand Hyperbaric Medicine Group and three other members of the Association entitled to vote.
(b) All officers of the Association, except those detailed in

22 (c), shall be elected by ***ballot using electronic means or a postal notice*** and ballot to individual members on request to the Secretary if the number of candidates exceeds the number of vacancies.
(c) The Editor, the Public Officer, ***the Webmaster*** and the Chairman of the Australian and New Zealand Hyperbaric Medicine Group shall be appointed to their positions. The first ***three*** by the Committee, the other by the Australian and New Zealand Hyperbaric Medicine Group.
An amendment to the wording of proposed constitutional changes in item 22 sub clause (b) from '**e-mail**' to '***electronic means***' was proposed by Richard Harris and seconded by Michael Bennett and passed by unanimous vote. With this proviso to previously advertised amendments, the motion was made that this change be accepted.
Proposed M Bennett, seconded J Lehm, carried unanimously.

Proposal five:

That the constitution be altered to allow notice of committee meetings to committee members to be delivered by e-mail. To whit:

Meetings of Committee and resolutions of Committee
24. (i) Written notice of each Committee Meeting shall be served on each member of the Committee by delivering it to him at a reasonable time before the meeting ***via e-mail or*** by sending it by pre-paid post addressed to him at his usual or last known place of abode at least ten business days before the date of the meeting, or in the case of any member residing out of Australia, at least fourteen business days before the date of the meeting.
Proposed M Bennett, seconded J Lehm, carried unanimously.

Proposal six:

That the constitution be altered to introduce key performance indicators for committee members in addition to the current stipulation that missing three consecutive committee meetings (without valid excuse) is grounds for removal from the Committee. To whit:

Performance indicators and termination of committee appointments on absence from three meetings and on death or resignation.

26. ***(a) All members of the Committee will be required to report to the Annual General Meeting on Key Performance Indicators. These indicators will be task-specific and defined for each term of each committee member by agreement within the Committee.***
(b) Any member of the Committee, who fails to attend three consecutive committee meetings without leave of absence being granted, shall cease to be a member of the Committee. His or her ***committee membership*** shall also cease on the death or resignation of a member.

Order of business at general meetings
11. The order of business at general meetings of the Association shall normally be:
(a) At annual general meetings:
(i) Apologies;
(ii) Reading and confirmation of minutes from previous annual general meeting or any special general meeting;
(iii) Matters arising from minutes;
(iv) Annual report;
(v) Committee performance indicator reports
(vi) Annual financial statement;
(vii) Fix the subscription for the coming year;
(viii) Announcement of the newly elected Committee and the holding of any ballots necessary under Rule 8 (d) (iii);
(ix) Appointment of Honorary Auditor;
(x) Any business of which notice has been given.
Proposed M Bennett, seconded J Lehm, carried unanimously.

Closed: 1853 h

President's report

The President's report to the AGM is reproduced at the front of this issue on the Presidents' Pages, p. 122-3.

Secretary's report

This is my final year as Secretary, so firstly I would like to thank the Committee for their support and assistance over the last three years. I was very junior in the Society when I took on the role of Secretary, having been a member for only 18 months at that time. Hence I would emphasise to all members that you do not have to have years of experience to nominate for a position on the Committee. What you do require is a level of commitment to the Society, diving and hyperbaric medicine, and the motivation and enthusiasm to learn and attend to the tasks involved.

In 2011 (as at 29 April), the SPUMS has a total membership of 450, with full membership totalling 384, 38 associated members, 21 corporate members, seven retired members and no students.

In May 2010, total membership was 506, with full membership totalling 437 and 69 associate, life or free members.

Hence this year, there has been a drop in the total membership of 56 and a decline in the full membership of 53. This is concerning and has been addressed previously in the President's report. I would again encourage all members to actively promote the SPUMS by inviting potential members to the Annual Scientific Meetings and being opportunistic in discussions at medical meetings and courses.

I would also encourage members to become more involved generally in the Society, perhaps by considering nominating for a position on the Committee, or volunteering to convene future meetings. It would certainly be a shame if the member numbers continue to drift down, as the older generations move on or retire, because of a lack of interest and commitment from the newer generations of diving and hyperbaric doctors, scientists, nurses, technicians and enthusiasts.

Sarah Lockley

Key words
Medical society, meetings

Treasurer's report

The SPUMS financial year is from January to December. Overall, the 2010 financial year was stable despite a falling membership. The subscription income has increased substantially since 2009 where late membership renewals caused a decrease in income for that year as previously discussed at the AGM and explained in this journal.

On the expense side, we managed to reduce the production costs of the Journal by finding a cheaper mail solution. Other costs were similar to previous years. The end result was a surplus of just over AUD 9,000 increasing the assets of the Society to AUD 120,000.

The Executive Committee proposes a minor increase in the annual membership fee. It is suggested to notify members by e-mail around 01 November each year and then offer a substantial discount for payments made within three months. It is proposed to set the new full membership fee at AUD 175, if paid on-line before 31 January, and AUD 200, if paid later. Paper renewals are an extra AUD 10 and shipping the Journal to an address outside Australia and New Zealand will add another AUD 10. It is also proposed to increase the corporate membership fee to AUD 440.

Jan Lehm

Key words
Medical society, meetings

Education Officer's report

SPUMS Diplomas

On behalf of the Academic Board of SPUMS, I offer my congratulations to Dr Cathy Meehan who completed her project entitled: *Medical assessment of fitness to dive – comparing a questionnaire and medical interview based approached*. This was published in *Diving Hyperb Med*. 2010;40(3):119-24.

Diving Medicine Courses

The International Collaborative to develop a curriculum and learning objectives for training in diving and hyperbaric medicine is progressing well. During the International Congress of Hyperbaric Medicine held in Cape Town, South Africa in March 2011, I attended further meetings in this regard. A module-based approach is being developed by the International Collaborative in both diving and hyperbaric medicine. Diving medicine has the following modules:
Module 1a – Medical examination of divers
Module 2a – Diving Medical Physician (air)
Module 3a – Diving Medical Physician (mixed gas)
Module 4a – Expert Diving Medical Physician

The Hyperbaric modules are as follows:
Module 1b – Associate Hyperbaric Medical Practitioner
Module 2b – Hyperbaric Medical Practitioner (Monoplace)
Module 3b – Hyperbaric Medical Practitioner (Multiplace)
Module 4b – Expert Hyperbaric Medical Practitioner

The course in South Africa is currently placed at Stellenbosch University. The course has the full backing of the UHMS. The modules and the curriculum will serve to allow international organisations to set-up courses that have parity with that of Stellenbosch. Module 1a is likely to correlate with the two week courses in diving medicine offered in Australia. Once the basic curriculum and knowledge requirements are agreed upon, it will be possible to evaluate the Australian courses and perform a gap analysis to allow recognition of prior learning and achieve international parity. The Stellenbosch University course is also available to Medical Officers outside South Africa with an interest in diving medicine. It is predominantly web-based with some face-to-face contact required and in the future it may be possible to perform this course across the web with arrangements to be made for practical attachments to hyperbaric facilities in Australia and New Zealand.

Associate Professor David Smart

Key words
Medical society, meetings

Chairman's Report, Australia and New Zealand Hyperbaric Medicine Group

Medical Services Advisory Committee

In 2010, the Australian and New Zealand Hyperbaric Medicine Group (a sub-committee of SPUMS) supported by the Australian Healthcare and Hospitals Association, Australian Society of Anaesthetists, forwarded a detailed submission regarding Medicare funding for hyperbaric oxygen treatment of late soft-tissue radiation injury and

non-diabetic hypoxic problem wounds. This submission was accepted by the Medical Services Advisory Committee. Associate Professors David Smart and Mike Bennett were invited to join this committee to undertake evaluation of the submission. The first meeting took place in November 2010 and, despite the detailed submission, MSAC has initiated another full review of the two clinical conditions. At present, this review is ongoing and further meetings have not been convened until there is the opportunity to review the documents that have been produced by the Federal Government-appointed MSAC reviewers.

Australian Federal Government Module Work, Health and Safety Regulations

In 2010, Safety Work Australia was tasked by the Federal Government to develop a model set of legislation to be universally applied to all industries including the diving industry. A draft of the legislation was released for public comment in February 2011. This legislation includes a total of only 11 pages specifically referring to occupational diving with an addition of approximately 10 pages of definitions. There are serious flaws in the current draft legislation. It has very few references to existing Australian Standards and completely omits any reference to the 2815 training standards. There is no reference to the 4774 series standards covering compressed air workers and hyperbaric facilities. The legislation currently permits highly hazardous free diving in the workplace and introduces concepts of limited "*scientific divers*" and "*incidental divers*", neither of which are required to have mandatory training qualifications. Despite this lack of requirement for training, the last two divers are permitted under the legislation to dive up to 30 metres' sea water. The draft legislation provides a formula for seriously compromising diving safety and is likely to lead to deaths in the occupational setting. The public comment period for legislation closed on the 04 April 2011. SPUMS has provided detailed comment on the legislation and this may be published in a later issue, based on a paper given at this Annual Scientific Meeting. It is yet to be proven whether or not the Federal Government will take on board the concerns of industry in their effort to produce a 'one size fits all' set of work, health and safety regulations.

Prior to 2010, the professional diving industry of Australia has referred to a series of Australian Standards that covered 1). diving training (2815 series); 2). operational diving in different industries such as construction, onshore and offshore diving, scientific diving, recreational instructors, film and photographic diving (2299 series); 3). work in compressed air and hyperbaric facilities (4474 series). These standards have developed and evolved with industry participation and cooperation since 1965. Although the standards have been given variable status in Australian law they are frequently referred to when guidance on issues of operational set up and safety within the diving industry are required. The Australian Standards have also served as a reference when evaluating accidents and deaths in the diving industry. Given the origins of the Standards and their long history of evolution to improve diving safety, the current move by the Federal Government is regarded as a potentially serious threat to diving safety.

Associate Professor David Smart

Key words
Medical society, meetings

Editor's report

My last report to the societies was for 2009; this one will cover an 18-month period, 2010 through till end May 2011, allowing the one report to cover both annual general meetings. Thereafter, each annual report will be from June of each year, so that news of the Journal's activities is as up to date as possible for members. The three goals set for 2010/11 in my last report were: Medline citation; revision of the financial structure of the Journal and establishing the journal website.

This year, *Diving and Hyperbaric Medicine* achieved a major milestone. We received notification in early 2011 from the National Library of Medicine in the USA that DHM will be indexed on MEDLINE from the beginning of 2011. I reported on this in more detail in my editorial for the March 2011 issue.[1] Achieving this was, in the opinion of many, absolutely critical to the long-term survival of DHM in this modern, competitive, professional-publication world. Those authors who contributed during the two-year period over which NLM assessed the Journal should be rightly proud of their achievement, as MEDLINE citation is dependent primarily on the quality of the material published in a journal.

Other factors that come to play are the quality of the Editorial Board and of the peer review process, timeliness of publication and the appearance of the published product. We have been advised by a number of sources that it is an extra challenge for a medical journal to become indexed if it is not published through a commercial publishing house, so everyone involved should take a pat on the back. You will not actually see abstracts appearing in Medline yet, as we are still working with NLM to get the correct structures in place, but this will happen well before 2011 is ended. There has been a noticeable increase in submissions since this news appeared in March – keep those papers coming! There is no excuse now for researchers in academic institutions not to consider *Diving and Hyperbaric Medicine* as a viable option for the publication of their work, and this can only grow the quality and international impact of the Journal.

This effort almost came undone in early 2010, when the mailing company dealing with the Journal failed to deliver

the March issue in a timely fashion, and, at the same time, there were major problems with the SPUMS membership database. This resulted in extra cost to SPUMS, as a second, partial mail out proved necessary. Nature also played its part in September 2010 and February 2011, when the work of the Journal office was severely disrupted by the Christchurch earthquakes, especially the February one. It is fair to say that we are still in catch-up mode.

Both society executives are struggling to achieve a stable financial basis for the Journal's publication. Attrition of membership of both societies (EUBS 20%, SPUMS 15% in the past two years, based on the size of the print runs) means that the Journal requires an ever increasing proportion of the membership dues from both, as about half the costs of running the Journal are 'fixed' costs, i.e., not proportional to subscription numbers. Alarmist talk of the Journal being "*very expensive to run*" has been heard from various quarters, especially at the 2010 EUBS Assembly. In fact, it is published on a shoe-string budget. Fundamentally, both societies seem to be failing to recruit new members and to hold onto old ones. Does this mean that the Journal no longer answers the professional needs of a largish minority of its readership, or is this simply another sign of the straightened economic times we live in? – I would like to think it is the latter, based on the positive feedback this office regularly receives from the membership. Therefore, as Editor, my perspective is that both societies need to do more to achieve growth. We also need to seek some financial support for the Journal in the form of commercial advertising. I am convinced that the solution of placing the publication of DHM into the hands of a commercial publishing house is not the answer to this problem, certainly not at this stage of its development.

The membership will be canvassed later this year on providing the option of a choice of an electronic or hard-copy version of the Journal or going fully electronic. This might seem an easy solution, but is, in fact, quite complex. Another issue is whether current articles should be freely available on request or charged through organisations like the Copyright Clearing House and RightsLink. Prior to the two societies formally joining forces, SPUMS had already established a policy of providing public domain access via the Rubicon Foundation for issues more than two years old; this is not yet fully in place. As far as I am aware, this policy has not been endorsed by EUBS.

Two issues relating to the EUBS meetings that affect the Journal have been resolved in the past year. Firstly, the criteria for the Zetterström Award, which include the requirement to submit the winning paper to DHM, have now been revised and accepted. Secondly, full papers will no longer be published in the meeting proceedings, only abstracts and 'mini-papers', and presenters will be encouraged instead to submit the full paper to DHM, as is the case with the SPUMS meetings.

The journal website has been established, though we are still waiting to hear from members what more they would like to see there. So far, not a single suggestion has been received from our 900-odd membership!

Goals for the editorial office for 2011/12 are:
- fully establishing the Medline indexing of journal abstracts;
- enlarging the Editorial Board to meet the increasing peer-review workload;
- seeking commercial advertising in DHM.

Suggested goals for the EUBS and SPUMS Executives are:
- to further improve the financial management structures for DHM;
- agree a joint policy regarding the availability of historic DHM articles in the public domain;
- agree a joint policy regarding the availability of current DHM articles through an electronic copyright company such as Copyright Clearing Centre/RightsLink;
- increase membership/subscription numbers.

Reference

1 Davis M. The Editor's offering. *Diving Hyperb Med*. 2011;41:1.

Michael Davis

Key words
Medical society, meetings

Election of Office Bearers
Third Ordinary Committee Member

At the 2011 Annual General Meeting in Guam, there were two nominations for the position of 'Ordinary Member' of the Committee and, therefore, SPUMS committed to a ballot of the membership via e-mail under the new rules allowing electronic communication with the members.

I have just received word from one of the nominees that he has withdrawn his nomination. It is my pleasure to announce that Peter Smith (currently Commanding Officer, Royal Australian Navy Submarine and Underwater Medicine Unit, Sydney) has been officially appointed to the SPUMS Committee for a three-year term from the AGM 2011.

Welcome aboard, Peter!

Mike Bennett, President SPUMS

South Pacific Underwater Medicine Society

41st Annual Scientific Meeting 2012
Preliminary announcement

Dates: 20–27 May 2012
Venue: Madang Resort, Madang, Papua New Guinea

Theme:
What lies beneath: the pleasures and perils of our diving environment

Keynote speakers:
Associate Professor Jamie Seymour, James Cook University, Queensland,
"*the jelly dude*"
Richard Fitzpatrick, James Cook University, Queensland
"*the shark guy*"

Abstracts:
Abstracts for presentation should be submitted before 31 March 2012 as a Word file of up to 250 words (excluding references – 4 only) and with one figure. Please forward to, e-mail: <cmeehan@mcleodstmed.com.au>

If you wish to present a paper please contact:
SPUMS ASM 2012 Convenor
Dr Cathy Meehan
E-mail: <cmeehan@mcleodstmed.com.au>
Mobile: +61-(0)4-1778-3653

For further information copy the link below into your web browser:
http://www.madangresort.com/convention_centre/spums-meeting-2012/

Registration information will be available later this year on the SPUMS website: <www.spums.org.au>

ANZCA Certificate in Diving and Hyperbaric Medicine

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 Diploma in Diving and Hyperbaric Medicine.

3 **EITHER:**
   a Completion of the Diploma of the South Pacific Underwater Medicine Society, including six months' full-time equivalent experience in a hyperbaric unit and successful completion of a thesis or research project approved by the Assessor, SPUMS
   b **and** Completion of a further 12 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 18 months' full-time equivalent experience in a hospital-based hyperbaric unit which is approved for training in Diving and Hyperbaric Medicine by the ANZCA
   d **and** 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/edutraining/DHM/index.htm>

Dr Margaret Walker, FANZCA
Chair, ANZCA/ASA Special Interest Group in Diving and Hyperbaric Medicine

Royal Australian Navy Medical Officers' Underwater Medicine Course 2011

Dates: 07–17 November 2011
Venue: HMAS PENGUIN, Sydney

The MOUM course seeks to provide the medical practitioner with an understanding of the range of potential medical problems faced by divers. Considerable emphasis is placed on the contra-indications to diving and the diving medical, together with the pathophysiology, diagnosis and management of the more common diving-related illnesses. The course includes scenario-based simulation focusing on management of diving emergencies and workshops covering the key components of the diving medical.

Cost: TBC (Approx AUD2,100 including accommodation at HMAS PENGUIN or AUD800 without accommodation)

For information and application forms contact:
Rajeev Karekar, for Officer in Charge,
Submarine and Underwater Medicine Unit
HMAS PENGUIN
Middle Head Rd, Mosman
NSW 2088, Australia
Phone: +61-(0)2-9647 5572
Fax: +61-(0)2-9960 4435
E-mail: <Rajeev.Karekar@defence.gov.au> with copy to: <Peter.Smith33@defence.gov.au>

Royal Adelaide Hospital

Medical Officers' Course
Units 1 and 2: 28 November–09 December 2011

Diver Medical Technicians' Full Course
Units 1, 2 and 3: 07–25 November 2011

Accommodation at a reasonable price is available for a limited number of registrants. Costs available on enquiry.

Contact for information:
Lorna Mirabelli, Senior Administrative Assistant
Hyperbaric Medicine Unit
Royal Adelaide Hospital, North Terrace
Adelaide, SA 5000
Australia
Phone: +61-(0)8-8222-5116
Fax: +61-(0)8-8232-4207
E-mail: <Lorna.mirabelli@health.sa.gov.au>

The Australia and New Zealand Hyperbaric Medicine Group Introductory Course in Diving and Hyperbaric Medicine

Dates: 20 February–02 March 2012
Venue: Prince of Wales Hospital, Sydney, Australia

Faculty includes Associate Professors Mike Bennett, Simon Mitchell and David Smart.

Course content includes:
- History of hyperbaric oxygen
- Physics and physiology of compression
- Pressure-related injuries (barotraumas, decompression illness)
- Accepted indications for hyperbaric oxygen therapy
- Wound assessment, including transcutaneous oximetry
- Gas toxicities, marine envenomation, drowning
- Practical sessions, including assessment of fitness to dive
- Visit to HMAS Penguin
- Visit to the NSW Water Police

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>

DIVING HISTORICAL SOCIETY AUSTRALIA, SE ASIA

P O Box 347, Dingley Village,
Victoria, 3172, Australia
Email:
<deswill@dingley.net>
Website:
<www.classicdiver.org>

Scott Haldane Foundation

The basic course (Part I plus Part II) complies fully with the current EDTC/ECHM curricula, and the different advanced courses offer modules to achieve Level IIa status according to the EDTC/ECHM guidelines.

12–19 Nov (departure 10 Nov): Basic course, diving medicine Part I (Palau)
19–26 Nov (departure 17 Nov): 19th Advanced course (Palau)
26 Nov– 03 Dec (departure 24 Nov): 19th Advanced course (Palau)

For further information: <www.scotthaldane.nl>

Hyperbaric oxygen, Karolinska

Dear colleagues and friends!

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. Our goal is to spread knowledge about hyperbaric oxygen therapy (HBOT) and to support evidence-based clinical practice and research for the benefit of patients around the world.

You need to register and obtain a password via e-mail; it is free and easy. Once registered, watch the lectures on-line, or download them to your iPhone or computer as QuickTime movies 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 Stockholm County Council report from May 2011:
Treatment with hyperbaric oxygen (HBO) at the Karolinska University Hospital including *The treatment of necrotizing fasciitis with hyperbaric oxygenation – a progress report of a Cochrane Review*

For further information contact:
Folke Lind, MD PhD,
E-mail: <folke.lind@karolinska.se>
Website: Editor <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_/_Termine/Kurse.html>

British Hyperbaric Association Annual Scientific Meeting 2011

Dates: 20–22 October 2011
Venue: QinetiQ Haslar, Haslar Marine Technology Park, Gosport

Hosts: QinetiQ Hyperbaric Medicine Unit, St Richard's Hospital, Chichester

Full information will be on the BHA website in the near future <http://www.hyperbaric.org.uk>

Contact for further information:
Dr Mark Glover
E-mail: <maglover1@qinetiq.com>
Phone: +44-(0)1243-776621

Inter-university Diploma in Diving and Hyperbaric Medicine, France

For further information go to:
<http://www.medsubhyp.org> or
<http://medecine.univ-lille2.fr/format/diu/hyperbar.htm>

Undersea and Hyperbaric Medical Society

45th Annual Scientific Meeting
Preliminary announcement

Dates: 20–23 June 2012
Venue: JW Marriott Desert Ridge Resort, Phoenix AZ
Contact: <www.uhms.org>

Instructions to authors

(Short version, updated November 2010)

Diving and Hyperbaric Medicine welcomes contributions (including letters to the Editor) on all aspects of diving and hyperbaric medicine. Manuscripts must be offered exclusively to *Diving and Hyperbaric Medicine*, unless clearly authenticated copyright exemption accompanies the manuscript. All manuscripts will be subject to peer review. Accepted contributions will also be subject to editing. An accompanying letter signed by all authors should be sent.
Contributions should be sent to:
The Editor, Diving and Hyperbaric Medicine,
C/o Hyperbaric Medicine Unit, Christchurch Hospital,
Private Bag 4710, Christchurch, New Zealand.
E-mail: *<editor@dhmjournal.com>*

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

The text should be 1.5 or single-spaced, using both upper and lower case. Headings should conform to the current format in *Diving and Hyperbaric Medicine*. All pages should be numbered. Underlining should not be used. SI units are to be used (mmHg is acceptable for blood pressure measurements; bar for cylinder pressures); normal ranges should be shown. Abbreviations may be used after being shown in brackets after the complete expression, e.g., decompression illness (DCI) can thereafter be referred to as DCI.

Preferred length for **Original Articles** is up to 3,000 words. Inclusion of more than five authors requires justification, as does that of more than 30 references. **Case Reports** should not exceed 1,500 words, and a maximum of 15 references. Abstracts are required for all articles. **Letters to the Editor** should not exceed 500 words and a maximum of five references. Legends for figures and tables should generally be shorter than 40 words in length.

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

Table data may be presented either as normal text with tab-separated columns (preferred) or in table format. No gridlines, borders or shading should be used.
Illustrations and figures should be submitted as separate electronic files in TIFF, high resolution JPG or BMP format. If figures are created in Excel, submit the complete Excel file. Large files (> 10 Mb) should be submitted on disk.
Photographs should be glossy, black-and-white or colour. Colour is available only when it is essential and will be at the authors' expense. Indicate magnification for photomicrographs.

References
The Journal reference style is the 'Vancouver' style (Uniform requirements for manuscripts submitted to biomedical journals, updated August 2009. Website for details: <http://www.nlm.nih.gov/bsd/uniform_requirements.html>). References must appear in the text as superscript numbers at the end of the sentence after the full stop.[1,2] The references are numbered in order of quoting. Index Medicus abbreviations for journal names are to be used (<http://www.nlm.nih.gov/tsd/serials/lji.html>). Examples of the exact format for a standard paper and a book are given below:

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

Accuracy of references is the responsibility of the authors.

Manuscripts not complying with the above requirements will be returned to the author(s) before being considered for publication.

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

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Full instructions to authors (revised June 2011) may be found on the DHM Journal, EUBS and SPUMS websites.

DIVER EMERGENCY SERVICES PHONE NUMBERS

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+61-8-8212-9242 (International)

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

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

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

EUROPE
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+44-07740-251-635

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

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>

DIVING INCIDENT MONITORING STUDY (DIMS)

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

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

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