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Official NEWSLETTER

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EUBS EXECUTIVE COMMITTEE

EDITORIAL

Dear EUBS Members!

This issue arrives late at your desks, and I'm awfully sorry for this. As you all know, I have no secretarial support in editing the EJUHM, and my own emergency hospitalisation kept me from continuing to work on this issue in December. At the same time I was very grateful to hear that our new President, and Chairman of the Review Board of this journal, Prof. Alf Brubakk, is in the meantime nicely recovering from his acute illness. My best wishes to him, I hope that we will be able to continue to nurse our little project, the further development of the Euorpean Journal of Underwater and Hyperbaric Medicine, for many years. The President's Column will re-appear in the next issue.

Progress in the talks with SPUMS on the intention to merge this journal with the SPUMS journal, which has successfully changed its name to "Diving and Hyperbaric Medicine", has been made, however only little. To get a journal indexed in Index Medicus is quite difficult, and a lot of support from the members and readers of a journal is necessary to have enough substantial papers, originals and reviews, before a journal will be considered to be indexed. This support from the members has been very poor, although the ones present at the General Assembly during the Annual Scientific Meetings have always expressed their willingness to submit to the EJUHM. This willingness seems to vanish when back home.

At this point I urge you all, if you do not want to submit to the EJUHM, do send your papers to "Diving and Hyperbaric Medicine" (DHM). This journal is already indexed in Embase, and more scientific contributions will increase the potential to get DHM into Index Medicus, and thus it will also become easier to merge the EJUHM into the much stronger journal "Diving and Hyperbaric Medicine". This would mean a great advantage and a huge step forward in the development of the EJUHM as Alf and myself believe. The editor of DHM, Prof. Mike Davis from Auckland, is awaiting your submissions at **spumsj.spumsj@cdhb.govt.nz**! Mike was also kind enough to do a Book Review for the EJUHM, which you find on p. 88.

For some time we have not been able to publish the full papers from the Zetterstrøm Award winners at the Annual Scientific Meeting. Therefore I'm glad that we have in this issue not only the winner of the ASM 2006, Marguerite St Leger Dowse and co-workers (pp. 84-86), but also the winner from the ASM 2004, Peter Germonpré and co-workers (p. 79-83). For a third paper, the winner from the ASM 2005 Andreas Møllerlokken and co-workers, has announced that they will be able to submit the full paper sometime soon.

We also have 2 abstracts from the ASM 2006 in this issue, where not the correct version had been submitted and the mistake was not noticed until too late to make any changes (p. 87), plus one Minipaper that did not appear in the Proceedings Book, although it had been submitted in time and had been reviewed by the Scientific Committee (pp. 75-78). Apologies from Dr. Einar Thorsen for that! The meeting itself was otherwise a great success as you can read from Dr. Bill Hamilton's report on page 74 and I can only congratulate our Norwegian hosts for everything.

Due to the delay of this issue and the present financial situation of the Society it is necessary to combine the next two issues. Therefore we will publish No 1 and 2 in April/May 2007 to give Dr. Adel Taher the opportunity to put some updated information on the Annual Scientific Meeting in Egypt in 2007 into it. For more detailed and always updated information on the ASM 2007 please check out the website of the meeting **www.eubs2007.org** regularly.

Peter

A MESSAGE FROM THE TREASURER & MEMBERSHIP SECRETARIAT

If anyone has not received an EUBS Membership Directory and would like one, you can email me and I will forward one on to you.

Many thanks, Tricia

MEETING REPORT

Another great EUBS Annual Scientific Meeting 2006

By R.W. Bill Hamilton

The annual meeting in Bergen met our fondest expectations. There was lots of good diving and hyperbaric science and medicine as well as a great social program.

Supeerbly organized by Arvid Hope and Einer Thorsen, the meeting began with a reception in Haakonshallen, a magnificent stone building built by King Haakonsson in 1261 for his son's wedding. The Hall is a short walk from the elegant Norge Hotel which was our headquarters. The walk took us along the Hanseatic Bryggen, the characteristic image of Bergen, and past the well-known fish market. On that first day we enjoyed the first of a remarkable string of 3 days of sunny weather not really characteristic of Bergen. We were greeted by a couple of brisk drummers as we approached the Hall. We enjoyed a glass of champagne and a nice spread of Norwegian delicacies as we greeted old friends. This was especially rewarding for me personally because I had spent a lot of time in Norway beginning almost 40 years ago, and it was great do see many old friends who don't usually go to far away places for meetings. On the walk back to the Norge we enjoyed another treat, a brilliant full moon that had the sky all to itself, with no clouds at all! How special can it get!!

Although a "European" meeting, of the 220 or so attendees there were 29 countries from 4 continents represented there. It was good to see nice representation from Russia and Eastern Europe.

We were in for a treat on the second night as well. Norway has several tall ships, and the flagship of that small fleet (in different ports) is the square-rigged sailing ship Statsraad Lehmkuhl, almost as characteristic a sight for Bergen visitors as the Bryggen itself. There was a full-evening tour out of the harbour and back, with a great Norwgian-flavored meal of shrimp and delicious bread, with other tidbits, followed by a band that got some people dancing. We of course passed NUI, also known as NUTEC, quite familiar to many on board and still functioning as Norway's offshore research and safety center. In the early 1980's Statsraad Lehmkuhl was used as a hotel ship for a big project at NUI, and many of us had had bunks there when she was tied up at the NUI quay. At that time the sails had deteriorated and there was no useable propulsion, but all that has since been fixed and the vessel now makes a good place for a party, among other things. On the way back we saw a beautiful 180 degree rainbow after a shower that drenched Bergen in our absence.

After a meeting like this it is fun to compare the numbers of diving and hyperbaric papers. This year two-thirds of the papers were on diving, and a few clearly were a combination of both themes. In the diving category there was some attention to the current interest in breath-hold diving. Among the many presentations were 3 papers that suggested that dehydration might not predispose to decompression sickness as is generally believed. This was not the objective of the studies so more research is needed to clear this up, but the thoughts are intriguing. There were also suggestions enforcing the observation that rehydration is a lot of help in treating DCS.

Because we have to have some of our presentations as posters, EUBS honors the best poster with the Zetterström Award, named in honor of the Swedish diver and inventor who pioneered the use of hydrogen as a diving gas. This year the award went to Marguerite St.Leger Dowse and colleagues for their paper on the relationship between decompression illness and the menstrual cycle.

Although the first two evening events were hard acts to follow, the Banquet made a magnificent effort. It was at the Floeien Folkerestaurant, which is up the mountain on the northeast side of Bergen. To get there we had to ride the funicular railroad Floeibannen, which the old Begensers among us had ridden many times. This night we were back in Bergen as it usually is, not being able to see the harbor because of rain and clouds, but the setting was nevertheless beautiful. We had a congenial time, again with lots of old friends and colleagues, and a good meal, again really the special taste of Norway. The waiters were well organized, bringing out each course with great flourish. Then we had opera singers, not announced ahead of time. This was spectacular, and very well received by the EUBS members.

Special credit goes to Anna Gurd Lindrup, a long time worker at NUI, and Silje Holte and Sandra Myrdal, the representative of the tour group who helped with the meeting. We also have to acknowledge our sponsors, which includes NUI, he Royal Norwegian Navy, University of Bergen, Haukeland University Hospital, Norwegian Baromedical Society, Norsk Hydro, Statoil, ExxonMobil.

This meeting was magnificent, but next year we are in for something very special. The EUBS membership voted last year to go to Sharm el-Sheikh in 2007. The dates are September 8th to 15th, late enough to be past the hottest part of the summer and long enough to allow plenty of diving and other recreation. Headquarters Hotel is the Hyatt Regency 20(69)360-1234. Our host will be Dr. Adel Taher (hyper_med_center@sinainet.com.eg). Sharm el-Sheikh is very special.. It is a closed community, with gate guards at all the entry points and a batch of very fine hotels and restaurants. Upcoming years following include Graz, the UK, and Greece.

Missing Papers from EUBS ASM 2006 Proceedings

EXPERIMENT ON "LONG DURATION IMMERSION" IN COLD WATER

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INTRODUCTION

The "Long duration immersion" operation took place in Toulon naval base on the premises of the hyperbaric centre of the Cephismer (human diving and underwater intervention unit). The IMNSSA (Institute of Naval Medicine for armed forces health service) was responsible for the scientific and technical coordination of six civilian and military teams, thus illustrating the transversality of common research projects.

The scientific name of this experiment is "Study of neuromuscular, cognitive, haemodynamic, metabolic and thermal consequences of exposure to long duration immersion in combat swimmers". At the request of the EMM (naval high command), this study aimed to verify the capacity of combat swimmers to support an increase (from 4 to 6 hours) in the duration of Seals Delivery Vehicle (SDV) missions.

This operation was the follow-on from the "Long duration hyperoxia" operation conducted 4 years before and which showed the feasibility of the profile of the mission (6 hours with Oxymixgers rebreathers with variations in depth and PO_2 associated with 2 h and 40 minutes of physical exercise). Although all the subjects completed the experiment, metabolic and thermal problems were highlighted.

This time the experiment was static, in total body immersion and with original collection of variables (blood samples, core and skin temperatures, electrocardiogram, electro-myogramme, etc. …). The aim was to:

- study the effects of immersion on major physiological functions and the onset of the signs of hypothermia,
- depending on the obtained results, propose if necessary exposure limits expressed as a duration, for each defined temperature,
- make available objective elements with figures as evidence to establish specifications and have manufactured by industrialists higher performance protective clothing,
- ultimately propose nutritional intake adapted to the operational activity of the combat diver and, above all, make better recovery possible.

PROTOCOL

The conditions for operational diving with exposure to long duration immersion were reproduced in a small, freestanding experimentation pool (L: 2,4 m x W: 1,6 m x H: 1,25 m) installed on the premises of the naval hyperbaric centre in Toulon (Photo n°1).

Photo n° 1: The experiment pool with (on the right) the submergeable seat.

The subject was installed in a half-seated position on an ergonomic device (Photo n°2) that could be reclined, raised and lowered so that the top of the subject's head was just touching the water line. In his mouth, the subject had a nozzle guaranteeing unidirectional flow and he breathed in atmospheric air by means of an intensive care ventilator of the Benett type. This device provided inspiratory assistance of approximately 8 to 10 cm of water, making it possible to minimise the respiratory effort.

The divers were exposed one by one, during a six hours immersion. Each immersion was preceded and followed by a considerable number of physiological examinations that lasted approximately 3 hours before and 3 hours after the dive. Each diver performed two dives, one at a temperature of 18°C, the other at 10°C. The order of passage was randomised. The first 5 divers did their first immersion at 18°C and then, one week later and in the same order, the second immersion at 10°C. The second group of 5 divers did the first immersion at 10°C and the second at 18°C, one week later.

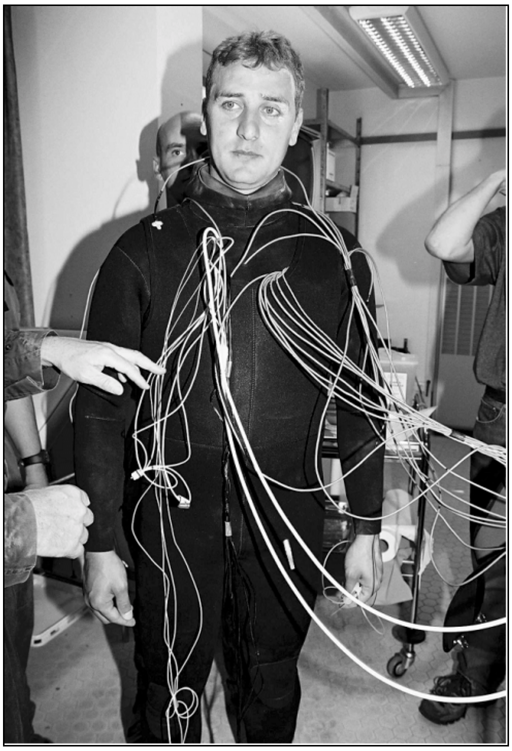

Photo n° 2: Side view of the seat with its reclining backrest, the straps and force pedals for the muscle.

Each diver wore a made-to-measure, double-thickness alveolated neoprene suit. The model was identical to that used for this type of mission. For the entire duration of the immersion, the diver was equipped with different sensors that made it possible to collect the physiological parameters needed for the study or to monitor the subjects' state of health. In all, there were 48 electrodes, probes or catheters (Photo n°3).

Photo n° 3: The diver equipped with all the sensors. The wires go through the two openings in the jacket, which is the last layer to be put on.

The diagram below and photo n°4 summarise the installation.

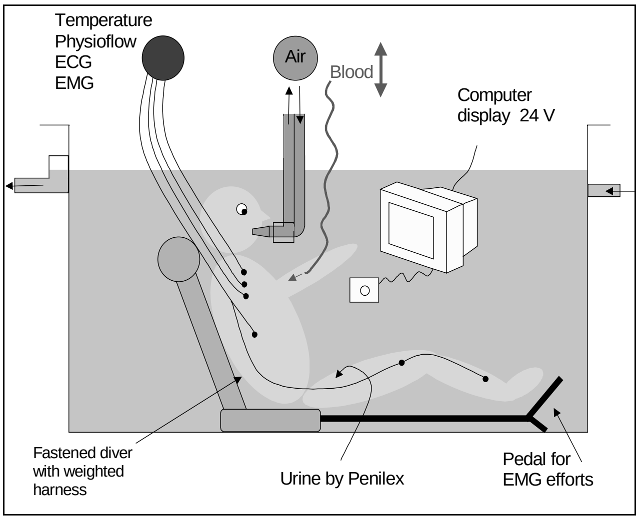

Photo n° 4: Progressive immersion of the diver into the pool. The investigators all regulate the length of the wires for their sensors.

All the divers tolerated both immersion conditions, but with major thermal discomfort, considerable shivering and an impact on hand and foot dexterity. These factors were those liable to have an impact on the operational availability of such personnel.

The immersion condition at 18°C was meant to represent thermal neutrality for a diver equipped with his suit. In reality, a range of clinical or metabolic variables showed that it was nothing of the sort and that this condition was already very difficult to tolerate.

The condition at 10°C was felt to be very difficult, both physically and mentally, and could only be tolerated because the divers were extremely motivated and highly trained.

RESULTS
(Main conclusions of the different teams)

A - THERMOPHYSIOLOGICAL LIMITS

Contrary to expectations, all the highly motivated divers tolerated the 6 h immersion at both 18 and 10°C despite having to fight against intense shivering, but without any medical problem.

Rectal temperature never fell below the critical threshold of 35.5°C. The minimum temperatures observed were 35.7°C at 18°C and 35.6°C at 10°C. At the end of the immersion, the mean core temperature was 36.2°C and there was no significant difference between the two diving conditions.

Skin temperatures were significantly lower in the water at 10°C than those observed at 18°C. Although mean skin temperature for the entire body never dropped below 25°C (29.3°C at 18°C and 25.6°C at 10°C), the temperature of the hands and feet dropped considerably, reaching 13.9°C and 13.8°C respectively at 10°C. These temperatures justified the divers' complaints of discomfort in these parts of the body. Although not measured precisely, manual dexterity seemed considerably modified when the divers came out of the water.

The results of this study show that it is possible to undergo immersion for six hours without physical activity at 18 and 10°C, even if the divers endured major thermal shivering and pronounced discomfort.

Heat loss was high, which explains that the internal temperature did not succeed in regulating itself despite the production of body heat thanks to the shivering and the thick protection of the neoprene suit. The physiological responses differed considerably from one diver to another because of morphological differences and the diver's degree of adaptation to cold.

Skin temperatures were low and very heterogeneous. The extremities and limbs temperatures were lower than those of the head and the trunk.

Despite the fact that the average internal temperature (average of the ten divers) was greater than 36°C at both 18°C and 10°C, some divers were below this limit at 10°C as well as at 18°C. The average skin temperature, and almost all the local skin temperatures, remained above the recommended limits. The temperatures of the hands and feet, however, went below the 15°C limit during the immersion at 10°C.

The risk of hypothermia during the 6 hours at 18°C and 10°C was thus relatively low, but not improbable for some divers. Thermal discomfort was high, particularly because of the temperatures of the extremities and limbs. These conditions could result in a decrease in performance and manual dexterity, thus penalising divers with regard to their mission.

The thermal protection provided by the diving suit was thus satisfactory, but should still be improved in order to limit heat loss, thermal discomfort and the divers' drop in performance.

B – PSYCHOLOGICAL INVESTIGATIONS

Given the relatively clement conditions of this study (no operational stress, no physical effort, total immersion but with no movement of the water and core temperatures greater than 36.2°C during the cognitive investigations), the results show that mental performances were maintained (with the exception of memory: the free recall process is deteriorated, but not storage or learning) after 5 hours of immersion in water at 10°C for the 10 subjects selected. All were well trained and used to such conditions (Navy combat swimmers) with a high degree of motivation and a will to succeed.

In total, and in terms of cognitive performances, all the subjects well tolerated immersion for 6 hours in water at 10°C (and at 18°C) without movement, thanks to maintenance of the core temperature at over 36°C. On the other hand, the subjective evaluations revealed that the limits for psychological (and probably physical and physiological) tolerance were reached at 10°C (but not at 18°C) after 6 hours of diving. These limits seem to be essentially associated with going beyond the capacity for adaptation to cold (in particular in the extremities). The cooling of the extremities, with its probable repercussions, is in addition a reservation that must imperatively lead to measures to improve the material. Finally, it is clear that this type of performance can only be envisaged for subjects who are fit, trained for such conditions and in excellent physical and mental health.

C – HYDROMINERAL AND ENERGETIC HOMEOSTASIS, VASCULAR CAPACITANCE, MEDIATORS OF HAEMODYNAMICS.

The results obtained showed considerable water loss (2 litres) and salt loss (6 to 8 g) after 6 hours' immersion with plasmatic residual hypovolaemia (-8 to –9% on average), similar for both conditions (18°C and 10°C).

The physiological and biological data highlighted the essentially renal origin of the hydromineral losses (1.8 litres of urine on average), as a consequence of neuro hormonal mechanisms with glomerular (increase in glomerular filtration) and tubular (increase in osmolar and free water clearances) points of impact.

The modifications of hormonal responses essentially concern the stop of secretion of renine, aldosterone and arginine vasopressine and also the increase of the production of natriuretic peptides.

All these modifications explain the importance of diuresis and natriuresis, the origin of dehydration with potentially dangerous post-immersion hypovolaemia. This is all the more true given that, as the hypovolaemia was iso-osmotic during the recovery period, it was not perceived and did not stimulate the thirst needed to restore the water capital.

The study also highlighted the importance of the solicitation of energetic metabolism, particularly at 10°C. Glycolysis and lipolysis effectively increased under the effects of the more intense thermal shivering. That increased energy expenditure, which could be evaluated on average at 1,300 kcal after 6 hours' immersion at 10°C.

To optimise recovery, practical guidelines could be established as a result of this. Ingestion in the 3 hours following the end of the immersion of sufficient quantities (2 to 3 litres) of a hot, isotonic drink containing 1.2 g/l of salt (NaCl) and 60 g/l of carbohydrates (glucose) would favour the restoration of the thermal, hydromineral and energetic disturbances in the organism.

During immersion, this exposure to cold was responsible for considerable mobilisation of noradrenalin in subjects without any particular physical activity. The vasoconstrictor activity of noradrenalin intervened to limit the loss of heat via the skin and mobilise the energetic substrates. The important implication of cardiac peptides, which was faster at 10°C, was also probable evidence of greater distension of the cardiac cavities at this temperature.

After the end of immersion, plasma concentrations of noradrenalin remained high almost 80 min after the end of immersion and had not returned to their baseline values 3 hours after emersion. These values, higher after immersion at 10°C than at 18°C indicate the persistence of the cold constraint even when the subjects were in a comfortable, out-of-the-water atmosphere. The cold to which they were subjected was what the tissues of the organism (skin, subcutaneous tissue, muscular mass of the limbs) had accumulated in the course of the immersion.

D – CARDIAC HAEMODYNAMICS

Signs of hypovolaemia were found after both immerged periods. A decrease in left atrial and left ventricular (LV) diameters was observed by the echocardiography study. The Doppler study reflected the drop in volaemia. LV filling was assessed on transmitral profile. An increase of the contribution of the atrial contraction to LV filling was observed. This modification suggested a decrease in pressure gradient between left atrium and left ventricle in early diastole. An increase in systemic arterial resistance was the sign of peripheral arterial vasoconstriction secondary to sympathetic hyperactivity and was observed after both exposures. After exposure at 10°C, a significant slowing down of the heart rate, which could be attributed to parasympathetic hyperactivity, was observed. Systemic blood pressure significantly decreased after immersion at 10°C in comparison with immersion at 18°C.

It is interesting to note that despite the possibility for the divers to eat and drink without constraint after the experiment, the ultrasonographic examination performed the next day (more than 10 hours after the end of immersion) showed that the signs of hypovolaemia persisted, regardless of the water temperature (10 or 18°C). Recommendations for rehydration in relation to the estimated losses (approximately 2 litres) are thus important to improve the recovery speed of divers performing this kind of mission.

E – CONSEQUENCES ON NEUROMUSCULAR FUNCTION

The following observations were made at the two temperatures tested:

- a total absence of modification to the maximum voluntary force of contraction (MVC) and endurance time for static effort maintained at 60% of the MVC.
- only at 10° C and for the most distal muscle (soleus, calf), a marked slow-down in muscular membrane electric transmission, source of hypo excitability.
- spontaneous electromyographic activities (EMG) associated with the thermoregulatory response (tonic activities and thermal shivering), recorded on the thigh muscle (vastus externus), particularly noticeable at 10°C.
- modifications in the EMG response to the tiring exercise, characterised by an accentuation of the preferential recruitment of slow motor units, phenomena recorded at both temperature conditions (18°C and 10°C). This response may explain how the endurance capacities were maintained.

CONCLUSIONS

1. Overall, the suit was reasonably successful and the specifications initially envisaged have not to be done for the moment. However, improving the thermal protection of the extremities (as it has been shown that actively heating the hands and feet would do more harm than good) requires an ergonomic study to improve operational availability.
2. The personnel who took part in this experiment with a great motivation and will to succeed were, to a great extent, responsible for this success.
3. Application of the practical rehydration recommendations with a warm beverage (both salted and sweet solution) that can already be proposed to the teams of SDV missions.
4. Follow-up: a) immersion with dynamic and static phases, same data collection to get closer the real diving profile and b) thermo-neutrality immersion to make de difference between physiological modifications dues to cold and to immersion.

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Zetterstrøm Award Winner 2004

INFLUENCE OF SCUBA DIVING ON ASYMPTOMATIC ISOLATED PULMONARY BULLA

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Germonpré, P. et al.: Influence of SCUBA diving on asymptomatic isolated pulmonary bulla. Europ J Underwater Hyperbaric Med 2006, 7(4): 79-85. Pulmonary blebs and bullae are generally considered an absolute contra-indication for SCUBA diving, because of a high estimated risk for pulmonary overpressure syndrome due to air-trapping inside the bulla. This is primarily based on a number of retrospective studies and case reports; formal prospective evidence of a higher risk is lacking. We present two cases where a pulmonary bulla was radiographically shown to increase in diameter, seemingly related to intensive SCUBA diving activity, giving ultimately rise to a barotraumatic diving accident. These cases provide physiopathological clues as to how even an isolated, non-ventilated bulla can be the cause of pulmonary barotrauma. The most likely mechanism for this phenomenon is a "stretching" of the bulla upon ascent from the dive: after a period of compression (Boyle's Law), there is a gradual diffusion of air through the bulla wall, with restoration of initial size at the end of the dive. Upon ascent, the air diffuses only slowly out of the bulla, causing a temporary increase in diameter and stretching of the bulla wall. This repeated stretching causes the bulla to grow gradually. At one point, the cyst wall may become critically thin and rupture during the ascent.

INTRODUCTION

SCUBA (Self Contained Underwater Breathing Apparatus) diving has gained enormous popularity over the past two decades. With the development of reliable, comfortable diving breathing apparatus, diving has become a popular recreational activity for people of all ages and physical fitness.

The usefulness of a medical examination prior to engaging in SCUBA diving is little disputed; however, the exact extent of such an examination for recreational divers is subject to much discussion. With regard to pulmonary function tests, there is evidence that abnormal flow-volume loops and compliance represent an increased risk for pulmonary barotrauma (PBT) (Godden, Currie et al. 2003). With regard to pulmonary blebs or bullae, the necessity to perform high-resolution imaging tests for detection has to be weighed against the estimated risk that such a bulla presents.

Asymptomatic pulmonary blebs can be found in a large number of persons, but no large series have been published to establish it's prevalence in a normal population (Millar 2004). Likewise, the prevalence of large bullae in a normal population is unknown. This makes any risk estimation practically impossible, since the denominator in the risk equation is missing. As pulmonary barotrauma in diving is – fortunately - a rare event (estimated between 1/19800 and 1/34.000 dives) (Leitch and Green 1986), this has led to the suggestion that it is not justified to use CT scan screening for blebs in recreational or even professional divers (Millar 2004).

Retrospectively however, in divers with pulmonary barotrauma (PBT), pulmonary functional or anatomical abnormalities (scarring, emphysematous bullae or blebs) can be demonstrated in a significant number of cases using high-resolution (spiral) CT scanning (Tetzlaff, Reuter et al. 1997). These lesions are often undetectable on plain chest radiographs. Even if no large series exist that compare divers with PBT with controls, the presence of such structural anomalies are general considered a contra-indication to diving (Godden, Currie et al. 2003), because of the risk of air-trapping on ascent.

In (large or small) ventilated bullae, air-trapping is considered possible on the basis of either a one-way valve mechanism ("real" air-trapping) or a volume increase upon ascent because of a narrow inlet-outlet opening ("virtual" air-trapping). The case of isolated, non-ventilated bullae is in most cases not considered different, although no plausible explanation is given. Some authors express criticism on the presumed risk of isolated bullae, since pressure-volume mechanistic theory (Boyle's Law) would predict that these will never expand to a higher than their initial volume (Denison 1995).

METHODS

We describe two patients in whom isolated, non-ventilated pulmonary bullae were observed to increase in size during a period of three years of intense SCUBA diving. In both cases, this led to an episode of pulmonary overpressure syndrome with cerebral arterial gas embolism (CAGE). In one diver, the condition was followed up and during the next 7 years of not-diving, the bulla remained stationary in size.

Case 1

D.A., male, born in 1942.

Heavy smoker from 1960 to 1973 (20 Pack-Years). Started recreational SCUBA diving in 1981, and performed approximately 1200 uneventful dives in 16 years (about 75 dives per year in mostly cold water, to depths of 40-50 msw).

In 1991, during a routine chest X-ray, a 35mm diameter thin-walled asymptomatic bulla was discovered in the base lobe of the left lung. On spiral CT-scanning, there was no apparent ventilation orifice of this lung cyst. Ventilation-perfusion scanning was not performed. Routine pulmonary function testing, including flow-volume-curve, was normal, and alpha-1-antitrypsin serum level was normal. He continued diving.

In April 1997, after an uneventful dive, he suddenly experienced severe general fatigue, headache, paresthesia and mild paresis of both lower limbs. These symptoms recovered with normobaric oxygen administration – no hyperbaric treatment was given. Emergency chest X-ray upon arrival in hospital revealed a large bulla – approximately 100 mm in diameter. A repeat chest X-ray and CT-scan 6 months later showed a reduction in the diameter of the cyst: 50mm, thin-walled. He discontinued diving.

In 2002, because he wished to resume diving, a new chest X-ray and CT-scan were done, revealing a bulla diameter of 51 mm. A ventilation-perfusion scanning showed an isolated, non ventilated bulla.

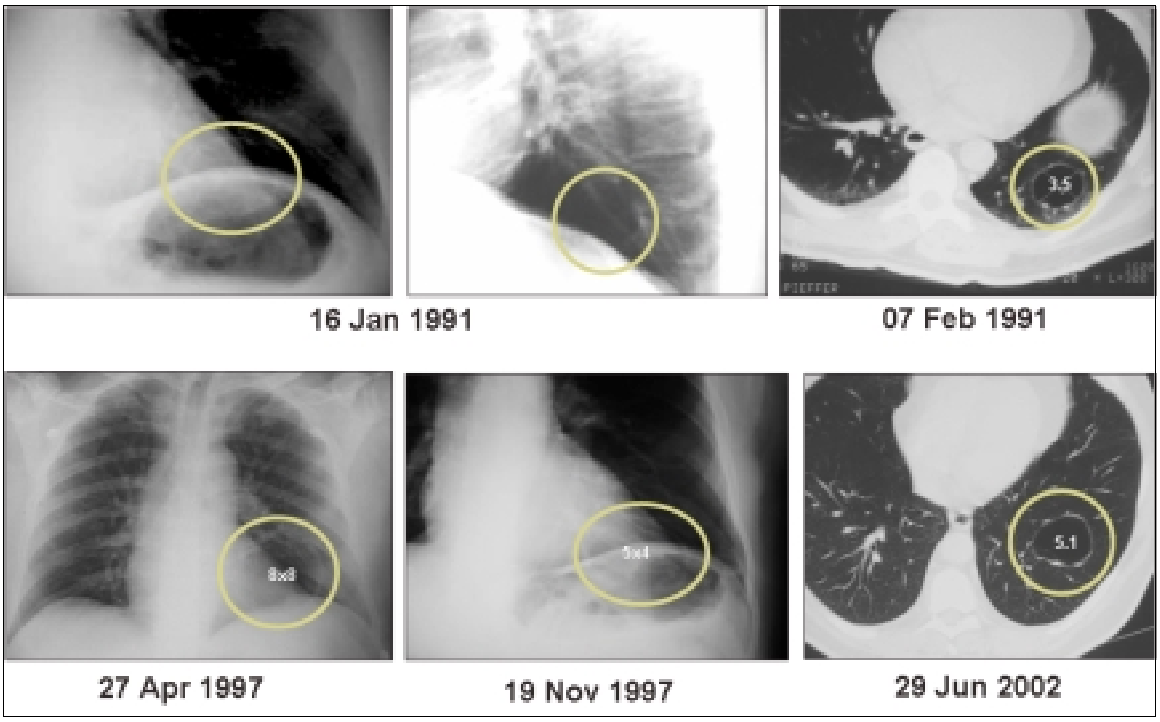

Figure 1. Case #1: Presence of bulla in left lower lung. *16 Jan 1991 and 07 Feb 1991*: no symptoms. Continued diving for 6 years. *27 Apr 1997*: immediately after diving and symptoms of cerebral arterial air embolism. *19 Nov 1997*: reduction of bulla volume after 6 months. *29 Jun 2002*: stable volume after 5 years (no diving).

Summary of case (Fig.1): asymptomatic bulla in left lower lung. Increased diameter after 6 years of diving. Hyperinflation immediately after diving accident with symptoms of CAGE. Stable diameter after 7 years of not-diving.

Case 2

P.R., female, born in 1950.

Non-smoker. She worked as a nurse in a Pneumology ward, where she had yearly chest X-rays as part of an occupational medicine protocol. These were always classified as “normal” by the reviewing radiologist. She had received prophylactic anti-tuberculosis treatment after a positive Mantoux-test in 1982.

She took up diving in 1988 and performed more than 100 dives per year for the next three years.

In December 1991, after an uneventful dive, she experienced the following symptoms upon surfacing: mild chest discomfort, moderate dyspnoea, general fatigue, rigidity of neck and jaw, dysarthry, marked coordination disturbances of the upper limbs with uncontrolled jerking when attempting to perform fine movements. These symptoms were initially attributed to cold, and no specific treatment other than rewarming was performed. She presented at the hospital 18 hours after surfacing, because these symptoms had taken longer than expected to resolve (more than 10 hours). She did not have major residual symptoms upon admission.

A chest X-ray revealed a large thin-walled bulla in the right lower lung, round, with a diameter of 7 cm. CT-scan confirmed this to be a thin-walled cyst with no apparent ventilation orifice. A ventilation-perfusion scanning showed no ventilation. She was not treated with hyperbaric oxygen because of absence of residual symptoms. A control chest X-ray 1 week after the incident showed a decreased diameter of the bulla, with a flattened aspect, of dimensions 6 x 3 cm. Serum alpha-1-antitrypsin level was normal. Routine pulmonary function testing, including flow-volume curve, was strictly normal.

A review of previous chest X-rays was undertaken:

14 Dec 1991 (one week prior to the accident): described as “normal”. Upon careful review, the lung cyst can be seen, faintly visible, flattened, of dimensions 6 x 3 cm

1990: classified “normal”. Upon review, the lung cyst is visible, but is notably smaller: 4 x 2 cm

1989: idem, dimensions of the bulla 3 x 1.5 cm

1988: idem, dimensions of the bulla 2 x 1 cm

She stopped diving. A control chest X-ray three months later showed a stable diameter of the bulla. She was then lost to follow-up.

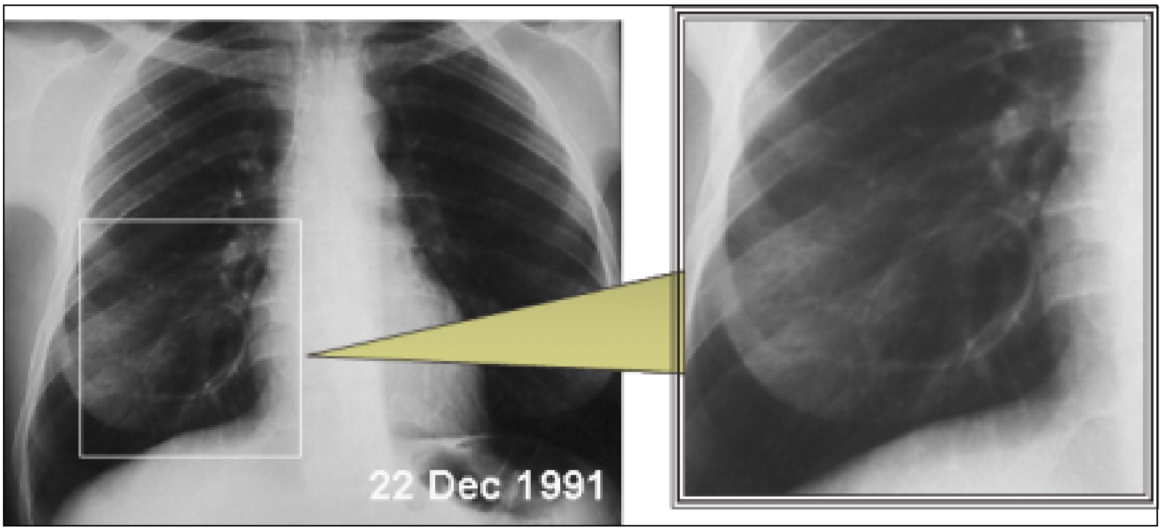

Figure 2. Case #2: Presence of large bulla in right lower lobe.

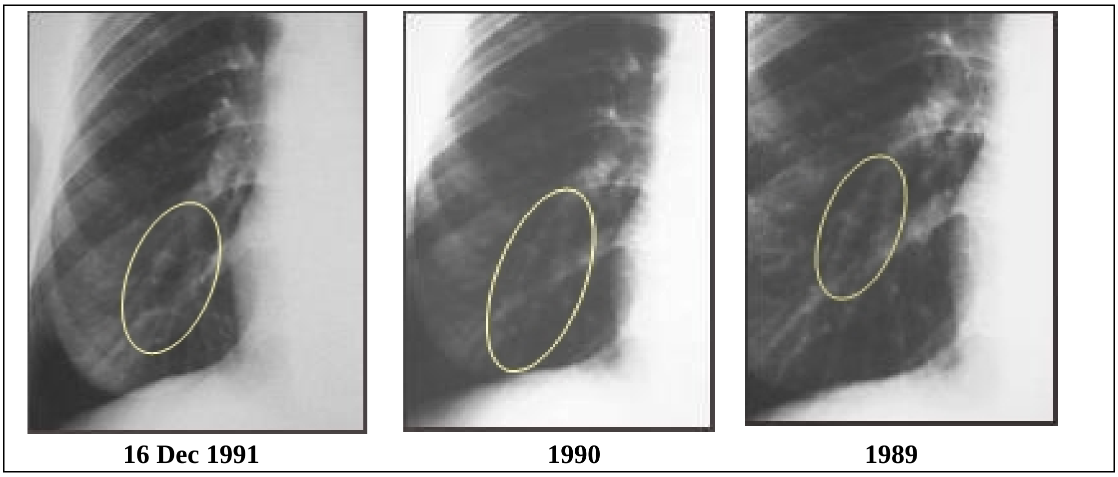

Figure 3. Case #2: Previous chest X-rays (all classified "normal")

Summary of case: asymptomatic bulla in right lower lobe. Progressive increase documented with yearly chest X-rays over 3 years of diving. Hyperinflation immediately after diving accident with symptoms of CAGE. All previous chest X-rays classified as "normal", but retrospectively showing presence of a smaller cyst.

DISCUSSION

Pulmonary barotrauma (PBT) is one of the most dreaded accidents in compressed-air diving, because of the high possibility of life-threatening complications such as tension pneumothorax and cerebral arterial gas embolism (CAGE) (Leitch and Green 1986). Although the occurrence of PBT is often associated with inappropriate ascent procedures (failing to exhale during ascent will induce a rapid increase in the pulmonary volume) (Murrison, Lacey et al. 1991; Vann, Denoble et al. 2004), many cases are reported where no such risk behaviour was observed or apparent (Tetzlaff, Reuter et al. 1997).

Alveolar rupture has been shown to occur with pulmonary overpressures of only 80mmHg (equivalent to a water depth of only 65cm). Proposed mechanisms by which such a slight increase of transpulmonary pressure might cause PBT include:

- *Decreased pulmonary elasticity* ("stiff lungs"). In a study of 14 young men who had suffered pulmonary barotrauma, it was shown that these individuals had less distensible lungs and airways than healthy divers and non-smoking non-divers (Colebatch and Ng 1991). The authors suggested that the relative stiffness of the airways increased the elastic stresses in the peribronchial alveolar tissue leading to an increased risk of alveolar rupture. It has been suggested that the increase in thoracic blood volume during immersion may compound this problem by further reducing lung distensibility (Francis 1997).
- *Local or regional air trapping*. Classically, asthma bronchiale (defined as a history of wheezing and abnormal pulmonary function tests) would disqualify a person from SCUBA diving, on the presumption that allergic or exercise-induced bronchospasm of the small airways may likely cause local zones of inefficient air exhalation, resulting in local overexpansion of pulmonary tissue (Anderson, Brannan et al. 1995; UKSDMC 2005). This is supported by a number of case reports, where asthma was considered to be the only risk factor present (Weiss and Van Meter 1995; Tetzlaff, Reuter et al. 1997). In recent years, and considering that many

asthmatic subjects apparently do dive without too high a rate of pulmonary barotrauma, these guidelines have been somewhat relaxed, excluding now only those individuals with active, exercise- or emotionally induced asthma (Wurzinger 1999; Godden, Currie et al. 2003), and giving a "word of warning" to the others. The value of pulmonary function tests as the sole criterion for detection of divers at risk for pulmonary barotrauma has been challenged because of a too low specificity (Benton, Francis et al. 1999).

- *The presence of pulmonary blebs or bullae*. Numerous case reports are available where divers with PBT were subsequently shown to have one or more (smaller) blebs or (larger) bullae, sometimes not visible on standard chest X-rays (Smit, Golding et al. 2004)The same observation has been made in patients with spontaneous (nontraumatic) pneumothorax (Gibson 1977; Keszler 1988; Mostafavi and Lieberman 1991) or recurrent spontaneous pneumothorax (Sihoe, Yim et al. 2000; Smit, Wienk et al. 2000). It is generally hypothesized that bullae predispose to pressure-reduction barotrauma either by a one-way valve mechanism at their "entrance" (allowing entry of air upon descent but blocking outflow of air during ascent from a dive), or by an insufficient outflow capacity through a small orifice during rapid ascents (Pare, Cote et al. 1989; Smit, Golding et al. 2004).

However, a direct causal relationship between the presence of bullous structures and lung tissue overpressure has not been established. Indeed, as imaging technology becomes more performant, asymptomatic pulmonary blebs can be found in a large number of persons. Although no exact prevalence is known, it is reported that radiologists in a major hospital do not even mention the presence of small blebs as "they are so common as to be considered normal findings in the patient population seen by a major hospital radiology department" (Millar 2004). The prevalence of large bullae in a normal population is essentially unknown. Moreover, the causal relationship between the presence of bullae or blebs on chest CT and the occurrence of a first pneumothorax on the contralateral lung or recurrent spontaneous pneumothorax on the ipsilateral lung is still heavily disputed (Sihoe, Yim et al. 2000; Smit, Wienk et al. 2000; Noppen 2001).

When a diver is found to have pulmonary function test abnormalities after a pulmonary barotraumatic incident, few people would question the statement that these were already present before the dive. This, of course, lends credibility to a possible causal relationship. That diving by itself may induce changes in pulmonary function, has been recently suggested (Thorsen, Segadal et al. 1990; Tetzlaff, Friege et al. 1998). Experienced sports divers were shown to have a significantly reduced MEF25 and MEF50 ($p<0.01$ and 0.05 respectively) compared to non-divers. There was a higher prevalence of cold-air hyperactivity in divers. There appeared to be a relationship with diving experience. The same observations have been made in professional saturation divers (Thorsen, Segadal et al. 1990).

When, after a pulmonary barotraumas, a diver is found to have pulmonary bullae on high-resolution CT scanning, it is often questioned whether these bullae were pre-existent or whether they are the consequence of the barotraumas, and are thus "de novo" findings. As pre-barotrauma high-resolution pulmonary CT scans are inevitably lacking, it is impossible to ascertain the pre-existant nature of any bulla observed.

Lacking this evidence, it is impossible to state with certainty a significant causal relationship. Criteria pleading for bullae not caused by the diving accident could be: thick bulla wall, absence of liquid level, presence of multiple non-ventilated spaces in the pulmonary parenchyma in combination with only localised barotrauma. Also, pulmonary overdistension bullae that have been acutely caused by PBT tend to resolve spontaneously within a few months (Reuter, Tetzlaff et al. 1997). A control CT scan some 4 months after the accident should be performed in all cases.

Although divers generally are excluded from further pressure exposure after a PBT and detection of lung cysts or bullae, there is controversy as to whether a diver with an asymptomatic, isolated bulla should be excluded from diving. The discussion focuses on the possible mechanisms for such a bulla to rupture in the course of a dive. After all, isn't there Boyle's Law of Physics, stating that such an air-filled structure would be compressed proportionally as the environmental pressure rises; then, when the diver ascends, the bulla will take on it's initial volume, but surely not greater? So how can it then, at one point, rupture?

We hypothesize that during the dive, even if there is no direct ventilation orifice, a gradual diffusion of nitrogen through the bulla wall can take place, driven by the pressure gradient. As the elasticity of the lung tissue counteracts the volume reduction by Boyle's Law, air will diffuse from the nearby lung tissue into the bulla cavity, causing it to gradually re-expand, while still remaining in pressure equilibrium with the surrounding lung tissue. Then, as the pressure is reduced, and the air is "trapped" inside the bulla, the bulla will grow beyond its initial volume. The elasticity of the surrounding lung tissue will now exert a concentric pressure on the bulla wall, and the resulting slight overpressure will make air (or nitrogen) diffuse out of the cavity into the surrounding tissue: the bulla will gradually take its initial volume again. It is conceivable that, when this cycle happens in a repetitive manner, the bulla wall gets stretched and the "resting volume" of the bulla increases. It is probable that the wall gets thinner as this happens. At one point, the acute stretching during an ascent from a dive will cause an air leak from the bulla wall and may cause symptoms of PBT.

CONCLUSIONS

To our knowledge, these are the first documented case reports of pulmonary bullae increasing in size, attributable to SCUBA diving activity. Although a causal relationship can not be demonstrated by the existing literature, the described case reports suggest strongly that at least some pre-existing bullae can and will increase in size over the course of a few years intensive diving. Because of the low sensitivity of plain chest X-rays, it may be advisable to obtain high-resolution CT scans of the chest in candidate divers where personal medical history leads to suspect possible pulmonary parenchymal damage. It would then however also be advisable to perform serial follow-up CT scanning after a number of years or exposures (dives), in those individuals that are allowed to dive in order to observe possible increase in size.

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The Baromedical Research Foundation has been awarded a substantial research grant from Sechrist Industries, Inc., to study hyperbaric oxygen's radiation sensitization effects. Study design, involving squamous cell carcinomas of the head and neck, has been completed. It involves both Phase I (dose escalation) and Phase III (randomized and double-blinded) components. Participating centers are The Mayo Clinic, Rochester, Minnesota, Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire, Sentara Norfolk General Hospital, Norfolk, Virginia and Palmetto Health Richland Hospital, Columbia, South Carolina. Foundation director Dick Clarke notes 'The best treatment for this form of cancer is not presently known. There is clearly room for long-term survival improvement, with tumor hypoxia a limiting factor in its control and eradication. This important award provides the opportunity to fully investigate the potential of hyperbaric oxygen to impact survival'. Patient enrollment will begin in March 2007 and take approximately 15 months to complete. For further information please contact **www.baromedicalresearch.org**.

Zetterstrøm Award Winner 2006

A RELATIONSHIP BETWEEN THE MENSTRUAL CYCLE AND DECOMPRESSION ILLNESS: IS THE EVIDENCE BUILDING ?

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St Leger Dowse, M. et al.: A relationship between the menstrual cycle and decompression illness: is the evidence building? Europ J Underwater Hyperbaric Med 2006, 7(4): 75-78. Controversy persists regarding any relationship between the menstrual cycle and decompression illness (DCI). Women now have greater involvement within the hypo and hyperbaric work place. Studies suggest a possible difference in risk of DCI, or problems during diving, over a typical 28-day cycle. We scrutinised the relevant published data from hypo and hyperbaric environments between the years 1988 to 2006. We also reviewed 250 records from a continued study involving 23 treatment chambers where women had been diagnosed and treated for DCI and for which the number of days between the first day of the last menstrual cycle and the problem dive was known. The 7 altitude and diving related abstracts and papers showed a relationship with DCI, or problems during diving, and the point in the menstrual cycle. Analysis of the 250 DCI treatment records also showed the incidence of DCI was not evenly distributed over the menstrual cycle, with more cases treated at the beginning and end of the typical 28 day cycle. The available evidence suggests there is a relationship between the risk of DCI, during hyperbaric or hypobaric exposure, or the occurrence of problems during hyperbaric exposure and the time in the menstrual cycle.

Decompression illness, women, menstrual cycle, risk

INTRODUCTION

Women now have greater involvement within the hypo and hyperbaric work place, as diving instructors, in the military, and as pressure chamber tenders. Since the 1970s controversy has persisted regarding the issue of a relationship between the menstrual cycle and decompression illness (DCI).

Although there are numerous non-diving studies comparing the effect of the menstrual cycle and sporting performance, the number of studies investigating DCI and the menstrual cycle is small. However, both retrospective and prospective work from the hypo and hyperbaric environments suggest a differing risk factor of DCI or problems during diving over a typical 28-day cycle (1-7). We scrutinised the available relevant published data ("*The Literature*") and reviewed records from women treated with DCI ("*The Study*") to investigate any potential relationship. In this paper DCI encompasses decompression sickness (DCS) and arterial gas embolism (AGE) following pulmonary barotrauma.

METHODS

The Literature

Results of relevant published studies in hypo and hyperbaric environments from 1988 to 2006 were evaluated (1-8). These studies have all been presented at international scientific meetings and/or published in peer reviewed journals and considered to be reliable studies which are altered pressure environment and menstrual cycle specific.

The Study

Records were evaluated from treatment chambers world-wide where women had been diagnosed and treated in a chamber for DCI (QinetiQ and DDRC 1997 – 2005). The study was questionnaire based. Only records fulfilling the inclusion criteria were used where the number of days between the first day of the last menstrual cycle and the problem dive was known.

Information regarding oral contraceptive pill use, usual length of menstrual cycle, age, depth of dive prior to onset of symptoms, type of symptoms, and smoking habits were also gathered.

All menstrual cycles were normalised to 28 days (0-27), with day 0 being the first day of bleed. The days from the first day of the last menstrual period to the day of the incident were calculated. The Chi-square goodness-of-fit test was used to assess whether the distribution of DCI incidents was uniform across the normalised four weeks (28 days) of the menstrual cycle.

RESULTS

The Literature

The 7 altitude and diving related publications (abstracts and papers) showed a relationship between DCI, or problems during diving, and the point in the menstrual cycle at which they occur (Table 1).

TABLE 1. Summary of the literature and conclusions:

The Literature	Conclusions
Dixon GA, Krutz RW, Fischer MS. (1)	Altitude DCI. All 5/30 female subjects with hypobaric DCS were in menses or early phase of cycle.
Rudge FW. (2)	Altitude DCI. Significant inverse linear correlation between number of days since start of LMP and DCS incident, highest risk at the beginning of a 28 day cycle. 81 retrospective records studied
Dunford RG, Hampson NB. (3)	Gender related risk of DCI. Menses was a significant risk factor for inside chamber attendants, but not for divers in open water. This study was based on small numbers, 9 in total.
Krause KM, Pilmanis AA, Webb JT. (4)	Altitude DCS. Correlation between menstrual day and DCS: greatest probability being on day two of bleed. 62 retrospective DCS records.
Lee V, St Leger Dowse M, Edge C, Gunby A, Bryson P. (5)	Suggested the risk of DCS may be dependent on the phase of the menstrual cycle with greatest risk of DCS, in the non-OCP group, being in the 1st week of a 28 day cycle, the lowest risk being in week 3. 150 prospective records.
Webb T, Kannan N, Pilmanis A. (6)	Altitude DCS gender related risk. Data from the non-ocp women agreed with Dunford, Krause, Lee, & Rudge, showing a reduction in susceptibility from week one through week four of the menstrual cycle. 70 women, 269 altitude exposures.
St Leger Dowse M, Gunby A, Moncad R, Fife C, Morsman J, Bryson P. (7)	Problems reported during diving were not evenly distributed over a menstrual cycle and suggested a risk factor associated with menses and diving. The highest was risk in week one, with the lowest risk in week three before rising again at the end of a 28 day cycle. 570 women, >50,000 dives, >11,000 menstrual cycles.

Controversy surrounds the effects of OCP and non-OCP use. Dixon and Dunford did not specifically account for OCP use in their analyses, whilst Rudge and Krause did not make any conclusions with regard to a correlation between OCP use and DCI (1-4). Lee, Webb, and St Leger Dowse differed regarding the relationships between OCP usage and DCI (5-7). Lee found no correlation between OCP use and DCI, though when age was taken into account there was a significant difference between OCP and non-OCP use (5). Webb found the subjects using the OCP showed a greater susceptibility to DCS in the last two weeks of the cycle (6). However, St Leger Dowse found no correlation between OCP use and problems during diving from the normalised cycle data, but when data was analysed from menstrual cycles of 28 days only the relationship with problems during diving and OCP usage was significant (7).

The Study

250 records (143 non-OCP, 107 OCP) were suitable for analysis from 23 chambers world-wide. The mean cycle length was 28.7 days (29.11 days non-OCP; 28.0 OCP) with a range of 21 to 45 days reported for the non-OCP users, and little variability for OCP users as would be expected. The mean age at the time of incident was 29.2 years (30.9 non-OCP, 26.8 OCP) with a range of16-51 years. The mean maximum depth of the dive recorded prior to the incidents was 22.8m. 24% of the women smoked cigarettes.

The incidence of DCI was not evenly distributed over the 4 weeks of the menstrual cycle. For the non-OCP group there was strong evidence (Chi-square) that the distribution was not uniform ($p<.01$) (Figure 1). For the OCP group however there was no evidence against a uniform distribution using the Chi-square test (Figure 1).

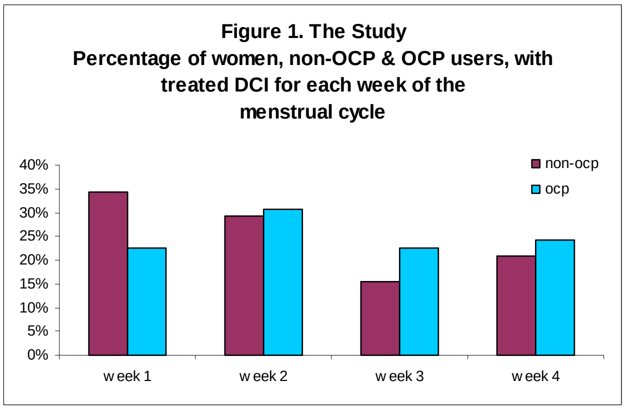

FIGURE 1. Percentage of women, non-OCP and OCP users, with treated DCI for each week of the menstrual cycle

DISCUSSION

The Literature

The conclusions of the literature (Table 1) were all consistent in spite of varying exposures, methodologies, analyses, and differing populations (1-7). The available evidence from the literature consistently suggests that there is a relationship between the risk of DCI during hyperbaric or hypobaric exposure, or the occurrence of problems during hyperbaric exposure, and the time in the menstrual cycle. Results were significant, particularly in the non-OCP groups. The issue regarding the OCP is inconclusive.

The Study

Overall the incidences of DCI were not evenly distributed over a typical 28 day menstrual cycle. This was particularly marked in the non-OCP group where there was strong evidence to support the confirmation of a relationship with the time in the menstrual cycle and the risk of DCI.

The OCP findings however are less clear. This may be due to a number of factors such as insufficient data for each week of the menstrual cycle, the varying types of OCP used by the women, and their usage of the OCP. Anecdotal evidence suggests women on the OCP extend their menstrual cycles for social reasons, with a recent study observing cycles of 21 to 40 days and more (8).

The Study and the Literature

Many studies assume women on the OCP to have a classic 28 day cycle. It could be argued that assuming a 28 day cycle, or normalising the OCP data, may shift the distribution of incidents across the cycle time-frame (8). Lee and St Leger Dowse found no relationship with the OCP when normalising their OCP data, but when OCP data were analysed in the St Leger Dowse study using only true 28 day cycles, the results were significant (5,7). Webb found a relationship in the last two weeks of the cycle in his OCP study group, but it is unclear whether the women in the study all had a classic 28 day cycle (6). The debate therefore regarding the risk factor between OCP usage and DCI will be ongoing and remain unclear until OCP usage is more accurately recorded in studies.

The literature over a period of 18 years was taken from both hypo and hyperbaric environments, retrospective and prospective data, and from military and civilian disciplines. Analysis over the menstrual cycle differed between studies, with some observing the incidence of DCI by individuals, whilst some aviation studies observed the incidence of DCI by altitude exposures. The size of the study groups varied widely from 9 to 570 (Table 1). It was also apparent that although some of the retrospective studies were able to initially interrogate records over 11 to 14 years, a large number of records did not fulfil the criteria required to establish any risk that might be associated with DCI and the menstrual cycle (2,3). In spite of these differences a similar trend was seen in all studies: whether this is the result of hormonal fluctuations of the menstrual cycle remains un-quantified and is a subject for further investigation.

CONCLUSION

We suggest evidence is building that a relationship between the menstrual cycle and DCI may exist. The results of the literature evaluated here are supported by analysis of the data of this study.

It is unclear whether these findings from the literature and the study are a result of an increase in risk during the early phase of the menstrual cycle or a protective factor during week 3 of the cycle. There may be a potential health and safety issue emerging regarding women, DCI and the menstrual cycle, and thus a case for implementing prospective research where the variables can be controlled.

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Corrigendum of Abstracts from EUBS ASM 2006

O13 SIMULATED DIVING POTENTIATES HEAT STRESS INDUCION OF HEAT SHOCK PROTEIN 70 IN HUMAN ENDOTHELIAL CELLS

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Brubakk et al. have shown that physical exercise 24 hours prior to diving can prevent bubble formation in both animals and humans. Exposing rats to heat stress prior to diving did not prevent production of vascular bubbles, but did protect the animals against decompression sickness (DCS). Furthermore, this protection was associated with a significant production of heat shock protein (HSP) 70. HSPs are part of cellular defence mechanisms and are induced by different types of stress like heat, hyperoxia and chemical exposure. Several lines of evidence indicate that neuronal DCS is due to initial damage to endothelial cells, and may be related to production of NO by the endothelial enzyme nitrogen oxide synthetase (eNOS). This enzyme has a cofactor that is dependent on cellular redox status and alterations of this may therefore affect eNOS activity. To investigate the mechanisms of protection against DCS induced by heat, we use cultured human endothelial cells as a model system to study the relation of heat stress, production of HSP and eNOS and the major cellular redox determinant, glutathione.

The present results demonstrate that heat alone induced HSP 70 several fold in human endothelial cells, but did not affect HSP90 and glutathione level. Exposing the cells to a simulated dive to 250 msw 24 hours after heat stress resulted in a significantly larger (up to 26 fold) increase in HSP 70. In contrast, there was no significant increase in HSP 70 after diving alone, indicating a potentiating effect of diving on the heat induction of HSP 70. The length of the dive did not seem to influence the expression of HSP 70. Preliminary results indicate that the glutathione status was relatively little affected under these conditions.

O18 BUBBLE GRADE VS NUMBER OF BUBBLES

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INTRODUCTION: Vascular gas bubble formation is accepted as a measure of decompression stress, and the grading system of Eftedal and Brubakk (EB) is one of several systems developed for analysis of ultrasonic signals. A table where EB bubble grades from ultrasound images were compared with the actual number of bubbles as counted by a computer program was published in 2003. Since then we have performed a *significant* number of experiments where we have collected data of number of bubbles and scoring according to the EB grade. This study was initiated in order to validate earlier published results considering analysis of ultrasonic signals.

METHOD: Data from 56 decompression studies was evaluated regarding counted number of bubbles per square centimetres by a specially developed computer programme, and observed bubble grade each 5th minute during and after decompression in these studies. Hence, a total of 1337 comparisons of bubble grading and bubble counting were performed.

RESULTS: The data show that there is an exponential relationship between the number of bubbles and bubble grade.

DISCUSSION: The main finding in the present study was that the relationship between the number of bubbles and bubble grade is exponential, and that the previous reported relationship between EB grade and number of bubbles per cm^2 is an overestimation after analysis of 1337 new comparisons of the number of bubbles and bubble grade.

BOOK REVIEW

Handbook on hyperbaric medicine, first edition
D Mathieu (ed)
812 pages, hardback
ISBN 1 4020 4376 7
Dordrecht: Springer; 2006.
Copies can be ordered online at <www.amazon.com>
Price: US$199.00

The Europeans have been active in the last two years in publishing their work. The European College of Hyperbaric Medicine (ECHM) Collection, Volumes 1 and 2 were reviewed recently in this journal[1] and now this textbook is intended as a state-of-the-art reference for the rational use of hyperbaric oxygen (HBO). It is the product of the Cooperation on Scientific and Technology (COST) programme, an initiative to implement and improve cooperation between scientists within the European Union. The HBO initiative (Action COST B14) was launched in 1998 and, under the chairmanship of Professor Mathieu of the University of Lille, has culminated in this book. The foreword states "*this handbook is intended as a reference document for researchers and clinicians alike – to be used both in the research laboratory and in everyday hyperbaric clinical practice; it also provides support material for teachers and will assist students in obtaining ECHM level II and III qualifications in hyperbaric medicine*."

This is truly an international collaboration with 60 contributors from 19 countries, stretching from Finland to South Africa, the French West Indies to Israel. Interestingly no scientists and only one physician from the United Kingdom contribute (to a single chapter), although another is a co-editor of the first of the three main sections. These three sections are devoted to the physical and pathophysiological bases of HBO, the clinical indications for HBO and the practice of hyperbaric medicine. Each is subdivided into a series of chapters written by experts, whilst the clinical indications section is further subdivided into recommended, optional and controversial or non indications for HBO.

At 800 pages long, this is not a text to read from cover to cover, but to use, as advocated, as a reference book. This reviewer has managed to read only about half the chapters and, therefore, cannot vouch for the entire text. The only other comprehensive textbook in hyperbaric medicine[2] was last published in 1999 so there has been a growing need for an up-to-date, authoritative publication. Professor Mathieu and his collaborators are to be congratulated on an excellent monograph that achieves their goals very well.

From a clinician's viewpoint (I am not a laboratory scientist), I found the information and commentaries in almost all the sections that I read to be informative and well presented in a logical manner, and that they often extended my knowledge and understanding. The third section provided an interesting insight into European hyperbaric medicine practice, including the approach to training and certification of personnel. As the programme director of a postgraduate, university-based course for diving and hyperbaric physicians, I found much useful material to assist in the preparation of our programme, and this will become one of our recommended textbooks.

Each chapter has an extensive international bibliography, including both English and non-English papers and lacking the tendency of USA publications to focus predominantly on American literature. However, such referencing needs to be contemporary, and this is not always the case. For instance, the most recent reference in the chapter on necrotising soft tissue infections is for 1997 – an inexcusable failure to review the most recent literature in an important topic. Likewise, for the chapters on the effects of HBO on the cardiovascular system and on microorganisms and host defences, the most recent references are for 2000. By contrast, over half of the 93 references for the chapter on ischaemia–reperfusion injury are for later than 2000, including several from 2005. These differences are not sufficiently explained by the current extent of research in these areas, and such deficiencies need correction in future editions.

Presentation of the text is first class, with each chapter clearly laid out in subsections. Inevitably there is a degree of repetition between chapters written by different authors on related topics, but this is not pronounced, different approaches often complementing rather than mimicking each other. Despite English not being the first language for almost all authors, instances of awkward or incorrect usage are tolerable; though as a journal editor, I consider the two English speaking editors could have done a better job of this − "caelioscopy" instead of laparoscopy and "high pressures of insufflation" instead of high inflation pressures (referring to mechanical ventilation of patients) are just two examples taken at random.

Searching for specific items can sometimes be daunting if using the index. For example, there are over 90 instances of the term 'decompression' listed. Once a chapter had been read, I found specific points again easily because of the clear subdivision of each chapter. There are relatively few typographical errors, and tables and diagrams are relevant, reasonably laid out and legible. However, the quality of photographs is generally disappointing, many being too small and of a poor standard. The book's cover disintegrated quite early suggesting the binding is inadequate.

This text is an important contribution to the hyperbaric literature for which the Europeans must be congratulated. It should be in the personal library of all physicians responsible for the care of patients undergoing HBO.

References

Mathieu D, editor. *The ECHM Collection, Volumes 1 and 2*. Flagstaff, AZ: Best Publishing Company; 2004 and 2005.

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1. Thorsen E, Risberg J, Segadal K, Hope A. Effects of venous gas microemboli on pulmonary gas transfer function. Undersea Hyperbaric Med 1995; 22:347-353.
2. Hempleman HV. History of decompression procedures. In: Bennett PB, Elliott EH, Eds. The physiology and medicine of diving. London: WB Saunders, 1993:324-375.
3. Kindwall EP, Goldmann RW. Hyperbaric medicine procedures. Milwaukee, WI: St. Luke's Medical Center, 1970.

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