The Editor's Offering

A happy Christmas and prosperous New Year to all our readers. They, like the Editor, owe a debt of gratitude to the Journal's two unpaid proof readers, Drs David Davies and John Couper-Smartt, for their attention to detail and accuracy in correcting misprints and missing words, to say nothing of making sure that everything is understandable. Spell checkers are wonderful gadgets which make sure that the words are correctly spelt, but they accept correctly spelt words in the wrong place quite happily. It takes humans, who are fallible, to correct machine errors.

Those who present papers at the Annual Scientific Meeting (ASM) are told by the Convenor that the papers will appear later in the Journal, so they must hand over the text, printed or electronic, before they speak. Unfortunately it appears that some cannot read or hear such clear instructions and their presentations, which have been recorded, have to be transcribed. However, a sufficient number of them have not only provided their papers, but also proof read the edited documents sent to them, to provide a good selection for this issue.

The original papers both successfully deal with real world problems. That is what the South Pacific Underwater Medicine Society Journal is all about, passing information on and making learning enjoyable. The Journal congratulates Dr David Vote on achieving the Diploma of Diving and Hyperbaric Medicine.

For those who have left their Christmas shopping until December a letter on page 197 is worth reading.

Deciding that someone who has just finished a dive, climbed on board and then complained of paralysis is probably suffering from decompression illness (DCI) is easy. That is a very obvious sign well known to be associated with inadequate decompression. But what of the diver who is weary and unwell but without objective signs? Salmon farming and tuna feeding operations have many divers who work with repetitive dives. When these industries started up there were epidemics of DCI. Later safety measures were introduced, which have reduced the incidence of florid DCI. David Doolette presented a paper at the 1999 ASM about an alternative method of diagnosing DCI by questionnaire, which is printed on page 203.

The 2000 ASM was largely devoted to fitness to dive, if a terrestrial air-breathing mammal can ever be really fit to dive instead of being less likely to damage itself when diving. David Elliott opened the batting with "Why fitness? Who benefits from diver medical examinations". There is no doubt that some illnesses are less than suitable for being taken underwater using scuba gear, such as epilepsy. There is much less certainty that asthmatics, who are excluded on the grounds that they might suffer air emboli from barotrauma, actually die from this cause while diving. There is evidence that they usually die from drowning, perhaps because they become too short of breath for the exertion needed to swim on the surface. One good reason for being physically fit before diving is to be strong enough to swim hard to get out of trouble.

Drew Richardson presented the PADI alternative, the RSTC (Recreational Scuba Training Council) questionnaire. Using this screening technique only those who give positive answers to questions have to see a doctor. But the trouble with questionnaires is that often questions mean something different to the reader from what the person who composed the question expected. But that will be dealt with in more detail in a later issue.

David Elliott and Jürg Wendling from Switzerland discussed what diving can be done by someone who is not perfect and practical solutions for divers with restricted fitness to dive. The latter include children.

Paul Langton and a team from the University of Western Australia (UWA) present the results of their survey of many recently trained divers and a few longer term divers. Thanks to the co-operative attitude of PADI Australia the investigators were given access to the names and addresses of those who had undertaken a PADI course in Western Australia in the previous year. The survey, by questionnaire, had a respectable return rate of over 50%. As far as the Editor knows this is the first time that such a large group of divers has been followed up. Unexpected findings were that many divers had ear problems, difficulty in swimming and mechanical problems. It is an eye-opening cross section of the recently trained divers of Western Australia. Of interest is that the divers from the UWA diving club, who were those who had been diving for some years, had a similar pattern of health and problems as the neophytes.

Chris Coxon, a Senior Inspector of Workplace Health and Safety in Queensland, discusses the Medical Declaration which is required before anyone can snorkel from a commercial dive boat in Queensland. It is likely that this form may be the reason that there have been no deaths in Resort divers, those untrained tourists doing a trial dive, since 1994 in spite of a huge increase in the number of such divers each year.

Giving up smoking has been known to be good for one for years. But Strauss et al. have shown that not smoking for as little as 46 hours produces a noticeable improvement in $PtCO_2$ even when breathing room air.

Our last two pages reprint an article about rebreathers from a 1999 issue of *Undercurrent*.

ORIGINAL PAPERS

MEASUREMENT OF PLASMA GLUCOSE UNDER HYPERBARIC OXYGEN CONDITIONS

D A Vote, P O Doar, R E Moon and J G Toffaletti

Key Words

Equipment, hyperbaric oxygen, hyperbaric research, plasma glucose measurement.

Abstract

This study was designed to evaluate the accuracy of the bedside glucometer SureStepPro (SSP, LifeScan Inc; Milpitas, California) against a standard laboratory instrument (Yellow Springs Instruments [YSI] 2300 STAT PLUS; Yellow Springs, Ohio) during hyperbaric oxygen therapy. Human blood samples were used to prepare plasma glucose (PG) concentrations over a range 25–300 mg/dl (1.4-16.6 mmol/l). Samples were sequentially tonometered (Instruments Lexington [IL] 237 Lexington, Maryland) with two separate gas mixes at 203 kPa (2 bar) to PO_2 values of 159 kPa (1,200 mmHg, 1.6 bar) and then 8.1 kPa (60 mmHg, 0.08 bar), allowing measurement of each blood sample at both PO_2 values. PG concentrations were immediately measured by a SSP at 203 kPa (2 bar) then analysed outside the chamber by both instruments. The YSI PG measurements were unaffected by high PO_2. Compared with PG concentrations measured at PO_2 of 8.1 kPa (60 mmHg, 0.08 bar), the YSI readings at PO_2 of 159 kPa (1,200 mmHg, 1.6 bar) were higher by only 1.8 ± 1.6 mg/dl (0.1 ± 0.09 mmol/l). At PO_2 8.1 kPa (60 mmHg, 0.08 bar), compared with the YSI, the mean bias and imprecision (SD of bias) of the SSP were 6.8 and 5.7 mg/dl (0.38 and 0.32 mmol/l). At PO_2 159 kPa (1,200 mmHg, 1.6 bar), the bias and imprecision of the SSP were 4.6 and 4.8 mg/dl (0.26 and 0.27 mmol/l). The PG concentrations at PO_2 159 kPa (1,200 mmHg, 1.6 bar) measured by the SSP, when used inside the hyperbaric chamber at 203 kPa (2 bar) were lower by only 3.5 ± 4.5 mg/dl (0.19 ± 0.25 mmol/l) compared with SSP values at 101 kPa (1 bar). Therefore, the SSP provides accurate measurement of PG in blood when used either at 101 kPa (1 bar) or inside the hyperbaric chamber at 203 kPa (2 bar).

Introduction

Diabetic patients make up a significant proportion of those treated with hyperbaric oxygen (HBO_2). These patients are at risk of a decrease in plasma glucose (PG) following HBO_2. Springer reported that glucose levels decreased an average of 51 mg/dl (2.8 mmol/dl) in 25 insulin-dependent diabetic patients after several HBO_2 treatments.[1] Hypoglycaemia during HBO_2 may cause the patient to exhibit seizure activity mimicking the neurological manifestations of oxygen toxicity. Because the treatment for hypoglycaemia differs from that of O_2 toxicity, the need to measure PG in patients during HBO_2 therapy becomes a necessity.

To date, investigations and clinical management of this phenomenon are confounded by erroneously high or low glucose measurements during HBO_2.[2-4] These measurement errors have also been described at high altitude and are believed due to either an instrument artifact induced by PO_2 variation or pressure induced instrument malfunction.[5-7] The standard glucose testing system uses a glucose-oxidase reaction shown in Figure 1, in which glucose oxidase (GO) impregnated reagent strips catalyse the reaction between glucose and oxygen (O_2) to form gluconic acid and hydrogen peroxide (H_2O_2). The hydrogen peroxide then reacts with a chromogen to form a coloured compound, which is monitored by reflectance photometry.

There are a number of additional limitations with previous studies. Either they have not reported the elevated PO_2 value[2-4] or failed to reference their results to a laboratory standard instrument.[2,3] Furthermore, the highest PO_2 tested was approximately 78 kPa (590 mmHg, 0.77 bar) in a study in which Edge et al.[4] exposed glucometers to air at 375 kPa (3.7 bar). Finally, no one has yet determined whether laboratory instruments are accurate at PO_2 values achieved during HBO_2.

Since the glucose oxidase reaction depends on PO_2, it is conceivable that extremely high PO_2 may either accelerate the reaction or change the equilibrium at reaction completion, resulting in a falsely elevated blood glucose measurement. Older test strip format design may make access for oxygen difficult. These strips have been

GLUCOSE + O_2 + *GLUCOSE OXIDASE* TO GLUCONIC ACID + H_2O_2

H_2O_2 + Reduced Chromogen (UNCOLOURED) to H_2O + Oxidised Chromogen (COLOURED)

Figure 1. The Glucose Oxidase reaction.

designed to function under relative low PO_2 conditions. The oxygen content in the sample may compete with the dye (reactant) in the oxidation reaction creating an oxygen dependency, resulting in a falsely low glucose measurement.

In summary, the effect of hyperbaric oxygen on blood glucose measurements has not been adequately addressed. Our study was designed to compare the measured PG in a blood sample at PO_2 values of 8.1 kPa (60 mmHg, 0.08 bar) and 159 kPa (1,200 mmHg, 1.6 bar) using a standard laboratory instrument (Yellow Springs Instrument [YSI] 2300 STAT PLUS; Yellow Springs, Ohio) to PG measured by a bedside glucometer (SureStepPro [SSP], LifeScan Inc; Milpitas, California) over the range of atmospheric and oxygen pressures encountered in clinical HBO_2 therapy.

Methods

BLOOD SAMPLES

PG concentrations were prepared over the range 25-300 mg/dl (1.4-16.6 mmol/l). Low values were achieved by incubation for 3 to 5 hours at 37°C in a water bath with constant rotation to the sample tubes. A curve of the decrease with time of PG in a blood collection tube (Vacutainer TM 5 ml; Becton Dickinson Inc; Franklin Lakes, New Jersey) containing lithium heparin (5U/ml) enabled appropriate timing to achieve low PG concentrations. High values were obtained by adding 10 to 30 µl of 50% dextrose to sample tubes.

In keeping with common clinical practice, we initially measured PG from the same blood sample in both LiHep (lithium heparin) and NaF (sodium fluoride) tubes. Fluoride prevents glycolysis by inhibiting glucose oxidase thus providing stable PG concentrations in blood collection tubes. The YSI was unaffected at 250 mg/dl NaF, as expected.[8] Unfortunately, the SSP was greatly affected by this concentration of NaF (see results). Therefore, all blood glucose measurements for the study were on samples containing lithium heparin.

INSTRUMENTS

The four instruments studied were a SSP glucometer, placed inside the hyperbaric chamber, and YSI, SSP, and IL instruments (Instruments Lexington [IL] 1640, Lexington, Maryland; blood gas analyser) located just outside the hyperbaric chamber. Each was calibrated according to the manufacturers' protocols. Immediately prior to tonometry, the three glucose instruments measured a baseline glucose concentration for each sample.

The 5 ml venous blood samples were emptied into the tonometer (IL 237, Lexington, Maryland) maintained at 37°C and the chamber was then pressurised to 203 kPa (2 bar). The tonometered blood sample PO_2 was typically stable at 159 kPa (1,200 mmHg, 1.6 bar) after an hour at 203 kPa (2 bar) using a gas mixture containing 94% O_2, 3% CO_2 and 3% N_2. Confirmation of PO_2 values were by the IL 1640 immediately after sample decompression. Although blood gas analysis was at 101 kPa (1 bar), not 203 kPa (2 bar) this method of measurement has been shown to be clinically accurate.[9] At a PO_2 159 kPa (1,200 mmHg, 1.6 bar) a gas tight glass syringe was used to withdraw half the blood sample, which underwent immediate PG measurement by the SSP in the chamber. The syringe was then decompressed over 5 seconds through a medical lock to 101 kPa (1 bar). Within 2 minutes this syringe sample had blood gas analysis and PG measurement by both the laboratory instrument and bedside glucometer.

Interim analysis of the first 13 samples showed a significant drop in PG as a result of tonometry to PO_2 159 kPa (1,200 mmHg, 1.6 bar), presumably as a result of ongoing glucose consumption by leucocytes and erythrocytes in the sample. Therefore, in order to measure glucose on a blood sample at both high and low PO_2 values within a short time interval, the following procedure was performed on 21 samples. After aspiration of a blood sample from the tonometer at a PO_2 of 203 kPa (2 bar), the remaining blood was tonometered at 203 kPa (2 bar) with a gas mixture containing 94% N_2, 3% O_2, 3% CO_2. Serial PO_2 measurement confirmed that a PO_2 of 8.1 kPa (60 mmHg, 0.08 bar) was achieved at 4 minutes, insufficient time for the glucose to change. These samples underwent identical handling and measurements. This method resulted in two plasma glucose measurements of the same blood sample at PO_2 159 kPa (1,200 mmHg, 1.6 bar) and 8.1 kPa (60 mmHg, 0.08 bar) on three separate instruments.

To test within-run precision, the same blood sample was measured 10 times by each glucose instrument. This was performed on three samples having different glucose concentrations: low, normal and high. The YSI measurements at PO_2 8.1 kPa (60 mmHg, 0.08 bar) were used as the standard for bias and imprecision. Bias is defined as the mean of the difference between simultaneous measurements by two methods.[10] Imprecision is defined as the standard deviation of these differences.[11]

Results

PRECISION

Within-run precision was determined by measuring glucose ten times on each of 3 samples containing lithium heparin by each instrument. The results are shown in Table 1.

METHOD COMPARISONS

YSI

The YSI glucose measured in blood at PO_2 159 kPa (1,200 mmHg, 1.6 bar) compared to measurements at PO_2 8.1 kPa (60 mmHg, 0.08 bar) were higher by 1.8 ± 1.6 mg/dl [0.10 ± 0.09 mmol/l (bias ± imprecision)] see Figure 2.

TABLE 1

WITHIN-RUN PRECISION
MEASURED GLUCOSE CONCENTRATIONS
(mg/dl)

Sample	SSP		YSI	
A	41	± 1	37	± 1
B	184	± 3	187	± 1
C	451	± 16	445	± 2

The same blood sample (LiHep tubes) measured 10 times (mean ± SD) by SS and YSI, at 3 different glucose concentrations.

SureStepPro

The SSP, operated at 203 kPa (2 bar) with a PO_2 of 8.1 kPa (60 mmHg, 0.08 bar) overestimated glucose by 6.8 ± 5.7 mg/dl [0.38 ± 0.32 mmol/l (bias ± imprecision)] compared with the YSI. At PO_2 159 kPa (1,200 mmHg, 1.6 bar), the SSP underestimated blood glucose by 0.4 ± 7.1 mg/dl [0.02 ± 0.39 mmol/l (bias ± imprecision)] (Figure 2). Figure 3 shows glucose concentrations measured in blood by the SSP operated at 203 kPa (2 bar), a PO_2 of 159 kPa (1,200 mmHg, 1.6 bar) were lower by 3.5 ± 4.5 mg/dl [0.19 ± 0.25 mmol/l (bias ± imprecision)] compared with SSP values at 1 bar. Figure 4 shows the overall bias and imprecision for each condition described relative to the YSI glucose measured at PO_2 8.1 kPa (60 mmHg, 0.08 bar).

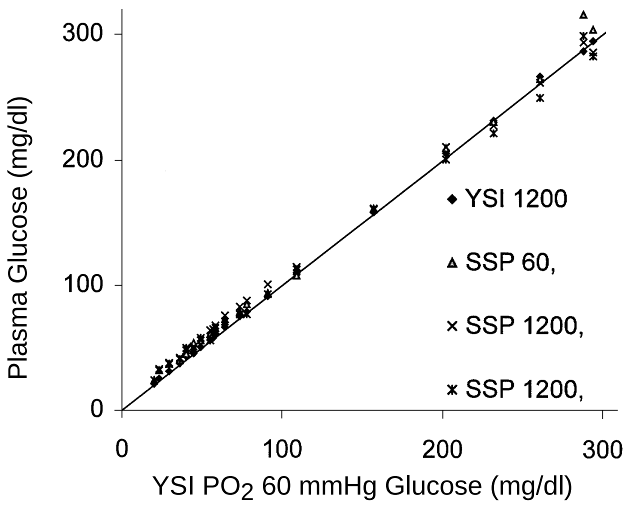


Figure 2. The effect of PO_2 on plasma glucose measurements. The results of all PG measurements of the same blood sample under each condition described: YSI at PO_2 at 159 kPa (1,200 mmHg, 1.6 bar), SS at PO 8.1 kPa (60 mmHg, 0.08 bar) and at159 kPa (1,200 mmHg, 1.6 bar) at 101 kPa (1 bar), and the SS at PO_2 159 kPa (1,200 mmHg, 1.6 bar) at 203 kPa (2 bar) against YSI at PO_2 at 8.1 kPa (60 mmHg, 0.08 bar) (line of idenity shown). The numbers against YSI and SSP are the pressures in mmHg of PO_2.

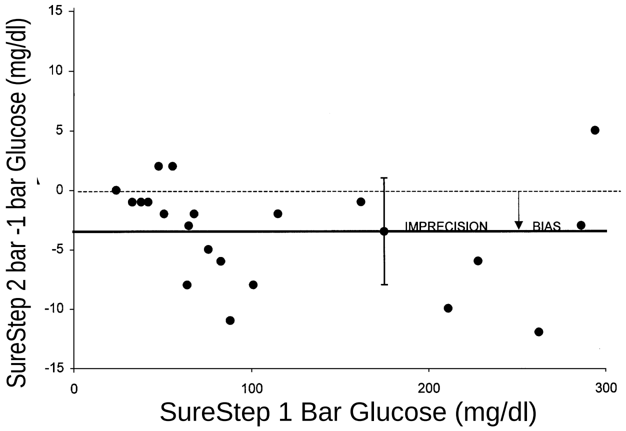


Figure 3. SS performance at 203 kPa (2 bar) compared with 101 kPa (1 bar) with PO_2 159 kPa (1.6 bar, 1,200 mmHg). Plasma glucose values were lower by 3.5 ± 4.5 mg/dl (bias ± imprecision).

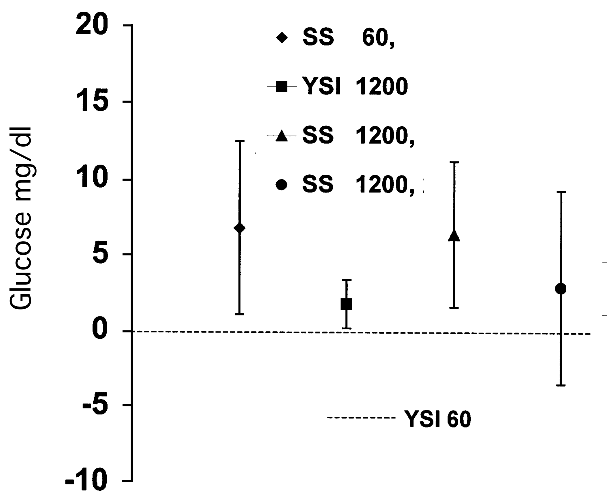


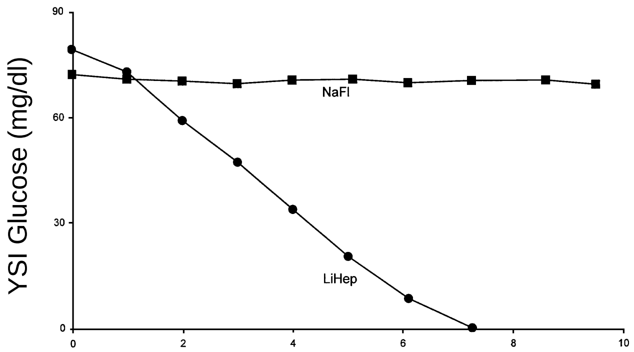
Figure 4. Displays Bias and Imprecision for each conditon described relative to the gold standard of YSI PG measurements at PO_2 8.1 kPa (60 mmHg, 0.08 bar). From the left the bars are SS at PO_2 8.1 kPa (60 mmHg, 0.08 bar), then YSI and SS at PO_2 159 kPa (1.6 bar, 1,200 mmHg) at 101 kPa (1 bar) and on the right SS at PO_2 159 kPa (1.6 bar, 1,200 mmHg) at 203 kPa (2 bar). The numbers against YSI and SSP in the graph above are the pressures in mmHg of PO_2.

EFFECT OF HEPARIN AND FLUORIDE

In similar samples containing either sodium fluoride or lithium heparin, plasma glucose measured by the YSI showed a mean difference (± SD) of only –0.6 ± 3.8 mg/dl [-0.03 ± 0.21 mmol/l (9 samples)], whereas simultaneous measurements of glucose by the SSP in 11 samples containing sodium fluoride showed a mean difference (± SD) of (56 ± 40 mg/dl (3.1 ± 2.2 mmol/l) versus YSI.

Discussion

This is the first study that has evaluated blood glucose measurements using both a bedside glucometer and a laboratory standard instrument under defined PO_2 conditions. Previous studies using laboratory instruments have either incomplete documentation of their results,[2] or not stated the time delay between glucometer and laboratory reading[4] or not used a laboratory instrument as a reference.[3] The time delay is important because PG decreases in blood over time (Figure 5). Our study has minimised the effects of glycolysis in samples by rapidly tonometering blood from PO_2 159 kPa (1,200 mmHg, 1.6 bar) to 8.1 kPa (60 mmHg, 0.08 bar) in 4 minutes, and measuring glucose within 2 minutes thereafter.



Time in hours

Figure 5. Serial plasma glucose measurements of the same sample by YSI in NaF and LiHep tubes over time.

Glucometers in the past have performed unsatisfactorily under a number of environmental conditions: hyperbaric,[1-3] humidity,[5-7] altitude[7] and low PO_2.[7] Shafer showed a significant difference between reaction rate and reaction end point glucometers; with the reaction rate technique performing better.[2] Her conclusion was, that since the reaction rate method made an estimation (at 20-30 seconds) of a glucose end point, this allowed a shorter strip exposure time to the high PO_2. The SSP chemistry is based on a reaction endpoint but was designed to allow the reaction site to be exposed to ambient oxygen.

The SSP enzymatic reactions occur at the bottom of the test strip that is open to ambient atmospheric oxygen and opposite to the site where blood is applied.[11] This design allows oxygen to exist in excess for the reaction. With the availability of ambient oxygen, the blood sample PO_2 is not reaction rate limiting. SSP monitors the reaction for its endpoint with glucose as the only rate-limiting substrate.

Other designs of test strip formats may make access for oxygen difficult. For example, Accuchek Easy (Boehringer Mannheim Inc, USA) is a system in which the reagent is coated onto a plastic window and sample is supplied from above. The colour formed is viewed from below through the window. In these systems oxygen must get to the reaction site primarily by diffusion through the sample because it can not easily pass through the window.[12] To obviate this, the manufacturers utilise a dye system that essentially takes the place of oxygen in the reaction.[13] Doing so provides for a very fast colour development but may create an oxygen dependency because the oxygen content in the sample may compete with glucose in the oxidation reaction.

Some other glucose meter systems based on glucose oxidase incorporate a mediator molecule or compound in the strip chemistry. This mediator shuttles electrons from the oxidation of glucose to the electrodes. Because oxygen can also perform this function, there can be competition between oxygen and the mediator for electrons. The test strips are factory calibrated with a certain level of blood PO_2 and this level must be relatively consistent with the oxygen level of blood samples. If blood samples have relatively lower or higher PO_2 levels, test inaccuracies could result.

For the YSI, glucose in the sample is stirred and diluted in the sample chamber. Glucose then diffuses through a thin polycarbonate membrane. Once past the polycarbonate membrane, glucose encounters an extremely thin layer of glucose oxidase. There the following reaction occurs:

$$\textbf{Glucose} + \mathbf{O_2} \text{---}> \mathbf{H_2O_2} + \textbf{By-product}.$$

Although oxygen is consumed in this reaction, the buffer is not seriously depleted of oxygen, nor is the rate of enzyme reaction very sensitive to small changes in oxygen concentration. Therefore, it is not necessary to measure or control the oxygen content in the sample chamber. Hydrogen peroxide diffuses toward the platinum anode in the probe assembly, where it is electrochemically oxidised, creating current that is measured.[8] The rate of the chemical reaction is limited primarily by diffusion. This results in improved linearity, calibration stability and freedom from enzyme inhibition errors.

In summary, the YSI remained accurate over the glucose range 25-300 mg/dl (1.4-16.6 mmol/l) at two PO_2 values of 8.1 kPa (60 mmHg, 0.08 bar) and 159 kPa (1,200 mmHg, 1.6 bar). The SSP remained within 14% of the YSI at PO_2 8.1 kPa (60 mmHg, 0.08 bar) measured values, within the tested glucose range under PO_2 variation from 8.1 kPa (60 mmHg, 0.08 bar) to 159 kPa (1,200 mmHg, 1.6 bar). Thus being well within the designed performance of the SSP, which is to measure blood glucose values to within 20% of laboratory values. The SSP is also accurate when used inside the hyperbaric chamber at 203 kPa (2 bar). Although the YSI measured glucose accurately in tubes containing sodium fluoride or lithium heparin, the same comparison with the SSP showed a large error in samples containing sodium fluoride.

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HYPERBARIC OXYGEN THERAPY FOR RADIATION-INDUCED HAEMORRHAGIC CYSTITIS

Andrew Waring and Harry Oxer

Key words

Hyperbaric oxygen, irradiation, treatment.

Summary

A retrospective study of the ten year experience of the Fremantle Hospital Hyperbaric Unit in the treatment of radiation-induced haemorrhagic cystitis. This is the largest reported series in Australia and the second largest found in the literature. The objective of this study is to examine the benefit of a course of hyperbaric oxygen therapy in this condition, for which other treatment modalities are often inadequate, temporary and associated with much morbidity. A majority of patients obtained at least symptomatic benefit with minimal discomfort and no major complications. There was a marked decrease in the requirement for blood transfusion. This suggests that hyperbaric oxygen (HBO_2) therapy in radiation-induced haemorrhagic cystitis is both efficacious and well-tolerated, and should be considered for all patients with this condition. Further trials, with more objective outcome measurements, need to be undertaken.

Introduction

Irradiation is a common therapy for a variety of malignant tumours in the pelvic region. Haemorrhagic radiation-induced cystitis and proctitis are side effects that occur in up to 10% of patients.[1,2] The consequences of these can be life-threatening and the symptoms debilitating.[3] Multiple blood transfusions are often required.

Conventional treatment modalities by urologic surgeons for haemorrhagic cystitis include fulguration,[3] instillation of formalin,[3,4] silver nitrate,[5] alum,[6] sodium pentosulfanpolysulphate,[2] hydrostatic bladder dilatation, and hypogastric artery ligation.[6] All of these have disappointing results in symptomatic relief. Furthermore, while sometimes ameliorating symptoms, they do not address the long-term healing of the underlying radiation damage.[7] Failure of these other conservative modalities may lead to a requirement for urinary diversionary surgery, with or without cystectomy, and further stresses on already debilitated patients.

Hyperbaric oxygen (HBO_2) therapy simultaneously addresses both these symptomatic and healing issues. Previous studies have suggested that hyperbaric oxygen treatment in this condition is beneficial, has minimal morbidity and is well tolerated.[1,2,7-9] This study examines the experience and results of the Fremantle Hospital Unit in the past ten years.

Methods

Between December 1989 and February 1998, 26 patients (male 21, female 4, average age 69 years (40-82) underwent 30 courses of hyperbaric oxygen at Fremantle Hospital for a total of 676 treatments. The average number of treatments was 22 (range 14-50). One patient was excluded from the analysis unable to continue beyond the first treatment.

The Fremantle Hospital Hyperbaric unit has a multi-place chamber. Patients are seated in armchairs in the chamber during treatment and 100% oxygen is delivered via a head hood. All patients are treated with the “FH10” treatment table (105 minutes total, at a pressure of 2 ATA), for 6 days per week. The usual number of treatments was twenty-four (four weeks), with a medical assessment and option to continue for a further 2-3 weeks at this time. Patients were followed up one month later by telephone, and if required, by personal interview. Patient data was collected from hospital, unit and consultant records, and studied retrospectively.

Results

Patients were referred to the Fremantle Hospital Hyperbaric Unit for treatment of their haemorrhagic radiation-induced cystitis on an average of 34 (range 1-96) months after radiotherapy (average dose 63 Gy). Three patients were referred by their radiation oncologist, and 22 by their urologist. The principal underlying diagnoses were carcinoma of the prostate and bladder. Eleven of the patients had undergone previous forms of symptomatic treatment, such as alum irrigation and fulguration of the bladder. Fifteen patients had required blood transfusion, with an average need for 6 units (range 2-17). All had radiation damage and cystitis, that was cystoscopically proven in 23 (not recorded for 1 and the other had necrosis of the bulbar urethra). Symptomatically, the cystitis was described as severe in nine and moderate in sixteen.

Immediately following their course of hyperbaric therapy, patients were assessed symptomatically by the unit director (HFO). Twenty-four patients (96%) reported symptomatic improvement. Six had complete resolution of haematuria and eleven reported a marked reduction. Decreased intermittent haematuria persisted in 1 patient, there was no change in 4 and information was not recorded for 2 patients. Other symptomatic improvements included a decrease in nocturia, frequency and strangury. There was no correlation between improvement and age, sex, or the original diagnosis.

Follow-up cystoscopy was available for 17 patients. Two were reported as normal cystoscopy, “improvement” (not otherwise specified) in a further 2, recurrent tumour was present in 2, ongoing radiation cystitis in 5. The remaining six cystoscopies had a range of results (infection, erythema, old clots).

At initial follow-up (usually one month later) each patient was assessed symptomatically by the unit director. Ten described complete, twelve partial and the remaining three poor or no response to the therapy. No patient died during the course of treatment, however two died within 3 months of completion from causes unrelated to the treatment (both due to their underlying conditions). Mean follow-up time was 5 months (range 1-18 months).

Complications in the series were minimal and none related specifically to the hyperbaric treatment. Two patients had severe persistent haematuria (one related to the underlying malignancy) during the course of treatment that required admission to hospital.

Five patients required further courses of hyperbaric treatment for recurrent haematuria. All these patients had had at least 18, and an average of 22, initial treatments. Four had repeat cystoscopies between the treatment courses; two showed continuing but diminished radiation damage, one had evidence of infection and point bleeding and one had recurrent tumour. The remaining patient was re-treated on symptoms alone.

Discussion

The underlying pathophysiology of haemorrhagic radiation-induced cystitis involves a combination of mucosal oedema, vascular telangiectasis, obliterative endarteritis[3] and smooth muscle fibrosis.[1,2,8,10] Endarteritis leads to ischaemia and hypoxia of the mucosa, with the clinical end-result of ulceration and bleeding.[1,8] Hyperbaric oxygen repairs these abnormalities by creating an angiogenic oxygen gradient, acting via tissue macrophages.

At 2 ATA using 100% oxygen, the tissue oxygen tension is increased 10 fold compared with ambient air and alternating HBO_2 treatments with the relative hypoxia encountered in room air, ensures the necessary oxygen gradients, and stimulus required.[6,9] This leads to new vessel formation, increasing the vascular density 8 to 9 fold,[8] ensuring a much improved oxygen supply to the hypoxic tissue.[3,10]

Although this angiogenic effect is due to hyperoxia[1] the same effect is not obtained breathing 100% normobaric oxygen as the driving gradient is insufficient to trigger the process. Follow-up at 4 years suggests these changes are permanent.[8]

Additionally, induction of hyperoxia improves wound healing and immune function (microbial killing is enhanced by augmentation of the "oxidative burst" phase

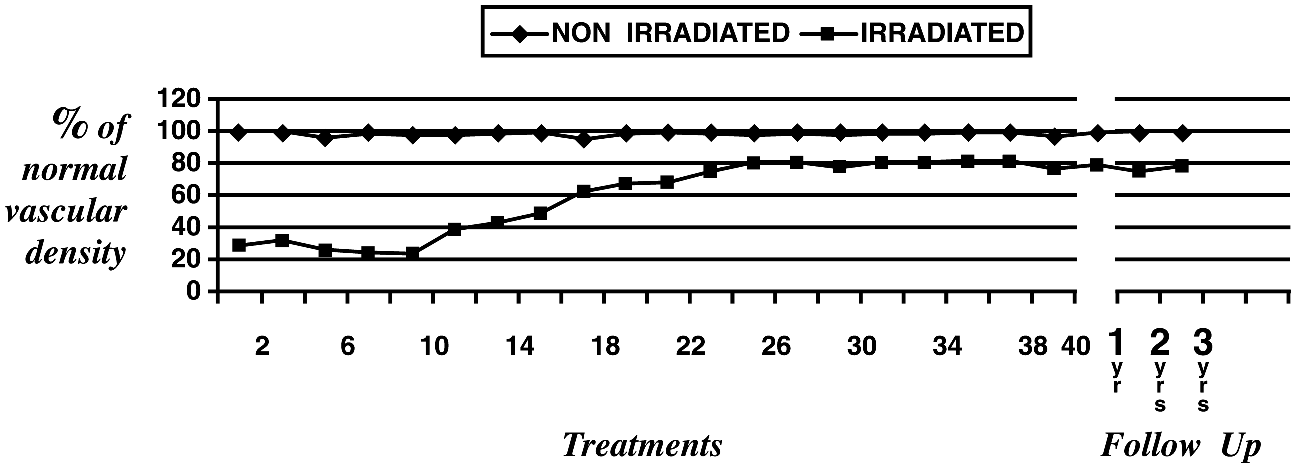

Figure 1. The effect of hyperbaric oxygen on radiation-damaged tissue.

TABLE 1

RESULTS OF OTHER STUDIES

Investigator	Patients	Pressure (ATA)	Duration (Minutes)	Times treated	Outcome	Notes
Norkool et al.[8]	14	2.4	90	28 (9-58)	8/14 complete resolution. 2/14 marked improvement. 3/14 little improvement.	Later shown to have malignancy recurrence
Weiss et al.[1]	13	2.0	120	60	12/13 durable cessation of haematuria	
Bevers et al.[7]	40	3.0	90	20	37/40 complete cessation or improvement.	Recurrence 0.12/year
Lee et al.[12]	20	2.5	100	44	16/20 haematuria resolved. 2/20 markedly decreased.	All female patients
Weiss et al.[6]	3	2	120	60	3/3 good response	
Schoenrock et al.[3]	1	2	105	19	All healed.	
TOTALS	**91**	**Av 2.6**	**Av 100**	**Av 33**	**81/91 At least "markedly improved"**	

of phagocytosis) in the setting of ischaemia.[1,3] Figure 1, adapted from Marx,[11] demonstrates the increase in vascularity over time in irradiated tissue exposed to hyperbaric oxygen. After an initial lag phase, the relative vascular density increases from approximately 30% to 80%, an effect that is sustained well beyond the period of treatment. Previous experience suggests that at least 20 treatments are necessary to achieve optimal benefit in both angiogenesis and immune function, following which there is a plateau in vascular density, which is maintained well beyond the duration of treatment.[11]

Results from this study confirm the findings of previous studies (Table 1) that the overwhelming number of patients respond well to hyperbaric treatment with a minimum of complications or side effects. Other treatment options at this time are of limited value and often are associated with significant morbidity. Additionally, many of the patients were considered refractory to conventional methods of treatment.

Patients receive hyperbaric treatment for radiation-induced haemorrhagic cystitis on the basis of symptoms. In this study, 96% of patients reported symptomatic improvement; a lesser number had complete resolution of their haematuria. This was associated with a marked reduction in transfusion requirement. In two of the three transfused this was for reasons other than haematuria, namely blood product requirement for the underlying malignancy (lymphoma and myelodysplastic syndrome).

In summary, hyperbaric oxygen is an efficacious, well-tolerated, non-invasive and durable treatment option for radiation-induced haemorrhagic cystitis.

Limitations

Limitations of this study include a lack of objective assessment of measuring haematuria, and limited follow-up, both clinical and cystoscopic. There is no uniform duration of treatment, so patients receive a variable "dose" of hyperbaric oxygen.

Assessment of the efficacy of hyperbaric treatment should additionally be made with objective measurements. There is a need to do follow-up cystoscopy on all patients following treatment, particularly those with recurrent haematuria, to exclude recurrent malignancy or infection. Objective measurement of the amount of haematuria before, during and after treatment is desirable. Although the changes induced by hyperbaric treatment are assumed to be permanent, there is a place for long-term follow-up of these patients.

Experimentally the number of treatments required to induce long-term benefits (in terms of vascular density) has been determined, but this has yet to be defined in the clinical setting (and the end-point, namely, symptomatic improvement or resolution of haematuria, is different from vascular density), since a number of patients relapsed despite apparently adequate treatment duration, not significantly different from those who responded.

The treatment pressure (and therefore PO_2) and duration have not been universally agreed upon. Nonetheless, results from both this study and that of Weiss[1] using 2 ATA treatment pressure have results as efficacious (see Table 1) as those treating at higher pressures.[7,8,12] Assessment of the effect of varying pressure is difficult due to the wide variation in the number of treatments. These factors all represent opportunities for further clinical research, and there is a need for a standardised, prospective, multi-centre trial.

Currently, hyperbaric treatment is generally used only after a prolonged period of cystitis, or after other modalities has been used. Further studies are warranted to investigate the value of hyperbaric oxygen used earlier in the management of radiation-induced haemorrhagic cystitis, possibly even in prophylaxis. If this is so, it becomes even more important to identify those who are likely to develop radiation-induced haemorrhagic cystitis.

References

1 Weiss, JP et al. Primary treatment of radiation-induced hemorrhagic cystitis with hyperbaric oxygen: 10-year experience. *J Urology* 1994; 151(6): 1514-1527

2 de Vries CR et al. Hemorrhagic cystitis: a review. *J Urology* 1990; 143; 1-7

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4 Benham K, Patil UB and Mariano E. Intravesical instillation of formalin for hemorrhagic cystitis secondary to radiation of gynecologic malignancies. *Gynecol Oncol* 1988; 16: 31-33

5 Kumar APM, Wrenn EL Jr, Jayalakshmamma B et al. Silver nitrate irrigation to control bladder hemorrhage in children receiving cancer therapy. *J Urology* 1976; 116; 85-86

6 Weiss JP et al. Treatment of radiation-induced cystitis with hyperbaric oxygen. *J Urology* 1985; 134; 352-354

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8 Norkool, DM et al. Hyperbaric oxygen therapy for radiation-induced haemorrhagic cystitis. *J Urology* 1993; 150 (2 Pt 1); 332-334

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11 Marx RE. Radiation injury to tissue. In *Hyperbaric Medicine Practice*. Kindwall EP. Ed. Flagstaff, Arizona: Best Publishing Company, 1994 : 447-503

12 Lee HC et al. Hyperbaric oxygen therapy in hemorrhagic radiation cystitis: a report of 20 cases. *Undersea Hyper Med* 1994; 21 (3): 321-327

At the time this paper was written Dr Andrew K Waring, MBBS, DRACOG, was a Senior Registrar working in the Hyperbaric Medicine Unit, Fremantle Hospital, and Dr Harry F Oxer, FANZCA, Dip DHM, was the Director of the Hyperbaric Medicine Unit, Fremantle Hospital.

Correspondence should be addressed to Dr Waring.

Dr A K Waring's address is Fremantle Hospital, PO Box 480, Fremantle, Western Australia 6160. Phone +61-(0)8- 9431-3750. Fax +61-(0)8-9431-3751. E-mail <Andrew.Waring@health.wa.gov.au>

THE WORLD AS IT IS

IMPROVING THE BUDDY SYSTEM

Sue Crowe

Key Words

Buddies, safety.

The ideal buddy system

Learner divers are told the "buddy system" is the best way to dive. But what exactly does having a buddy mean and is it the best system for all of us?

When I learnt to dive I was told that one should always dive with a buddy because:

your buddy checks your equipment and you theirs,
buddies keep an eye on each other,
your buddy is there when you need assistance and vice versa,
your buddy can save your life and you can do the same for them, and
having a buddy makes diving more fun.

In the PADI open water manual, the buddy system only rates one page and I quote,

"You should always dive with a buddy who stays nearby at all times. A buddy provides general assistance in putting on and checking your equipment before the dive; in helping remind you of your depth, time and air supply limits; and in giving you emergency assistance in the ***unlikely*** *event you need it. Your buddy will get the same assistance from you and both of you will feel more secure diving together than alone.*

"Diving is a social activity - diving with someone adds to the fun. Together you and your buddy will share experiences and witness the immense variety of scenes the underwater world displays. You may be surprised how many new friends you meet through diving and the buddy system.

"Keep in mind the three general reasons for diving with a buddy: 1) practicality, 2) safety and 3) fun. Remember you have a responsibility to your diving partner and that for the buddy system to work, you and your buddy must want it to work. Realise the need and value of the buddy system and decide now to always abide by it while diving."

Quite a responsibility. Most people do dive with a buddy. BUT during my diving years, the reality of the buddy system has been quite different.

The actual buddy system

For a start, if I am diving somewhere and I don't know anyone, I am usually buddied with a diver who I know nothing about. Once I was buddied with a diver, who, it turned out after I asked a few questions, did not even have a ticket!

Often, depending on which ticket I give the shop, I am buddied with a brand new diver and am expected to look after them and hold their hand. Most of the time this is fine but often I have to cut my dive short because my new buddy has run low on air or they are so nervous that I spend all my time watching them carefully and not enjoying the dive.

I have had buddies I have had to chase all over the dive site just to keep up and then they have the audacity to complain they didn't see anything! One of the things they definitely missed was me! The sad buddy stories are too many to mention.

I am not saying the buddy system is all bad. Just that it is not always that good and people have to be realistic about it. Do we expect too much of the buddy system? I think we do.

On the other hand I have had absolutely wonderful buddies who I would dive with over and over. The best buddies are without a doubt the people you dive most with, people who know you, who accept your limits as well as knowing their own. People who do not push you into a dive you do not want to do. People who are self reliant but prefer diving with you because they enjoy the company not because they are relying on you to bail them out if something goes wrong. Buddies who are there for you no matter what, buddies who are well trained, this is the buddy system at its best.

Self-sufficiency is really the only answer. If you can look after yourself but are aware of and care about your diving partner, you will probably be a great buddy.

To work, the buddy system has to be understood. There has to be a reasonable amount of communication before and during the dive. Buddies should stay together. I might start my dive with a buddy but unfortunately there is no guarantee that an unknown buddy will end the dive with me unless tied to me by a buddy line as Royal Australian Navy divers are. Too many divers (126 between 1972 and 1993) have died separated from their buddies, either before the incident (87) or during in the incident (39). They provided 71% of the 178 scuba divers who died in Australia during those 22 years.[1]

What is a good buddy?

Being a good buddy means different things to different people and this is where the problems lie. To be a great buddy takes dedication and practice, lots of it.

At the recent Melbourne Dive Show and OzTek2000, I did a small survey and asked passers by what their definition of a good buddy was. Here are some of the responses:

Someone who doesn't complain;
Someone with a big light/torch;
Someone capable of looking after themselves;
Someone who won't worry when they discover I'm not there;
Someone who will stick closely by my side;
Someone who will help me if things go wrong;
Someone who will occasionally but regularly look around;
Someone who breathes as much air as I do;
Someone who is not a marathon swimmer;
My best friend;
Someone who won't stick to my side like glue;
A good model who will do as they're told (!);
No one.

There was more but I think you get the idea. Divers should not take the buddy system for granted. Divers need to be aware buddies may not be able to help, may not notice when their air is low, may not look for you, chase after you, communicate with you, and consequently, divers need to be prepared for any eventuality.

Diving is wonderful but it is also all about taking responsibility for yourself and, if you choose, for others. "If you cannot look after yourself how can you look after someone else". It isn't only in diving this cliche holds true.

Now to give you my tips to help you be great buddy.

How to be a great buddy

DEFINE YOUR COMFORT ZONE

Although safety is a key element in recreational diving, it need not take the joy out of your sport. You need to provide a margin of safety and then dive within your own comfort zone, defined by depth, time, activity and water conditions. Finding a buddy with a similar comfort zone is the ideal solution. Understanding the comfort zone of the less experienced diver takes precedence. (For example; a strong swimmer should slow his or her pace for a weaker swimmer rather than the other way round.) Although defining a common comfort zone may sometimes lead to a restriction for the more experienced buddy, by working together dives can be created to suit both divers. It is far better to discuss and agree on the dive profile before diving than to discover the differences during a dive!

SELECTING COMPATIBLE ACTIVITIES

This does not mean you always have to do the same thing, but it does mean your pursuits are compatible. A diver into macro-photography with a buddy who loves high speed drift diving are not going to get along! (No pun intended!) However, sightseeing and videography can definitely go hand in hand.

Compatibility also applies to diving skills: one buddy might be terrific at compass navigation while the other is better at natural navigation or one buddy might be brilliant at spotting tiny marine life while the other keeps their eyes peeled for the bigger 'stuff'. As long as you can communicate effectively, you will both benefit from diving together.

COMMUNICATION AND CO-OPERATION

Buddy diving should be a “team event” not a leader/follower scenario. A good buddy team has each others interests at heart and does not engage in dangerous competitions about who can go deeper, faster, breathe less etc.

Communication is important above and below the water. A co-operative buddy pair can abort a dive at any time and know their buddy will understand.

REDUCING STRESS

Diving with a known and trusted buddy reduces stress. If you have a buddy who makes you feel uncomfortable or anxious, get another one. Ideally buddy teams should know each other well, know each other’s comfort levels, likes and dislikes and care about each other!

INCREASING AWARENESS

Increased awareness of your own limits, your environment, and especially your buddy is an important step to being a great buddy.

Underwater, increased awareness does not start off as a “sixth sense”; it usually develops over time with slight touches, listening to sounds and brief sideways glances. Learn to know where your buddy is at any given time. If you have agreed to stay on the left side, do so, don’t make it harder than it needs to be.

The goal of these techniques is to reduce the possibility of separation while sharing the dive experience in the best and most relaxed way possible.

RESPONSIBILITY

Buddy diving is based on the concept of individual responsibility. By agreeing to be a buddy, you take on moral (and legal) obligations; to stay together, to help each other, to provide assistance in an emergency and to follow generally accepted safe diving practices to the best of your ability.

PLAN TOGETHER

I know you have heard it all before (or I would hope so) but a basic dive plan is the starting point, even if it is simply a verbal discussion and understanding. For more complicated or advanced dives a written plan is a must. Whether written or verbal, dive plans should include:

a The reason for the dive, what do you wish to achieve (which may be simply to have a good time!);
b The general direction to be taken and route of the dive;
c Cut off points for depth, time, air or decompression; and
d What to do in an emergency i.e. separation, equipment failure etc.

CHECK AND DOUBLE CHECK

Checking and double-checking is the only effective way to learn about each other’s equipment, frame of mind and the environment. The more you dive with the same person, the quicker and easier this becomes. As well as pre-dive checks, share dive experiences, talk about the dive after the dive, this helps notice any difficulties.

It does not matter what form of communication you use, hand signals, gestures or slates. Agree beforehand which to use and how. If you cannot communicate you might as well go home before going in the water.

KEEPING TOGETHER

Staying close to each other is an important key to being a great buddy. Visibility will dictate how close it is safe to be. Stay aware of each other’s location in relation to your own.

Brightly coloured or distinctive dive gear can help too. If you can recognise your partner immediately, you are less likely to lose them or to feel confused if a big crowd of divers swims past. If visibility becomes poor, holding hands works well or use a line to prevent separation.

AIR CONSUMPTION

Monitor each other’s air consumption. Always agree on what is the air pressure at which you the end of the dive. And remember, it does not matter who reaches the agreed mark first! Always aim to end your dive when you are down to 50 bar or even earlier. This allows for any surface problems and again, reduces stress.

Reference

1 Walker DG. *Report on Australian Diving Deaths 1972-1993*. Melbourne: DAN SE Asia Pacific, 1998; 224

Sue Crowe is the Editor of Australian Scuba Diver. She is a diving instructor. Her address is Australian Scuba Diver, Yaffa Publishing Group PL, 17-21 Bellevue Street, Surry Hills, New South Wales 2017, Australia. Phone +61-(0)2-9281-2333. Fax +61-(0)2-9281-2750. E-mail <suecrowe@yaffa.com.au>.

This is a reworked version of the paper “Two’s a Perfect Number? Says Who?” which appeared in Australian Scuba Diver 2000; September-October: 46-47.

SPUMS NOTICES

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY
DIPLOMA OF
DIVING AND HYPERBARIC MEDICINE

Requirements for candidates

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

1 The candidate must be a financial member of the Society.
2 The candidate must supply evidence of satisfactory completion of examined courses in both Basic and Advanced Course in Diving and Hyperbaric Medicine at an approved institution.
3 The candidate must have completed the equivalent (as determined by the Education Officer) of at least six months full time training in an approved Hyperbaric Medicine Unit.
4 The candidate must submit a written research proposal in a standard format for approval by the Education Officer before commencing their research project.
5 The candidate must produce, to the satisfaction of the Education Officer, a written report on the approved research project, in the form of a scientific paper suitable for publication.

Additional information

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

All research reports must clearly test a hypothesis. Preference will be given to reports of original basic or clinical research. 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 NH&MRC/AVCC statement and guidelines on research practice" (available at http://www.health.gov.au/nhmrc/research/nhmrcavc.htm). All research involving humans or animals must be accompanied by documentary evidence of approval by an appropriate research ethics committee. It is expected that research project and the written report will be primarily the work of the candidate.

The Education Officer reserves the right to modify any of these requirements from time to time.

The Education Officer's address is Dr David Doolette, Department of Anaesthesia and Intensive Care, The University of Adelaide, Adelaide, South Australia 5005. Telephone(0)8-8303-6382. Fax (0)8-8303-3909. E-mail <David.Doolette@adelaide.edu.au>

Key Words
Qualifications.

REGISTRAR PLACES FOR THE DIPLOMA OF DIVING AND HYPERBARIC MEDICINE

New South Wales

Department of Diving and Hyperbaric Medicine
Prince of Wales Hospital
Dr Mike Bennett <M.Bennett@unsw.edu.au>
High Street, Randwick, New South Wales 2031
Phone +61-(0)2-9382-3881
Fax +61-(0)2-9382-3882
One 6 month full time (Anaesthetic Provisional Fellow)
One 3 month part (50%) time rotation of anaesthetic registrar.

Submarine and Underwater Medicine Unit
Royal Australian Navy
Captain Robert Green <Robert.Green2@defence.gov.au>
Officer in Charge
HMAS PENGUIN
Middle Head Road
Mosman, New South Wales 2088
Phone +61-(0)2-9960-0333
Fax +61-(0)2-9960-4435
Paid position only available for RAN MOs
No objection to someone getting self-funded work experience through this unit.

New Zealand

Slark Hyperbaric Unit
Royal New Zealand Navy
Dr Alison Drewry <navyhosp@ihug.co.nz>
Naval Base
Private Bag 32901, Auckland
Phone +64-(0)9-445-5972
Fax +64-(0)9-445-5973
One full-time Military Medical Officer.
Up to two self-funded positions for doctors (>3 years post graduation).

Queensland

Wesley Hospital Centre for Hyperbaric Medicine
Dr Simon Mitchell <smitchell@wesley.com.au>
Suite 53, Sandford Jackson Building
Auchenflower, Queensland 4066
Phone + 61-(0)7-3371-6033
Mobile + 61-0413-315-135
Fax + 61-(0)7-3371-1566
No funded training post.
No objection to someone getting self funded work experience through this unit.

South Australia

Hyperbaric Medicine Unit
Royal Adelaide Hospital
Dr David Wilkinson <dwilkins@mail.rah.sa.gov.au>
North Terrace
Adelaide, South Australia 5000
Phone +61-(0)8-8222-5116
Fax +61-(0)88232-4207
One 6 month anaesthetic rotation as part of a Provisional Fellowship year.

Tasmania

Hyperbaric Medicine Unit
Royal Hobart Hospital
Dr Margaret Walker <margaret.walker@dchs.tas.gov.au>
Hobart, TAS 7000
Phone +61-(0)3-6222-8193
Fax +61-(0)3-6222-8322
One anaesthetic registrar post, half time anaesthesia, half-time hyperbaric medicine.

Victoria

The Alfred Hyperbaric Service
Dr Ian Millar <I.Millar@alfred.org.au>
Alfred Hospital
Commercial Road
Prahran, Victoria 3181
Phone +61-(0)3-9276-2269
Fax +61-(0)3-9276 3052
One 6 month full-time registrar position available to those in anaesthesia, intensive care physician or emergency medicine training programs.

Western Australia

Department of Diving and Hyperbaric Medicine
Fremantle Hospital
Dr Robert Wong <Robert.Wong@health.wa.gov.au>
Fremantle Hospital
Fremantle Western Australia 6160
Phone +61-(0)8-9431-2233
Fax +61-(0)8-9431-2819
One full-time registrar, one part-time anaesthetic registrar (6 months part-time rotation) and one emergency medicine registrar (12 months part time).

Key Words
Qualifications.

MINUTES OF THE SPUMS EXECUTIVE COMMITTEE MEETING, CASTAWAY ISLAND, FIJI

held on 2000/5/9 and 2000/5/11

Present

Drs R Walker (President), G Williams (Immediate Past-President), C Meehan (Secretary), J Knight (Editor), S Mitchell (Committee Member), M Bennett (ANZHMG Representative), V Haller (Co-convener 2000 ASM). Dr H Staunstrup attended 11 May from 1350.

Apologies

Drs C Acott and D Walker (Committee Members), P Dupont (Treasurer).

1 Minutes of the previous meeting (2000/2/13)

Moved that the minutes be accepted as a true record. Proposed John Knight, seconded Guy Williams, carried.

2 Matters arising from the minutes

2.1 Job description of the Convener.
The final version will be circulated and should contain a statement on allocation of the FOCs.

2.2 Update on the SPUMS website.

Steve Goble is keeping abreast with the website and the day to day update of it. The DDL is now available on the website. Further modifications to the website will be discussed at the next meeting.

2.3 SPUMS dive medical on website.
This has been delayed by technical problems.

2.4 All risks insurance policy for SPUMS equipment.
All committee members holding SPUMS equipment need to ensure that their home contents insurance cover is adequate to include cover for the equipment in their possession. It is not possible to insure the equipment in any other way. The projector has not been insured with an all risk policy. It must be covered by the home contents insurance of the person who is responsible for storing the projector. Dr R Walker will look into this.

2.5 Education Officer/Board of Censors.
Dr D Griffiths resignation has been received and accepted. Proposed changes to the Board of Censors and the requirements of the Diploma have been circulated. There is a proposal for a constitutional change that needs to go to the AGM. It will be proposed that David Doolette be elected to full membership. He will be acting Education Officer until he can be can be formally co-opted. Drs Bennett and Mitchell will liaise with him. The ANZHMG position was discussed.

2.6 Job conditions of the Administrator.
The final version has been circulated.

2.7 Update on indexing the Journal.
The Editor will explore other indexing agencies. The name of the Journal will be changed from the SPUMS Journal to the South Pacific Underwater Medicine Society Journal.

2.8 GST update.
Nothing is to hand at present. In future the Administrator shall keep all the financial records of the Society.

2.9 SPUMS involvement with an UHMS meeting proposed in Sydney.
There should be a SPUMS committee member on the committee created to organise this. It was proposed that Dr S Mitchell fulfil this role.

2.10 Written statement from Allways with regard to ASM costing and timing of payments, to be obtained by Peter Dupont.

3 Annual Scientific Meetings

3.1 1999 ASM, Layang Layang.
Final figures for profit and loss are still to be provided.

3.2 2000 ASM, Castaway Island, Fiji. All going well.

3.3 2001 ASM, Madang, PNG. Dates set for 26 May to 2 June 2001

3.4 Future ASMs. Venues such as Maldives, Tahiti, and Red Sea were discussed. It was proposed that Dr R Walker be the convener for the ASM in 2002

4 Treasurer's Report

The Committee set the subscription fee at $110 for full membership and $55 for Associate membership. GST is 10%. The Administrator is to provide the Treasurer with monthly financial statements and to all committee members before each committee meeting. The Administrator shall keep the financial records of the Society.

5 Correspondence

5.1 Letter of complaint about a dive instructor and PADI's response were discussed.

5.2 Letter from a disgruntled patient was discussed.

6 Other Business

6.1 Review of the Honorarium for the Editor. This was increased, in line with the CPI, to $1330 per month

6.2 Review of the Administrators wages. This was increased to $16 per hour plus CPI.

6.3 Suggested changes to the constitution (Dr Robyn Walker)

That the heading Board of Censors on page 19 be changed to *Academic Board*.

That Rule 42 be changed by replacing the existing wording with *The Committee will appoint an Academic Board headed by the Education Officer*.

That Rule 42 (a) be changed by replacing the existing wording with *The make up of this Board will comprise individuals with proven clinical, scientific and research skills in the fields of diving and hyperbaric medicine. The minimum number of Board Members will be the Education Officer and two others.*

That Rules 42 (b) and 42 (c) be amended by removing the words *of Censors* from both rules.

6.4 Dr Des Gorman to speak to the motions for the election to full membership of Terry Cummins and David Doolette.

6.5 New PADI dive courses and the minimum age needs to be discussed

6.6 The next SPUMS committee meeting will be held on Sunday 10 September at the Mercure Hotel Brisbane after the HTNA meeting there

6.7 Update on the New Zealand chapter, and the committee position for the NZ chapter representative. Dr M Kluger will contact us about the situation.

RESIGNATION OF TREASURER

Dr Peter Dupont resigned from the position of Treasurer effective 10 September 2000. As President, and a past Treasurer of SPUMS, I have assumed these duties until such time as the Committee co-opts a new Treasurer.

The Committee, despite considerable effort, is aware that the financial reports for the years 1998 and 1999 have not been published in the Journal. A full audit of the accounts is being undertaken and these will be published in the Journal as soon as they are released by the auditor.

Robyn Walker
President

INTRODUCTORY COURSE IN DIVING AND HYPERBARIC MEDICINE

Department of Diving and Hyperbaric Medicine
Prince of Wales Hospital
Barker Street, Randwick NSW 2031

Monday 5th to Friday 16th of March 2001

Objectives of the course

To provide a broad introduction to the theory and practice of diving and hyperbaric medicine (DHM)
To provide the formal teaching component required for the SPUMS Diploma of DHM
To promote integrated teaching of DHM
To promote the evidence-based practice of DHM

Course content includes

History and chamber types
Physics and physiology of compression
Decompression illness
Assessment of fitness to dive
Other accepted indications for hyperbaric oxygen (HBO) therapy
Wound assessment including transcutaneous oximetry
Practical sessions including in chamber treatment

Cost **$A 1,500.00**

For further information contact

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Fax +61-2-9382-3882
E-mail <janikg@sesahs.nsw.gov.au>

SPUMS

ANNUAL SCIENTIFIC MEETING 2001

will be held from
May 26th to June 2nd 2001
in
Madang, Papua New Guinea

Guest speakers
Dr James Francis and Dr Craig Conoscenti

Convenor Dr Guy Williams

Theme
Diving and the Lung

Workshop
Drowning/Near Drowning

Members wishing to present papers should contact
Dr Guy Williams
PO Box 190 Red Hill South
Victoria 3937, Australia
Tel + 61-(0)3-5981-1555 Fax + 61-(0)3-5981-2213
E-mail <guyw@surf.net.au>

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LETTERS TO THE EDITOR

DECOMPRESSION ILLNESS SEQUELAE

7 Beach Rd, Milford
Auckland
New Zealand
September 2000

Dear Editor

I was most interested to read Dr Acott's paper in the June issue of the Journal, "Decompression Illness Sequelae in Tuna Farm Divers".[1] This study identified persisting problems in over one third of cases (9/21). Dr Acott kindly referred to papers from New Zealand describing similar post-treatment sequelae.[2,3]

I followed up the divers treated at HMNZS Philomel for decompression illness (DCI) during 1987 and identified that approximately one third had persisting physical problems and another third had less serious problems adversely affecting their domestic and work lives.[2,3] I was alerted to this latter group by the several requests for help from the spouses and work mates of patients whom we had classified as being cured. I attempted to describe the variable symptoms as "personality changes" and "mild depression" together with "soft neurology" and as Dr Acott describes, "fatigue" and "myalgia". The head injury team kindly assessed two of our cases and confirmed their neuro-psychological difficulties.[3] Overall it is my impression that, of the diving accident patients treated in New Zealand, one third are left with physical problems (some rather minor). Futhermore, the majority of this physically injured group, together with another third of patients, suffered a change in personality as identified by their family members. We all recognise other grumpy divers and difficult fellow SPUMS members!

Maybe there is a physical basis for their personality traits? At the Safe Diving Symposium in Cairns in 1994, Dr David Youngblood commenting on one of the patients we presented,[4] mentioned that the aerospace industry was also aware that, occasionally, aviators and astronauts "went off in subtle ways" and that "when recognised they were usually promoted to a non-active role".

If this small amount of data is representative of decompression illness causing a change in personality and other subtle changes, then it poses a major problem to the sports diving and related industries. I congratulate Dr Acott for proceeding with further investigations in this area.

Unfortunately very, very few divers with DCI have had a neuropschyatric examination before they have their diving accident so there is no base line for comparison with their post-treatment personality.

Adequate follow up of divers after treatment is difficult because of the drop out rate. I suggest that hyperbaric units should routinely include interviews with partners, spouses and work mates to find out whether the cases reported in the above papers are unusual or relatively common.

Allan Sutherland.

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Key Words

Decompression illness, letter, medical conditions and problems, treatment sequelae.

A CHRISTMAS PRESENT ?

8 Sloane Street
Hobart, Tasmania 7000
September 2000

Dear Editor

I wrote the piece below before I saw the review of *Stars Beneath the Sea* by Trevor Norton on pages 90-91 of the June Journal. I enjoyed reading the book, which I think will make an excellent Christmas present for divers and non-divers alike, so much that I compiled a rough index for my own use. My only complaint about the book is that it does not have an index. I want to make mine available to all members of SPUMS to help them find what is where in the book. I hope that you will publish my review and somehow make the index available.

Trevor Norton is Professor of Marine Biology at Liverpool University. This book is not about echinoderms however, though some of its protagonists appear to share the survival qualities of that hardy phylum. *Stars Beneath the Sea* is in fact a potted history of diving and hyperbaric research, seen through a series of personal profiles rather than an organised sequential history. Reading it, we may wonder at the hardihood of some of these pioneers from the "good old days" before colour coordinated accessories, when a diver had to invent and make most of his own gear, and "divers had the bends for breakfast".

It is a pleasure to find an academic who agrees with Dr Carl Edmonds that, with a little humour, a book full of facts may become a pleasure to read. The book introduces the early naturalists with milk churns on their heads, plodding along the sea floor in leaden sandals, while assistants worked above, sweating over foot-pumps. The story goes on to the skin divers who seized the idea of air supply to become thoughtless predators and looters of wrecks. It then traces their personal evolution towards photography, study and conservation.

The same evolution is seen in the policies of the great museums, who first utilised divers to destroy reefs, and to ship tonnes of coral back to the city to be dried, painted, and fitted with wax fish for exhibition.

Chapters are devoted to the heroic researches and self-experimenting of the Haldanes and of Horace Wright, subjecting themselves to ordeals bordering on the masochistic. There is a good coverage of the pioneers of underwater still and cine photography, including the filming of Jules Verne's *Twenty Thousand Leagues Under the Sea*, complete with large rubber octopus. There is also an interesting account of the development of marine archaeology in the Mediterranean.

Norton is himself a keen diver, and his enthusiasm comes through in the text. In contrast to the weighty volumes usually reviewed in these columns, *Stars Beneath the Sea* is a mere $Aust 20 paperback, but it is a recommended read, if only for its deluge of facts and anecdotes with which to bemuse one's companions on the dive boat or at dinner. Who could forget the late, balding, Charles Bebe, resembling "an alert egg" as he emerged from the water? Or the late Jack Kitching, so unconcerned by personal appearance or nutrition that "if he had been a chicken, you wouldn't have eaten him"? Of course much history had to be omitted, but at least we learn that probably the first Scuba Club was called *"The Bottom Scratchers"*.

To compensate for omissions, Norton has provided twelve pages of references for further reading and research.

Jim Marwood

Key Words

Diving operations, history, general interest, letter.

Editor's announcement

Dr Marwood's rough index for *Stars Beneath the Sea* is available by e-mailing the Editor at <spumsj@labyrinth.net.au>.

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BOOK REVIEWS

RECREATIONAL NITROX GAS BLENDING MANUAL

Bart Bjorkman
Best Publishing Company, P.O.Box 30100, Flagstaff, Arizona 86003-0100, U.S.A.
Price from the publishers $US 9.95. Postage and packing extra. Credit card orders may be placed by phone on +1-520-527-1055 or faxed to +1-520-526-0370. E-mail <divebooks@bestpub.com>.

This is another specialised diving text from the Best Publishing Company. It is a short book of 60 pages, some of which are tables and quizzes. Its target audience seems to be dive shop owners who are trying to decide how to set up for nitrox diving. The how and why of oxygen cleaning of systems are explained and various methods of mixing nitrox are outlined. Trimix is not considered in this book.

There is no indication of the experience of the author in this book, so I am not sure if it is a good effort by a writer with little experience in the area, or a less good effort from an expert. He uses the expression “we” when talking about gas mixing, so I presume he is involved with gas supply for nitrox diving. The various ways of mixing gases are outlined but the explanations could be improved. In some areas I was not able to relate his illustrations to the text. I would also dispute his suggestion that mixing gases by weight is not suitable for most applications. Good quality digital scales now allow mixing with good precision and reasonable costs.

The book is a good primer on the subject but it has a few minor errors. For example, he suggests that we should use US Pharmacopoeia grade oxygen instead of Aviator grade because aviator grade is drier and dry oxygen is hard on the mucous membranes. He is correct if the moisture is at the maximum specified but most makers take it from the same supply and Pharmacopoeia oxygen will be drier than the maximum moisture specified. Even then, the difference between the two standards is so slight that a sensitive analyser would be needed to detect the difference between a sample that passed one but not the other. To mucous membranes both seem dry.

The book follows the rule that is attributed to the National Oceanic and Atmospheric Administration (NOAA) on oxygen and fire risks. This is that an enriched oxygen mixture with less than 40% oxygen can be treated as air. The risk is proportional to oxygen pressure, so this rule may turn out to be a dangerous simplification.

A dive shop owner who is thinking of installing a nitrox system might buy this book and find it useful. Most SPUMS members, even those who use nitrox regularly, would probably not get much benefit from it unless they are involved in gas mixing.

John Pennefather

Key Words
Book review, mixed gases, oxygen.

THE PRACTICE OF OXYGEN MEASUREMENT

J S Lamb
Best Publishing Company, P.O.Box 30100, Flagstaff, Arizona 86003-0100, U.S.A.
Price from the publishers $US 19.95. Postage and packing extra. Credit card orders may be placed by phone on +1-520-527-1055 or faxed to +1-520-526-0370. E-mail <divebooks@bestpub.com>.

This book is written to help divers to measure the oxygen content of their diving gases. Given this aim, the book is likely to be of interest only to those SPUMS members who are deeply involved in technical diving. It is by a man who has worked in medical electronics and then moved to a sales career in medical equipment. Oxygen monitoring has been a major interest for him. As a diver, the evolution of technical diving gave him another area for applying his expertise.

Most of the text is on using galvanic fuel cell analysers for measuring the oxygen content of diving gases. The book meets its aim, so it could be regarded as a success.

In some areas I found the book unsatisfactory as it contains errors that could have been eliminated if the author had got a critical reviewer to go through the draft text. An example is on the effect of humidity on the oxygen reading; in several places the book says you can calibrate an analyser to read 20.9% oxygen in ambient air. But he also says that, for air at 25°C and 100% humidity, it should be calibrated to 20.25% because of the contribution water vapour makes to the mixture. In fact, **any** water vapour causes an error in calibrating this type of analyser unless it is allowed for, or the gas is dried; the magnitude increases with temperature and humidity. Tables to correct for humidity are available and one could have been presented here.

A minor but annoying point is that most people who did high school science regard standard temperature and pressure (STP) as 1 ATA and 0°C. In this text we are told that it is 1 ATA and 25°C, this may be an engineering STP, but I have not found it in any of my texts. Another problem is that some of the figures are wrongly, or not clearly, labelled, so one has to guess what they are meant to show us.

I would buy this book now if I needed more background on galvanic cell oxygen analysers than provided in the supplier's handbooks. Otherwise I would save my money, or hope for a second edition with an improved text.

John Pennefather

Key Words

Book review, mixed gases, oxygen.

THE TERRIBLE HOURS

Peter Maas
1999
Harper Collins, 25 Ryde Rd, Pymble NSW 2073
Price $24.95 from Dymocks

In 1925 the US submarine *S-51* was struck by the passenger liner *City of Rome* and sank in 131 feet (40 m) of water near New York. There were ships on the scene soon after, but all were helpless and unable to assist the trapped crew. The skipper of a sister submarine, the *S-1*, found the bubbles and oil slick and months later witnessed the contorted faces and flesh-shredded fingers of those who had not drowned immediately. This captain's name was Charles "Swede" Momsen.

Two years later a similar accident occurred to the *S-4* when she was hit by a Coast Guard cutter chasing prohibition runners. This submarine sank in 110 feet (33 m) with all 40 crew members alive. For 3 days the entombed crew tapped out their messages on the steel hull to the helpless ships overhead. Gradually the taps became feebler and then ceased altogether. Momsen had to reply to all the letters of protest from a concerned and angry public. Still the US Navy had no apparatus or techniques available to rescue these victims.

As a result of these experiences, Momsen designed a rescue bell, to be lowered from a ship, that would fit over a hatch on the sunken vessel and allow the crew to be evacuated to the surface in safety. These plans and specifications were submitted to the Navy's Bureau of Construction and Repair but, like so many brilliant ideas, were dismissed as being "impractical from the standpoint of seamanship".

On his transfer to the Navy Experimental Diving Unit (EDU) Momsen initially took a sidestep and designed, developed and tested a personal escape apparatus that became known as the Momsen Lung. This apparatus he tested personally from depths of up to 207 feet (62 m) from a submerged submarine. As a result of his experiments and development, every US submarine was equipped with this apparatus for its crew.

Momsen did not let this interfere with his interest in the rescue bell and eventually he was able to have one built and this was tested to depths of 300 feet (90 m).

US Submarine *Squalus* was launched in 1939. She was 310 feet (93 m) long, 27 feet (9 m) wide, weighed 1,450 tons and had a crew of 57. On May 23, 1939 on her 19th trial dive, during which she was to practice an emergency battle descent, the 31 inch (0.9 m) diameter air induction valve for the diesel motors opened underwater, rapidly flooding the after section of the ship. *Squalus* sank in 243 feet (73 m) of water about 15 miles (24 km) south-east of Portsmouth, New Hampshire. There were 33 survivors in the unflooded compartments.

A full-scale rescue effort was initiated within hours of her failing to surface. This included the sister submarine *Sculpin*, which located the *Squalus*, and the submarine rescue vessel *Falcon.* For the rescue chamber to function a guideline had to be attached to the escape hatch by a diver. At that depth the problems of nitrogen narcosis made every action very difficult and prone to error and it is a great credit to the diving crew, led by Momsen, that all the diving was completed without significant morbidity.

It was a stroke of genius that two brilliant doctors, Behnke and Yarborough, accompanied Momsen from the EDU. These three were currently experimenting with the use of helium-oxygen mixtures for deep diving to overcome the problems of nitrogen narcosis and had planned to use the summer months for further testing. This occurred, but not in the manner envisaged. Although this breathing mixture was not used for the crew rescue, it was used extensively during the recovery phase of the submarine and enabled the vessel to be completely recovered. This introduced a number of other problems such as hypothermia and CO_2 retention that the trio had to solve before the operation could be completed. Both Behnke and Yarborough went on to make significant contributions to the fund of knowledge about decompression tables for deep diving and the use of mixed gases.

After her recovery *Squalus* was refitted, renamed the *Sailfish,* and went on to serve with distinction in the Pacific theatre of war.

Momsen too continued with the Navy during and after the war. He identified and corrected a malfunction in the detonator cap of Mark 6 torpedoes and introduced the submarine wolf pack strategy to the Pacific. During the 1950s he was instrumental in the design and development of the experimental *Albacore*, which was the forerunner of the first nuclear powered submarine *Nautilus. Albacore,* although conventionally powered, was able to travel at up to 30 knots for short periods, do tight turns and change depth rapidly, more like an aircraft. This design became the base from which all US submarines subsequently were developed. Vice-Admiral Momsen left the US Navy in 1955 and died from cancer in 1967.

Peter Maas has a long history of investigative writing and this is an excellent example of the genre. He is the author of numerous books such as Serpico, The Valachi Papers, The Rescuer, Manhunt and Underboss. He served in the US Navy during the Korean conflict and with this experience is able to explain naval jargon is simple terms. His explanation of decompression sickness may be a trifle simplistic but is easy to follow and quite in context. *The Terrible Hours* is a book that holds the reader's interest from the first to the last word. It relates the story of the momentous 39 hours that made submarine history and records the enormous contribution that Swede Momsen made to the welfare and survival of submarine crews everywhere. At only 260 pages it makes an easy and fascinating afternoon's read. Strongly recommended.

David Davies

Key Words

Book review, diving operations, history, general interest, rescue, submarine.

HISTORY OF HYPERBARIC CHAMBERS

Gerhard F K Haux and Tom Workman
ISBN 0-941332-82-9. Published 2000. 154 pp.
Best Publishing Company, P.O.Box 30100, Flagstaff, Arizona 86003-0100, U.S.A.
Price from the publishers $US 14.95. Postage and packing extra.
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Nothing is new, indeed a diving researcher once said to me "Nothing is new since Boyle", indeed this may be true. Looking back into history is one way of avoiding the mistakes of those who have gone before. Sound advice, but until now, where to look for the history of hyperbaric chambers has been a task in itself. Most hyperbaric and even some diving textbooks have some information on the early history of chambers, some do this very well, such as Eric Kindwall. But all these have only used the "History" as a lead in to their text. Haux, has been much more thorough. He has been in this chamber business a long time, he is a collector of knowledge and photographs. This book is a tribute to his knowledge, contacts and the many photos that he and his partner Petra have gathered in their travels. It covers diving and clinical systems.

The first thing that strikes one about this book is the plethora of photographs, some of which date from the late 1800s. The text starts correctly in 1662, with Henshaw, stops briefly with Priestly, 1774, and heads off to really get to grips with the earliest days of hyperbaric chambers in around 1830s and onward.

The time line that the book follows clearly shows how design styles changes. Design, before there were graduate engineers, was intuitive and functional, this is seen in the comfortable, room-like chambers of the late 1800s early 1900s. The Dianabad, Germany, chambers were prime early examples of this. But it is not for me to say if Dr Orval J Cunningham went too far in this direction, with the 6 floor high, 72 room, spherical "hyperbaric hotel" of 1928. The sphere and cylinders that came with technology restricted hyperbaric chamber design with the efficient shape approach. It is only in the comparatively recent times that a few engineers braved the effective round shapes of the past and looked again to function. Engineers like Haux, and Fink in Australia, have moved HBO_2T along with providing the industry a great new tools to work with, that the clients like. These new shapes of course only really apply to clinical HBO_2T, diving chambers are not so forgiving, and in the main remain conventional in shape.

Tom Workman provides a chapter on the future of hyperbaric chamber design and what direction that the industry may take. This is a good closing section, recording where we have been and where we now are. The book is not all history, information right up until 1999 is included.

The book comes to a logical concluding chapter by Haux, a collection of pairs of photographs, old and newer shots of like equipment, in many cases often separated by "only" 100 years.

Most countries that have hyperbaric chambers (possibly all) are recognised in the text and by photos, however German chambers predominate. Gerhard's career has had a profound impact on chamber design over the last 40 years, so I suggest that this small indulgence is quite acceptable. The fact that the book was originally written in German, has resulted in, at times, a rather tortured version of English (a point that, as only a speaker of English, I am rather reluctant to make). But these criticisms are quite minor when the real value of the book is considered.

I enjoyed the book and highly recommend it, both as an interesting one to read, but also because it can stay near the desk as a reference. As the millennium passes, it is timely to record HBO_2 of the past. Gerhard, Petra and Tom have done an excellent job for future generations and for us.

Bob Ramsay

Key Words

History, hyperbaric facilities.

SPUMS ANNUAL SCIENTIFIC MEETING 1999

FIELD IDENTIFICATION OF DECOMPRESSION SICKNESS

David Doolette

Key Words

Clinical diagnosis, decompression illness, investigations, occupational diving.

Background

The diagnosis of decompression illness, distinguishing divers who have the disease from those who do not, is important for treatment decisions. A similar binary classification of decompression sickness (DCS) has been used in the validation of decompression schedules. Decompression schedules are tested under medical supervision and the outcome for each diver is classified as DCS or no-DCS. Each decompression schedule is accepted as "safe" after a pre-determined number of DCS free dives.

There are several problems with this approach to validation of decompression schedules. Firstly, between fulminant DCS and absence of symptoms there is a spectrum of diving outcomes that may escape appropriate binary classification. The diagnosis for DCS is not straightforward as there is no definitive diagnostic test so diagnosis is based on history, signs and symptoms.[1] Unfortunately the signs and symptoms of DCS are similar to those of many other disorders.[2] Exemplifying these difficulties, diving medical specialists in three hyperbaric medicine units in Australia were asked to indicate diagnosis for decompression illness (yes, no, uncertain) for divers, following the first hyperbaric treatment where this occurred. The diagnosis of uncertain decompression illness was given for 15 of 100 divers. Secondly, it is typical to accept each decompression schedule after 20 DCS free dives, according to binomial theory this results in 95% confidence intervals for the true incidence of DCS for the schedule of 0-17%. 366 DCS free dives for each schedule would be required to establish an incidence of less than 1% with 95% confidence.

One method to reduce the requirement for test dive numbers is the development of statistically based decompression schedules that utilise non-linear regression procedures to fit models to observations of depth/time diving profiles and DCS outcome data.[3] Test dive depth/time profiles do not need to be identical because it is the underlying model and not specific schedules that is validated. Therefore, test dives need not be part of a purpose designed testing program. Although these techniques have been applied to data collected during carefully monitored test diving programs, the widespread use of depth/time recorders by occupational and recreational divers might allow the collection of objective depth/time profile data in the field. Although the data will not be of the quality collected from controlled trials, such depth/time profile data could provide a useful source of data for decompression model calibration if diving health outcome could be reliably measured in the field.

Health outcome measurement for statistical decompression tables

CONTROLLED TRIAL DATA COLLECTION

Statistically based decompression models have so far been selected retrospectively by best fit to military diving exposure.[4,5] In these databases outcome is coded as DCS or no-DCS, and can be assigned values of 1 and 0 respectively. Therefore, modelling techniques were developed appropriate to this binary outcome. For each depth/time profile, the model predicts the probability (a value between 0 and 1) of DCS. This approach has the same requirements as traditional validation techniques of a definitive diagnosis for DCS. Also, the degrees of freedom of binary modelling procedures are constrained by the number of the least frequent outcome,[6] in this case DCS. Since DCS is rare, many dives have to be monitored to collect sufficient numbers of incidents of DCS to allow fitting of complex decompression models. It has been recognised that the dives that produce "marginal" symptoms of DCS, but were not definitively categorised, contain valuable information. Subsequently, marginal DCS symptoms have been included within binary modelling techniques, typically ranked at a value of 0.1, resulting in a quasi-multinomial approach.[4] Statistically based decompression models have also been fitted to ultrasonic Doppler venous bubble scores,[7] which alleviates the need for definitive diagnosis of DCS. Bubble scores have been assigned to three ranks and modelled using similar techniques.

FIELD DATA COLLECTION

The capability of the modern generation of diver-carried decompression computers to record and then unload depth/time profiles to deskbound computer has provided a potential source of decompression data from the field. Such data must be carefully audited for accuracy and matched to a valid and reliable evaluation of diving health outcome. For field data collection there are two choices for measuring diving health outcome, evaluation of divers by field data collectors or diver self-assessment. In either case, reliable identification of DCS by those without specialist medical training is unlikely. Therefore, field data collection requires a measure of diving outcome without need to identify DCS.

FIELD DATA COLLECTORS

Trained field data collectors can collect diving health outcome data that can be later evaluated by those with the necessary specialist skills. Diver's Alert Network (DAN) is using this approach to collect recreational decompression data in Project Dive Exploration.[8] In DAN Europe's Project Safe Dive/Dive Exploration,[9] some field data collectors make ultrasonic Doppler recordings of venous bubbles from some divers. However, the bulk of health outcome data collected in Project Dive Exploration is from interview of the participating divers by trained volunteer field data collectors. Adverse health outcome is documented on an incident report form that comprises a checklist of 18 symptoms including time of onset, location, evolution, and a free description of how the symptom arose.

SELF ASSESSMENT

Divers may be reluctant to report symptoms of DCS for a variety of reasons.[10] Self-assessment allows for data to be de-identified; circumventing some economic and peer pressures against reporting. Clearly, even in the case of de-identified data, divers are unlikely to be able or willing to self-diagnose DCS. An alternative is for divers to list any unusual symptoms, whether related to DCS or not. The problem associated with such free response is that it is variable process: a possibly vague confused idea or symptom must be brought to awareness, a decision made to communicate this symptom, and then the symptom must be put into words. Additionally, at the stage of coding free responses, the coder must decide how to score these responses.

Using standardised questions and standardised responses can circumvent these problems associated with free responses. Routine self-assessment following every dive can also eliminate the need to evaluate significance of symptoms in the decision to report. Health status can be reliably measured in the field by standardised, self-administered, multi-item inventories.[11]

Diver Health Survey

A short-form, multi-item inventory of standardised questions and responses (diver health survey) was developed to measure health status following decompression.[12] The format of the nine explicit questions and responses are similar to the Medical Outcomes Study Short Forms.[11,13] Nine explicit items cover five general concepts indicative of health status[11] (physical functioning, role limitation, general health perception, bodily pain, and vitality), six common symptoms of DCI[2] (pain, paraesthesia, weakness, vitality, rash, and balance/ dizziness), and time of onset of symptoms relative to diving activity. There is space for unsolicited health comments and an unscored record-keeping item. A response to each of the nine explicit items is chosen from four check boxes with semantic anchors representing ranks of 0 through 3. Additional symptoms listed at item 11 are scored 1 each to a maximum of 3. The item scores are summed to give the final score.

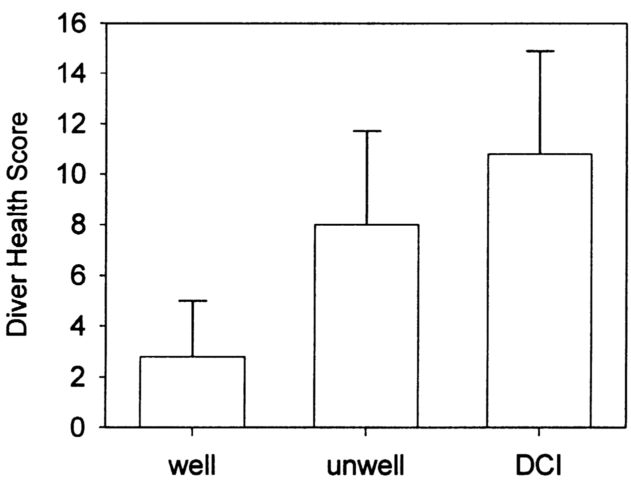

Figure 1. Mean diver health survey scores for nine well and 12 unwell divers diagnosed as without DCI and 48 divers diagnosed as having DCI. All groups have significantly different scores (ANOVA and *a priori* contrast, $P<0.05$). Error bars are plus 1 standard deviation.

Psychometric testing of this diver health survey show that it is a valid measure of decompression related health outcome and is sufficiently reliable for collection of grouped data for decompression model calibration.[12] Figure 1 shows the diver health survey scores from well divers diagnosed without DCS, divers with health complaints diagnosed as not DCS, and divers diagnosed with DCS.

The diver health survey has been used for collection of decompression data and decompression model calibration for occupational tuna farm divers,[14] and data collection is in progress for recompression chamber inside attendants. In these programs, no attempt is made to categorise dives as resulting in DCS or not, decompression health outcome is the untransformed diver health survey score. Such summative scales are approximately linearly related (interval data) to the attribute being measured;[15] in the case of the diver health survey this is decompression health outcome. An interval health score has advantages over a binary classification for describing diving outcome.

For decompression model calibration, normally distributed residuals about interval data allow use of a variety of non-linear estimation procedures. Furthermore, assigning a score to every outcome rather than relatively few incidents of DCI increases model degrees of freedom, relaxing restriction on the number of model parameters or allows fitting of models to smaller data sets.

Summary

Field data collection of diving depth/time profiles and health outcome data may prove a valuable source of data for decompression model calibration. Definitive diagnosis for DCS is not always straightforward and is not feasible for field data collection. Health outcome for field decompression data can be collected as symptoms by either field data collectors or by self-assessment. A diver health survey has been developed that allows valid, reliable self-assessment of decompression outcome for decompression data collection.

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SPUMS ANNUAL SCIENTIFIC MEETING 2000

WHY FITNESS? WHO BENEFITS FROM DIVER MEDICAL EXAMINATIONS?

David Elliott

Key Words

Diving medicals, fitness to dive, medical conditions and problems, recreational diving, standards.

Is the assessment of recreational diver fitness important?

Polo, show-jumping, fox-hunting and indeed most forms of horse riding are perceived as being at the pinnacle of social acceptability. Yet, among all recreational activities, riding on the back of a horse is one of the most hazardous pleasures. A rapid descent may be accomplished safely but sometimes will result in quadriplegia or death. All sport and recreational activities carry some risk of injury, but at the amateur level, how many sports other than diving require medical screening for fitness to participate? We need to review what we are doing and why.

This need to exclude those with a medical, mental or physical factor that has a potential role in an accident is, in part, because diving is a group activity. Few would dispute that the primary objective of the medical examination of a diver is to minimise his or her personal hazards underwater. Also important is that, like when piloting a plane but unlike when riding a horse, good medical screening beforehand should reduce the risk of later loss of life or serious injury to others.

Fitness to dive therefore benefits

- the diver,
- his or her buddy and
- other divers who may become involved in a rescue.

A logical extension of individual freedom might say therefore that the solo diver has no buddies and so a solo diver (who has already accepted the risk of facing a life-threatening incident without a buddy present to try and save him) should not be required to demonstrate medical fitness. Would that be accepted as a consensus agreement?

For most divers that is academic because most of us dive with a buddy. However on several occasions when a diving fatality has occurred the buddy has been scrutinised, to say the least, by the deceased's lawyers even after the most heroic, if not foolhardy, attempts of rescue. So, confirmed fitness of the other member of a buddy pair seems a reasonable personal objective.

For dive shops, boats and guides who cater for recreational divers, the benefits of screening are slightly different. The exclusion of a few high-risk customers would reduce their exposure to risk of bad publicity and adverse litigation. This is perfectly legitimate but some opinions would suggest that this approach is a restriction upon the freedom of the individual. Some would regard as unreasonable the exclusion, by a dive shop, of a quiescent and stable asthmatic who possesses no significant trigger factors and who has unimpaired pulmonary function after hard exercise. Having to remain on the beach could be attributed by them to the terms of the dive shop's insurance policy and the screening procedures that this imposes. Are there any data to prove the insurers wrong? Maybe, were the data known, the answer would be found among those who are unfit but less honest in completing the self-declaration form and yet dive without problems.

A sort of answer should be available from looking at underwater accidents. In this context we need not look at the decompression illnesses too closely because there is no known condition, except perhaps ethanol excess, that would predispose to decompression sickness (to use the terminology of pathology intentionally). Also, most of them occur after surfacing and thereby do not affect the safety of a buddy. Only when one considers the possibility of gas embolism, which may cause the victim to lose consciousness near the surface and sink back down again, might other divers be exposed to the hazards of making an emergency recovery. So, if only for the sake of the diver's own health, the presence of factors affecting the likelihood of pulmonary barotrauma does need to be considered in such a screening. Most underwater fatalities have died of drowning and it is not easy to find out what was the trigger for the sequence leading to that terminal event and to what extent medical unfitness may have played a part.

I have been asked to look at asthma and diabetes in particular and, although I am not a clinical specialist in either field, I will therefore focus on these two while reserving the inclination to wander into other medical disqualifying conditions from time to time.

Any data?

Data is not easy to acquire. Commercial diving and military diving in the UK provides useful information on many topics and they are required to provide reports on all diving incidents. In spite of this, and perhaps because their divers have to pass an annual medical assessment, there are only a few isolated examples of illness as a contributory factor in diving incidents and, in working divers, no consistent evidence that could benefit recreational divers.

Recreational diving cannot provide better information. For example, a problem with the BSAC annual reports of diving incidents is that this is necessarily a voluntary system largely dependent upon receiving incident reports. Nevertheless, among the fatalities, the trend is clear. Of fifteen cases in 1998 in whom it was possible to make an assessment of causal factors, there were twelve in whom there were failures of safe diving practice and three who had heart attacks underwater. The indications are that each of them was unaware of their potential problem and that a cardiac death could equally well have happened at the surface.[1]

The annual data collected for around the same period by DAN is also necessarily limited by the voluntary nature of its reporting procedures but is more extensive.[2] A finding of 8 cardiac deaths among 82 fatalities is almost the same proportion as those found in the UK. Also, various conditions, predominantly cardiac, were listed as pre-existent in 25 other fatalities but their contribution to a death remains uncertain. Only one of these 82 was listed as having bronchial asthma. The word “diabetes” did not appear. Alas, other than reminding us of the potential for myocardial infarction in the exercising elderly male, this can tell us nothing useful.

Undoubtedly, the best source for detailed accident data is that compiled by Walker, a collection of 301 diving deaths over a 22-year span.[3] The report includes an analysis of these fatalities by Knight, Pescod & Lippmann that is both informative and depressing. Everyone who wishes to be a diving instructor should read it. Carl Edmonds reminds us in the Foreword, “*he who does not know history, is doomed to repeat it*”. The lessons to be learned are consistent and predictable: the major cause of diving deaths is diving beyond one’s competence and in disregard of the accepted safe practices. The recurring phrase is “gross inexperience”.

Very few specific medical conditions as a significant factor in the diving fatalities were found over this period.[3] But that may simply indicate the success of medical screening because the majority of persons with such conditions have been excluded from diving as a recreational activity for them. How does that compare with the 828 fatalities reported by DAN over 9 years in an area where such screening is less formal?[4] Age, gender, certification, out-of-air and equipment problems are graphed but on fitness, other than a mention that cardiovascular factors were found in an average of about 10% each year, no details are given. However in the 83 fatalities of 1998, the subject year being reported in more detail, 19 divers out of 46 for whom data were available shared 20 medical problems.[4] There is, of course, no data offered on the extent to which these were relevant to the cause of death. Cardiovascular problems were found in more than 10% of this small group, diabetes in 6% and asthma, allergies, nervous disorders, etc. were equal at about 2% each among the also-rans.

Eighteen diving fatalities (perhaps not the same divers for the report does not say) were reported as using medications, but when one looks at this, one wonders about the relevance of the use of birth control drugs to underwater deaths. Some 4% of those about to die were using motion sickness drugs, so does that mean that those drugs are associated with risk, or is there a greater risk associated with not taking them? Perhaps it means that most fatal dives are done in calm water. Who knows? Among the rest, 25% were classified as cardiovascular medications; decongestants 14%; anti-histamines 12%; insulin 11%; asthma 7%; et cetera. It is not easy to interpret that predigested information and not possible to compare it statistically with the Project Stickybeak data.[3]

In a separate bar chart, the DAN report suggests about 8% of the deaths were cardiac, but no details are given.[4] The comparable figure in Project Stickybeak is 14 cardiovascular related deaths in 178 scuba divers, also 8%. Interesting perhaps, but this only leads back to the need for more data. However, as stated by the editors,[4] “*seldom was there any adverse medical record available, which is natural … lest he be advised not to dive*.” Also, “*it is not known how many divers have a history of diabetes, epilepsy, coronary heart disease, asthma or other contraindications to diving but who are never identified because they suffer no critical misadventure*.” Although asthma was identified as a possible factor in 9 of the Australian scuba fatalities (5%), it was considered to be significant in only two (1%).

Is what is presented in these reports sufficient evidence that some types of diving accident are indeed more common in association with particular medical conditions?

It could be said by some that the desire for medical screening of the candidate diver is no more than paternalistic caution, but does the knowledge that medical screening is required before scuba diver training discourage potential fatalities from pursuing this activity? Indeed, among those not so discouraged, what are the rejection rates of those attending for a SPUMS medical examination? That figure (potential lives saved would be putting it too strongly perhaps, but that is what it is about) could be a justification for all the screening.

An interpretation of all these reports is that a number of deaths were:

due to previously known medical conditions such as asthma;

due to unforeseen medical events (such as haemorrhage from an acute gastric ulcer, ruptured aortic aneurysm, but cardiac events predominantly) which might, or might not, have been detected by prior medical screening depending on how meticulous that would have been;

associated with medical factors that may have influenced the course of events or which may have been totally irrelevant;

associated with medical factors not detected at autopsy and concealed before the dive.

It would be wrong to conclude from the reviewed data that because medical factors played only a minor role in these fatalities, there is no need for screening. The culture and practice of diving is such that those who have had conditions regarded as disqualifying have been excluded from the population at risk. To justify screening, one needs to know how many candidates for training are turned away as unfit? Each one of them could have been a fatality avoided.

Non-medical factors predominated in these hundreds of deaths and it seems that only a few were perhaps unavoidable but, alas, "*there is no screening test for stupidity*".[5]

If needed, what sort of fitness?

Excluded from the dive boat solely by their honesty in having admitted a past history of "asthma", an emotive word, some persons may in fact be fit to dive but are not allowed to do so. For the purposes of our discussion, such an individual is not a "perfect specimen" and so needs to be considered as a variety of disabled diver. Together with others eliminated by basic screening, they form a category of disability that will be discussed tomorrow

What is fitness? Is it merely the absence of detectable illness? No. For safe diving, it is more than that.

One definition of health, and certainly the state to have attained before being confronted by a life-threatening emergency, is that "*Health is that state of moral, mental and physical well-being which enables a man to face any crisis in life with the utmost facility and grace*" (attributed to Pericles, 430 BC).

No-one would deny that for diving one needs to have full mental, medical and physical fitness. However that is largely the responsibility of the individual diver and, except for some forms of commercial deep diving and military diving, no assessment of fitness to dive goes quite that far.

So what is needed? The late Jefferson Davis emphasised the need for medical standards and reminded us that, in contrast to professional diving, there are many things favourable to recreational diving, particularly that the sport diver can choose the time, place and water conditions of the dive.[6] On a given day, with a temporary illness that makes diving more hazardous, a sport diver can abort the dive without any repercussions. The sport diver can simply avoid cold water, rough seas or low visibility diving if not adequately experienced, or just not feeling up to it.

If one needs fitness screening, how should it be done?

There is a need to confirm the absence of any detectable illness that may have an adverse effect on the safety of a diver and, first, we must review the procedure for assessment.

In many systems the assessment comes in two phases: a self-declaration form and an examination by a doctor. One extreme example is found with the working diver who may be asked to complete a detailed form covering past medical history and diving accidents. This is then reviewed by the Medical Examiner of Divers and signed by the diver. This has an additional purpose, not appropriate in recreational diving, of documenting episodes of decompression illness (or possibly their concealment). The annual examination may be lengthy but is straightforward and is conducted by a doctor who has been approved as being knowledgeable about diving. With ageing and after illness or injury, pass/fail criteria are not appropriate and a careful assessment of the individual and his or her diving hazards is required by a doctor who knows the environment and its demands.

The other extreme takes the form of no medical screening at all among those who may be self-taught and who have access to all the necessary equipment including a compressor. In many countries there is no law against this, even for the working diver.

For the recreational diver the system is usually voluntary, but relevant regulations do exist in a number of countries such as France, Norway, Portugal and Israel. In many countries the sport is self-regulated by one of its training agencies. The British Sub-Aqua Club was one of the first to set medical standards and has recently joined with the Sub-Aqua Association and Scottish Sub-Aqua Club in currently revising its procedures through the UK Sport Diving Medical Committee (UKSDMC). The diver is required to complete a medical questionnaire and sign it. There is some printed guidance to help the diver in this task. Should any of the answers to these questions be positive then the diver is directed to a Medical Referee, a doctor who is usually an experienced recreational diver, for detailed assessment. The Committee also maintains for these Referees a set of guidance notes on the principal issues in diving medicine. An important feature is that this self-declaration form is valid for only 5 years, after the age of 40 for only 3 years and, after 50, only 1 year. These medical certificates are retained by the club.

I have no personal experience of the SPUMS Diving Medical. An important feature of it is that only doctors who have been approved after attending a suitable instructional course can carry it out. The medical guidance is written for entry-level recreational scuba diving and, other than a suggestion that it should also be carried out prior to any training, the duration of a fitness certificate's validity appears to be unlimited.

A similar but arguably less stringent system for use worldwide has been created in the USA by the Recreational Scuba Training Council (RSTC). Again, the diver is required to complete a self-assessment form and only if a positive answer is made to any of a short set of questions will the diver be sent to see a doctor. A difference that may be considered significant is that any doctor will do. No understanding of diving is required by the doctor but only the ability to read a short set of Guidance Notes that is provided, together with the DAN telephone numbers in case of doubt. If the diver is considered fit and then passes his training course there is, again, no requirement for him or her ever to have another medical check up.

These three examples are not far apart for entry level diving as long as the diver is healthy or, at the other extreme, has one of the obvious absolute disqualifications. The differences between them become apparent in those persons with something close to the pass/fail border.

Without any diving background the non-diving doctor is likely to err on the side of caution and decide in favour of unfitness.

More important, other than for clubs such as BS-AC, there is no procedure for reviewing the continued health of someone who trained many years ago.

A dive resort can request that a customer repeats the basic questionnaire. If the diver has had an injury or illness since certification, this reassessment could be important. If it is needed, then it is not acceptable that *any* doctor can do this review. Essential are an understanding of the environment and of what the diver is likely to be doing, of relevant applied physiology and of diving illness pathology.

Among the most rigorous requirements are those found in Malta, where the doctors check all those who apply for a local diving certificate. Those vacationing divers who opt to dive with local diving schools or instructors, and not independently, have to present a valid diving medical to the school/instructor which/who is obliged to forward a copy to the Health Department's Hyperbaric Unit within the week. Random checks of these are made.

There is much published opinion on the wisdom of allowing or not allowing persons with some specified condition to dive, with or without a restriction. Some examples of these difficult assessments will be reviewed over the next few days. What needs to be mentioned here, in closing these introductory remarks, is that sadly too many doctors with no diving experience may voice erroneous opinions. This may mean that either someone is deprived of a relatively safe activity or, at the other extreme, becomes exposed to an inappropriate risk with unforeseen consequences.

Conclusions

In summary therefore, my opinion is that the recreational diver needs:

a pre-training medical assessment to exclude the presence of illness that may be incompatible with the underwater exposure;

periodical assessment thereafter to ensure that ageing has not impaired his or her potential safety in an unforgiving environment;

specific review is required after significant illness, surgery, diving incidents and other accidents for the same reason;

all this to be done by doctors who understand the hazards of diving.

How this should be achieved is another matter but the fact is that none of the systems in current use fully meets all of these basic objectives.

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THE RSTC MEDICAL STATEMENT AND CANDIDATE SCREENING MODEL

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Key Words

Fitness to dive, safety

Introduction

Recreational scuba diving is an enjoyable leisure activity which has attracted millions of participants.[1.2] Due to the unique physical and environmental nature of breathing compressed air, scuba diving poses potential health risks. Most diver training organisations do not require every student to undergo a medical examination, by a medical practitioner, before enrolling in a scuba course. They do, however, require some type of medical and health screening as a prerequisite to scuba diving activity.[3] Before 1989 industry organisations had developed their own screening process and methods with wide variation in content and approach.

In 1989, a standardised and objective assessment of medical fitness to participate in scuba diving was voluntarily sought by the diving educational organisations (NASDS, PADI, SSI, PDIC, YMCA and IDEA) who were members of the Recreational Scuba Training Council (RSTC). This was accomplished in November 1989 with the release of the RSTC Medical Statement.

In 1989, RSTC member organisations adopted the Medical Statement for use. These organisations train approximately 70% of the world's divers. The PADI Medical Statement is a reproduction of this form.[4]

Development of the Medical Statement

The RSTC used diving medical expertise and guidance to develop requirement for medical eligibility for diving students. The RSTC Medical Statement was developed by well known members of the Undersea and Hyperbaric Medical Society (Drs Paul Tombs, Keith Vandermeter, Peter Bennett, Robert Goldmann, Richard Moon, Paul Linaweaver, Roy Myers and James Vorosmarti) along with physicians from DAN in conjunction with training organisations affiliated with the RSTC. The medical statement reflects the conventional thought of the United States diving medical community as to what constitutes medical eligibility to learn to dive at the time it was developed.[5]

The medical content has evolved since its release with various revisions suggested from the international medical community, including input from the United Kingdom and the 1995 SPUMS workshop policy on medical practitioner certification of fitness for diving.[6,7]

Since its release ten years ago, the RSTC Medical Statement has been adopted and applied internationally in over 175 countries and territories throughout the world. Conservative estimates indicate that the RSTC Medical Statement has been utilised as a scuba diver health screening system over eight million times. Initially released in English it has been translated into several languages.

The medical statement is currently utilised by all RSTC member affiliates of the RSTC Canada, RSTC, RSTC-Europe and Barakuda, FIAS, ANIS, SSI Europe, PADI Norway, PADI Sweden, PADI Asia Pacific, PADI Japan, PADI Canada, PADI Americas, PADI Worldwide, IDD Europe, YMCA, IDEA, PDIC, SSI International, BSAC Japan and NASDS Japan.

How the Medical Statement System Works

The RSTC Medical Statement system is designed to help the diving candidate, the examining physician and the scuba instructor ensure that a student is medically fit for diving. The statement is composed of three sections, a medical questionnaire, guidelines for recreational scuba diver's physical examination and a bibliography.

The medical health screening questionnaire was designed to be comprehensive enough to identify appropriate questions yet decrease the number of unneeded physical exams. The standards of RSTC member organisations stipulate that it is necessary for prospective diving candidates to complete the medical questionnaire before breathing compressed air. If a candidate answers in the affirmative for any question, they are advised to contact a medical practitioner for an opinion, a consultation or physical examination as required.

The statement was designed to accommodate the geographical and operational problems facing diving operators throughout the world. The limited number and distribution of physicians with expertise in diving medicine in the majority of world, including the US, makes it difficult, if not impossible, for many diving students to ever see a qualified medical practitioner. In some developing countries, a physician may not be available at all.

With the increase in scuba diving, the chances that a primary care physician will deal with a diving problem is increasingly likely. Physicians living far away from diving sites are not excluded from the possibility of encountering diving medical problems. Many divers travel to exotic areas for diving and may complete a medical before leaving. As a result the statement includes a section on guidelines for any physician to follow, with a bibliography to assist the examining medical practitioner to assess the patient's health and medical conditions in the context of diving physiology and so make an informed recommendation. Contact information for the Diver Alert Network (DAN) and the medical endorsers are provided to assist further with difficult or unusual cases. Instructions and guidelines for recreational scuba divers' physical examination are provided to correspond with each area of the health screening questionnaire and identify associated relative and absolute contraindications to further guide the examining physician.

Role of the Diving Candidate

The first two pages of the six page statement are filled in by the student at the beginning of every diving course. To encourage honesty, risks are outlined and the importance of personal health for safe participation is highlighted, the text appears in Box 1.

After reading and signing this section, the student completes the medical questionnaire with a written yes or no answer for every question. All blanks are checked by the instructor to insure no questions are left unanswered. If an affirmative answer is given to any question, the student is referred to a physician, taking with him or her the statement guidelines, for examination. The student must return with an unconditional medical approval prior to water activities or be disqualified from further participation. This relieves the instructor from the burden of deciding whether a student should be seen by a physician or not. In the past, scuba instructors were occasionally placed in the uncomfortable position of wanting to teach a willing student to dive, but not knowing if diving could compromise the student's health. With the new statement, a doctor makes a decision based on his or her knowledge and expertise along with the patient history and the use of the guidelines written expressly for this purpose.

Role of the Medical Practitioner

A long standing concern within the diving medical community is that not all physicians are aware of certain physical and emotional factors peculiar to scuba diving and so are unable to provide suitable medical examinations.

In addressing this concern, the medical statement assumes that a physician should be the medical decision maker. Physicians make daily decisions with their patients regarding risk to benefit ratios of diagnostic procedure and treatment. It is logical to extend this process to risk assessment in recreational scuba diving. The RSTC statement provides diving-specific, medically-based guidelines to the physician. The statement assumes physicians have a sufficient background in physiology to learn enough about diving medicine to make informed decisions based on risk assessment. The examining

BOX 1

OPENING STATEMENT OF THE RSTC MEDICAL FORM

"This is a statement in which you are informed of some potential risks involved in scuba diving and the conduct required of you during the scuba training program.

Your signature on this statement is required for you to participate in the scuba training program offered by ____ (Instructor) and ____ (Facility) located in the city of ___________________________ and state of _________________________.

Read and discuss this statement prior to signing it.

You must complete this Medical Statement, which includes the medical history section, to enroll in the scuba training program. If you are a minor, you must have this Statement signed by a parent.

Diving is an exciting and demanding activity. When performed correctly, applying correct techniques, it is very safe. When established safety procedures are not followed, however; there are dangers.

To scuba dive safely, you must not be extremely overweight or out of condition. Diving can be strenuous under certain conditions. Your respiratory and circulatory systems must be in good health. All body air spaces must be normal and healthy. A person with heart trouble, a current cold or congestion, epilepsy, asthma, a severe medical problem, or who is under the influence of alcohol or drugs should not dive. If taking medication, consult your doctor and the instructor before participation in this program. You will also need to learn from the instructor the important safety rules regarding breathing and equalisation while scuba diving. Improper use of scuba equipment can result in serious injury. You must be thoroughly instructed in its use under direct supervision of a qualified instructor to use it safely.

If you have any additional questions regarding this Medical Statement or the Medical History, section, review with your instructor before signing."

physician is provided with the student medical questionnaire, guidelines and the instructions in Box 2.

BOX 2

"Recreational scuba (self contained underwater breathing apparatus) diving has an excellent safety record. To maintain this status it is important to screen student divers for physical deficiencies that could place them in peril in the underwater environment.

The Recreational Scuba Diver's Physical Examination contains elements of medical history, review of systems and physical examination. It is designed to detect conditions that put a diver at increased risk for decompression sickness, pulmonary over-inflation syndrome with subsequent cerebral gas immobilisation and loss of consciousness that could lead to drowning.

Additionally, the diver must be able to withstand some degree of cold stress, cope with the optical effects of water and have a reserve of physical and mental abilities to deal with possible emergencies.

The history, review of systems and physical examination should include, as a minimum, the points listed below. The list of contraindicating, relative and absolute, is not all inclusive. It contains the most commonly encountered medical problems that put the diver at risk, and (lead him) to consider the individual patient's state of health.

Diagnostic studies and specialty consultations should be obtained as indicated to satisfy the physician as to the diver's status. A list of references is included to aid in clarifying issues that arise. Physicians at the Divers Alert Network (DAN) are available for consultation at worldwide locations.

Some conditions are absolute contraindicating to scuba diving. Conditions that are absolute contraindicating place the diver at increased risk for injury or death. Others are relative contraindicating to scuba that may be resolved with time and proper medical intervention. Ultimately the physician should decide with the individual, based on his knowledge of the patient's medical status, whether the individual is physically qualified to participate in scuba diving.

Remember at all times that scuba is a recreational sport, and it should be fun, not a source of morbidity or mortality."

Physicians are then guided through each screening area which identifies relative and absolute contraindications for the following areas,

1. cardiovascular system,
2. pulmonary,
3. neurological,
4. otolaryngological,
5. gastro intestinal,
6. metabolic,
7. endocrinological,
8. pregnancy,
9. haematological,
10. orthopaedic and
11. behavioural health.

If any negative responses are noted, the physician is asked for an opinion as to the medical fitness for scuba diving. The general principles for disqualification include

1. diving causes a deterioration in the medical condition and
2. the medical condition presents an increased risk for a diving injury to both the individual and the diving partner.[8,9]

Role of the Diving Instructor

Because, typically, scuba instructors are not medical practitioners, they should not be expected to medically screen, make diagnoses nor render definitive opinions as to whether a course applicant is medically eligible to participate in a scuba course. This responsibility should rest with the medical community. The RSTC form provides a medically-based standardised approach to the health screening process to address this problem. This effectively reduces the problem of lay people being faced with medical and health screening decisions. If an answer to a screening question is unclear, the instructor can inform potential students that their cases are complex and invite them to discuss medical issues with a physician before completing the questionnaire.

When a physician gives approval to a student as to his medical eligibility to dive, the instructor must then decide whether or not to take the student under instruction. If an applicant is medically approved for diving and the instructor believes the student has a condition that may not be suitable for diving, it may be appropriate for the instructor to seek further guidance from the physician who examined the student. Coren discusses this point, "ultimately, the scuba instructor must make the final decision as to whom will be permitted to take a scuba course. Scuba instruction is not a right to which all persons are entitled. It is a private recreational choice on the part of both the instructor and the applicant. An instructor has absolutely no legal obligation to accept every applicant. Therefore, keeping in mind these considerations in the area of medical fitness, an instructor may exercise discretion by refusing admission to an application if, in the instructor's judgement, there is cause for concern".[10]

It is important for an instructor not to assume responsibility for medical judgements or approvals. This is solely the physician's area of expertise. The instructor is required by the training agency, to leave this responsibility to the physician.

Conclusions

By using the RSTC Medical Statement system, instructors, students and physicians are linked together to determine individual health for diving. The process of student, instructor and physician interaction is designed to provide information about student medical history and risk identification to make an informed health assessment and recommendation before scuba diving. This in turn supports safe and enjoyable scuba diving for the majority of the interested population. The past ten years have shown this system to be responsive and effective in supporting this purpose.

The future of the RSTC Medical Statement

The RSTC Medical Statement is currently under active review and updating with the UHMS Diving Committee. The three goals of this process are

1 to evolve the semantics and content to current 2000 diving medical conventional thought,
2 broaden the international endorser group on the statement, and
3 release it completed back to the RSTC by July 2000.

Recently in the United Kingdom, a system very similar to the RSTC Statement has been proposed which uses a self-assessment based health questionnaire which only refers the student to a medical referee qualified in diving medicine if the candidate answers in the affirmative for any question.[6]

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QUESTIONS AND ANSWERS AFTER THESE PAPERS BY DAVID ELLIOTT AND DREW RICHARDSON

Robyn Walker

In Australia there are people who go from doctor to doctor to get dive medicals, amending their medical history until they find a doctor who will pass them. A dive medical once passed lasts for life. However if something occurs later on, there is no way which we can take certificates away from them. All we can do is ring the dive shop and warn them that the person should not be diving.

David Elliott

That introduces the question I was going to ask Drew Richardson. While there is obviously still a lot of work to be done on the wording of those forms, the principle is totally acceptable, particularly where medical services are few and far between. What I think has not yet been properly addressed, are the problems of the older diver, the person who has been sick and so forth. I am surprised that questionnaires are not used more often. Sometimes a PADI dive resort will slap the questionnaire down in front of you, before you fill in your disclaimer. I think that is entirely acceptable. It would answer an awful lot of the doubts that people have about the once-only nature of examinations or questionnaires.

Drew Richardson

That is the standard practice. Resorts, because of legal liability concerns if for no other reason, typically want medical questionnaires filled in along with the disclaimer which is essential if one wishes to dive at a resort. The more one goes to resorts or travelling the more likely one will face this medical screen

David Elliott

As I went through the PADI Instructor Manual the other day for quasi-medico-legal reasons, I saw, and had not appreciated, that PADI does require each instructor to have a medical certificate from a doctor. I think you do not really emphasise that enough.

Drew Richardson

Yes, I did not say anything about that. Before one can become a Dive Master there is a medical assessment by a physician. At least within our standards, although it is in other groups as well, if there is a change in health status then that diver has to step out of the water until all is well again. This is routinely done, believe it or not. A lot of diving instructors are concerned if they have become ill and want to know whether or not it is going to affect their career, so voluntarily go to see the diving doctor. Not always but usually. Which is a change from the old commercial field when it sometimes suited the divers to hide being unwell because they would miss out on depth pay or whatever.

Jürg Wendling (Switzerland)

I would like to repeat what David said, that these forms are good for the Bongo Bongo lands. But now, especially in Europe, there are now hundreds of trained doctors in many countries. This was not the case 10 years ago. This will go on and go on. I think it is good to have a form which is universally applicable, but it should be mentioned somewhere on the form that it is recommended for novice divers to have a medical with a doctor trained in diving medicine. It is an easy phrase to put in, and would not make any harm for the Bongo Bongo lands where there are no trained doctors.

There are a few well evolved local systems. The UK has a referee system. No system is perfect. The pragmatic reality is that diving occurs around the world and it is impossible for every learner diver to have a medical examination before they start diving.

There is a trend towards travel agencies telling people to have their medical in their home countries, and not in the remote area where they will be diving. Look at the forms we signed here, the only informed consent is no signature, no diving.

Drew Richardson

The diving industry is working in liaison with travel agents, because we do not want a customer being upset by being denied access to diving or feeling that they were hoodwinked into seeing a doctor. So it is in everyone's best interest to try to use the internet and other media to encourage medicals before they travel. I completely agree with you.

David Taylor (Melbourne)

I am very interested in the behaviour of divers. It is something I have been interested in for quite some time; whether divers in fact select themselves to become adventurous people or whether the diving itself actually causes them to become adventurous and thrill seeking. I do not know. However I have recently just completed a pilot study on a group of divers in the US, looking at their interests and preferences. We found that divers tended to be very much outgoing, very adventurous, thrill seeking, but not disinhibited. We want to extend our survey across North America and also through Australasia looking at this and various other things.

Paul Langton (Perth)

One of the resources that is increasingly utilised by tourists before they go travelling is internet-based searching. There are now quite a lot of US and some Far North Queensland based sites that not only advertise their dive training, but have on their web side the recreational scuba training council medical certificate, with a recommendation that the candidates fill it in and seek medical assessment by a trained doctor before they go on their holiday. This is to try to overcome some of the problems of someone arriving wanting to do the dive course, starting that afternoon, and where they are probably more likely to fib about their past history.

Mike Davis (Christchurch)

I am totally confused. SPUMS is an organisation that has developed an approach to diving medicals in Australia which is increasingly permissive and is not based on a prescriptive approach at all. PADI on the other hand is asking for a prescriptive approach to medical certification of recreational divers. I am at a complete loss about what does happen in Australia. Every quarter I get a list of diving doctors from SPUMS, my understanding is that sport divers in your community are required to go to these doctors to get a medical clearance for recreational diving and that the medical is meant to be according to AS4005.1. However the diver training organisations are asking for something completely different. In Christchurch I do not do a lot of sport diving medicals but I do see those that people have not been happy with before and, in fact, this is the first time I have ever seen this form. So one wonders just what is going on in our own communities. It does not seem to fit with your reality Drew at all.

Terry Cummins (Sydney)

In Australia what happens is the PADI dive shops give trainees one of our questionnaires but they will advise them that they should have a dive medical with a diving doctor. They do not have to, but they are advised to. The dive shops are really quite keen on that. So people in Australia are advised to see a diving doctor. Even with the PADI questionnaire.

Mike Davis, Christchurch

What sort of permissive discretionary approach do you take Vanessa? In particular, which form and what approach to permission and clearance for recreational diving do you take? Do you take the discretionary one that is our Society's policy or do you take PADI's.

Vanessa Haller (Victoria)

I use the medical form in the Australian Standard, AS4005.1 Training and Certification of Recreational Divers Part1. But it is very similar to the one in AS2299 Occupational Diving. There is not a lot of difference between them. The AS4005.1 form has probably got more in it.

John Knight, Melbourne.

For those who do not live in Australia, it is composed of a number of States which do not have exactly the same laws, it is a Federation. Australian Standards exist for States to put into their legislation if they want to. The only State that has put AS4005.1 into its legislation is Queensland and the law in Queensland requires somebody who wants to learn to scuba dive for recreational reasons to go to a doctor with special training. Training as laid down by the Censors of the South Pacific Underwater Medicine Society. In the rest of Australia, there is no compulsion but most of the training organisations are keen on getting their trainees medically examined, as this will shift the liability for taking somebody who does something unhealthy, like having a fit underwater, off their shoulders and onto the doctor.

Chris Coxon (Cairns)

It appears that PADI and the other training organisations are developing a proliferation of shorter courses than entry level certification courses. I understand these have lowered the previous age limits and some of them can be used later to shorten the basic certification course. Could Drew Richardson explain what these courses are and how the RSTC medical screening process fits in? I raise the matter, because I could not see any age reference in the whole document.

Drew Richardson

For *Discover Scubas*, and other non-certificate courses, the battery of questions is adapted for the screening element. If someone answers in the affirmative, they are referred to the full document. But there is no lower age at the moment (May 2000). However we are under revision right now.

Henrik Staunstrup, Denmark.

I agree that at least 10 years ago this medical statement was great for a lot of areas in the world. But in those 10 years an awful lot of diving doctors have been educated. I think that this RSTC statement should reflect that we have a different world now. That there are many areas filled with approved diving doctors who can do good dive medicals. I think you should really emphasise that the RSTC statement can be used, but in areas where there are plenty of diving doctors it is advised that one should have a medical examination. What is the policy of RSTC, to have this all over the world or to try and develop dive medicals and diving medicine?

Drew Richardson

I disagree with the suggestion that we now have a proliferation of physicians with expertise in diving medicine that we did not have ten years ago. I believe that the number is probably flat or declining. Look at the UHMS. Its focus now is much less on diving medicine. It is going into other hyperbarics. So I think there are actually fewer and fewer diving doctors. The number of divers has increased significantly. So, although the number of doctors probably is keeping up with society's needs, the number of diving doctors is falling behind its user group. I believe there is even more of a demand for diving doctors than there used to be. However we do, generally in Australia and New Zealand, make the recommendation to see a diving doctor.

FIT FOR WHAT? WHAT DIVING CAN BE DONE BY SOMEONE WHO IS NOT PERFECT?

David Elliott

Key Words

Diving medicals, fitness to dive, medical conditions and problems, recreational diving, standards.

Introduction

If we are to endorse good medical standards, set pass/fail criteria or provide doctors with well-considered guidance, are these to be identical for *all* divers? For example, does the vacationer in a tropical resort who wants to try his or her first "diving experience", need the same medical screening as an experienced North Sea oxy-helium saturation diver? For some things, yes (neither should have a pneumothorax), in other things, no (screening a novice for dysbaric osteonecrosis is certainly not necessary) but in other ways, the novice should have a greater level of screening (consider the potential for a panic attack in a first-ever dive). So, not all fitness assessments are the same. Now, primarily for lack of time, we should put aside all the different varieties of working divers and, in doing so, acknowledge that in many countries the instructors of recreational divers are recognised as working divers and required to have annual health checks. This may be simply in accordance with regulations, but is also advised because their underwater responsibilities extend to the safety of the novices whom they train. This needs to be more widely known because a number of competent US/Caribbean recreational instructors have found themselves medically disqualified when seeking employment in the UK.

The recreational envelope

In this context we are concerned with fitness for open water *unrestricted* diving within the recreational envelope (whatever that may be). This does not include those who are disabled and dive only with prescribed restrictions.

Many recreational divers in North America would interpret the recreational envelope as being repetitive no-stop diving to a maximum of around 130 fsw (40 m) but many Europeans would routinely include decompression dives. So is there any international definition for this? Certainly the various definitions as applied by different training agencies and by DAN (para 3.2) are incompatible.[1] Perhaps SPUMS could consider, at least for accident analysis purposes, something along the lines of:

Recreational diving, PADI-style, is repetitive no-stop diving to a maximum of around 130 fsw (40 m) although it would be reasonable to extend the depth to 140 fsw (43 m), the maximum depth of their tables or perhaps a little deeper still for diver-rescue by an instructor. This category of recreational diving can include scuba nitrox as a sub-variety because when dived as taught it is safe.

Extreme air diving should be defined as scuba diving somewhere below 50 m, because it is not reasonable for the few crazy extremists (certified or not) to contaminate the good record of the majority of divers. For compatibility with PADI and similar agencies, the threshold depth could be any diving beyond the agreed recreational depth limits. Alas, there is no medical screening test for stupidity and overconfidence.

Advanced recreational diving, using air or nitrox scuba, covers wreck, cave and virtual overhead diving. The term "*virtual overhead diving*" is one used by DAN that neatly covers those who cannot return to the surface without complying with decompression stops.[1] Dived as taught, overhead diving is also relatively safe.

Technical diving, as Bill Hamilton put forward at the SPUMS meeting in 1996, is diving with a change of breathing gas during the dive. This covers recreational divers who carry several tanks so that they can switch gas mixtures during deep dives and it also covers those who use rebreathers. These rebreathers are usually either closed circuit with a constant PO_2 system (i.e., implying a percentage change of inspired gas during changes of depth) or one of the premix nitrox semi-closed rebreathers (implying a change of O_2% during changes of work rate). These dives may be intended to be safe but do carry increased risk.

Restricted diving is for those who are not fit to dive like others within the recreational diving envelope of depth and exposure time but who, for medical reasons as will be discussed tomorrow, have prescribed limits that are likely to be procedural rather than restrictions of depth or time. There is also the issue of unknown fitness among those who take a resort course or just a diving experience "try dive". Fatalities do occur. These dives are under supervision in clear water and so, fit or not, they are not making unrestricted dives.

So dives in these unrestricted categories that are not "for reward" together define the boundaries of the recreational envelope and within that envelope the medical standards should be the same.

Should the physical fitness standards be the same also? A strong adverse current can affect anyone, a life-threatening crisis underwater can occur at any time and who would not try to rescue an unconscious buddy in a rough sea? All divers should be physically fit but only professional divers are assessed. Physical fitness needs to be emphasised in training courses but without setting any standards.

Unrestricted diving

Disability and diving restrictions, is it right to link these two phrases? A disability can be mental, medical or physical. Procedures for those with a motor impairment are provided in the PADI training manual but not, it seems, for those with another physical impairment, significant hearing loss, even though those who use sign language underwater may have some advantage over the "fit" diver.

The loss of a few fingers is a physical impairment that may make life difficult but for diving may cause no significant loss of functional capability, no physical disability.

In contrast, paraplegia following spinal trauma is an impairment that is also a disability that must restrict diving. Nevertheless, one working diver, a marine scientist who became paraplegic from a car accident about 20 years ago, has continued to dive regularly while accepting some appropriate operational conditions. Though restricted by the routine need for a dedicated buddy to protect his lower limbs from scrapes and to help with safe egress from the water, he points out cheerfully that he has less risk of spinal decompression sickness than others have.

For other reasons, diving restrictions may apply to those with a medical disability, but there are some with an impairment who can make unrestricted dives. This is partly a matter of semantics. Divers with medical disabilities that require their diving to be modified or restricted will be discussed tomorrow but there are others who may have a different type of medical disability that also questions their fitness to dive. Included in this group are persons who would fail the self-declaration form but whom, on assessment by a doctor, are considered to be fit for *unrestricted* diving. One example that will be detailed later is a stable asthmatic even though his or her fitness should be time-limited and depend on the absence of deterioration. These persons when fit require no special in-water support and need no limitations upon their activity.

Assessment after head injury

Slightly different is the exampleof the person with a history of head injury. In this case restricted diving would be inappropriate and the choice should be all-or-none, simply either fit or unfit for unrestricted diving. But when is that transformation?

Assessment of recovery from head injury is not an easy process but is a good illustration of an assessment that could result in unrestricted diving. Obviously that assessment must include other factors such as neurological impairment and post-concussion syndrome. The latter includes headache, dizziness, poor memory, poor concentration and irritability, which are all symptoms similar to those expressed by some divers after decompression illness. One of the reasons persons should not dive after a significant head injury is the risk of subsequent epilepsy, an absolute disqualification from diving.

As reviewed by Dick the severity of a head injury is measured historically by the length of coma, the clinical state on arrival and the duration of post traumatic amnesia (PTA).[2] The depth of coma can be measured using the Glasgow coma scale but the best indicator of the severity is PTA. This is the time from the head injury until the time the patient begins to lay down a *continuous memory*. Islands of memory *do not* represent the end of amnesia. PTA does not shrink with the passage of time. This is in contrast to retrograde amnesia, the amnesia of incidents leading up to the injury. PTA is always longer than the interval from the injury until when speech starts. PTA may correlate well with the degree of damage shown on magnetic resonance imaging.

Post traumatic epilepsy can follow head injury. In 5% it occurs in the first week and there is an increased risk of this with depressed skull fracture, intracranial haematoma, prolonged PTA and focal neurological signs. Late epilepsy can occur in 5% and there is an increased risk if there is an intracranial haematoma (31%), early epilepsy (25%) or a depressed skull fracture (15%). With none of these, the risk is 1%. Sixty per cent of the first post-traumatic fits occur within 1 year, 24% in 1-4 years and 16% after 4 years. The occurrence of fits is dependant on the severity of the head injury as shown in Table 1.

Rather than pursue this debate along a well-trodden track of scientific citations, let us take a brief look at summaries of how guidance is presented by some different diving Authorities.

HEALTH & SAFETY EXECUTIVE (FOR WORKING DIVERS)

There are inherent dangers in diving if there has been significant brain damage or if there is a risk of post traumatic epilepsy. After head injury where there has been any of:

a depressed skull fracture;
intracranial haematoma;
unconsciousness or post traumatic amnesia greater than 30 minutes; or
focal neurological signs

there is a significant risk of post-traumatic epilepsy and the person should be rejected.

More minor episodes of head injury (less than 30 minutes unconsciousness or PTA) are a reason for

TABLE 1

HEAD INJURY CLASSIFICATION AND OCCURRENCE OF FITS IN APPROXIMATELY 3,000 PATIENTS

Head injury	Fits within 1 year	Fits within 5 years
Severe		
Confusion, haematoma, > 24 hours coma, amnesia	7.1%	11.5%
Moderate		
Skull fracture with 30 min to 24 hours unconsciousness	0.7%	1.6%
Mild		
< 30 min unconsciousness or amnesia	0.1%	0.6%

temporary unfitness for a period of 4 weeks subject to review by a medical examiner. However, minor head injuries can cause cognitive dysfunction.

UK SPORT DIVING MEDICAL COMMITTEE (UKSDMC)

Because head injury may be followed by epilepsy, the fitness of divers who have sustained this type of injury needs to be carefully considered. The following guidelines are suggested.[3]

The length of post traumatic amnesia (PTA) including any period of unconsciousness may be used as an index to the severity of injury. Where PTA has been less than one hour, there should be a three week layoff from diving. With PTA of an hour to 24 hours, there should be a two month layoff. Where the period of PTA exceeds 24 hours, there inevitably has been severe brain damage and there is considerable likelihood of subsequent epilepsy and impaired mental functioning. A minimum period off diving of three months is suggested and cerebral function should have returned to normal.

Where enquiries are being made about an incident in the past, the individual sometimes has difficulty in recalling the period of PTA and in such cases the period of unconsciousness may be doubled as a rough guide.

If epilepsy should have developed as a result of injury then further diving is banned unless it was an isolated fit occurring at the time of injury. Likewise, if anticonvulsant medication is being taken as a prophylactic measure, diving should be banned, but may be resumed three months after this is withdrawn if the individual never had a fit.

THE SPUMS DIVING MEDICAL

Candidates with a history of head injury involving significant unconsciousness or concussion associated with repeated headaches, or intra-cranial surgery, should be individually assessed by a neurologist.

THE RSTC GUIDELINES

Neurologic abnormalities that affect a diver's ability to perform exercise should be assessed individually based on the degree of compromise involved.

Relative Contraindications:

History of head injury with sequelae other than seizure

History of spinal cord or brain injury without residual neurologic deficit.

Absolute Contraindications:

History of seizures other than childhood febrile.

Assessment of asthma

Asthma is another example of a disability in a diver that, like recovery from a head injury, means only either disqualification or unrestricted diving. Restrictions are not appropriate though a fitness certificate may be time-limited. There is no logic in a fit asthmatic diver being restricted to shallow diving (which is just where Boyle's Law is most active), nor can one ask an asthmatic to avoid life-threatening situations. However, unlike head injury that can only improve, there is a need for the asthmatic to monitor for any deterioration over time. In the meanwhile, if they can dive, they should dive without any medically-imposed restriction.

The difficulty lies in deciding just whether or not a particular individual can dive. What follows is not a comprehensive review but a distillation from two relevant meetings.[4,5] In simplistic terms, the main problem of a candidate who has some history of asthma is determined by pulmonary function, can he or she exercise adequately when in the water? The diver will have normal lung function when he is not suffering from the acute effects of his condition, but can one ensure that they will not get into any difficulty when in the water, especially when breathing cold gas that, with some regulators, might also be a sea-water aerosol.

Those who have significant broncho-constriction on exercise should not dive. Beware of sports divers who have quite marked impairment on exercise and yet who claim never to have problems in the water because they probably never achieve the level of ventilation necessary to trigger exercise-induced asthma. However it might arise in a life-threatening situation.

The exercise test is therefore an essential step. Divers can be considered fit provided that they demonstrate less than a 20% reduction of peak flow or FEV_1 after about 6 minutes of hard exercise. Indeed it has been suggested that the use of steroids to maintain stability in a working diver with good peak flow is not per se a contraindication to diving.

Other challenge tests are said to be less useful. In a few persons the response to inhalation of nebulised normal saline is sufficient to convince them that hang gliding might be a more attractive pursuit. Bronchial hyperactivity in response to a histamine challenge does not add any useful information.

The controversy about asthmatics diving tends to focus on the risks of pulmonary barotrauma and gas embolism. Asthma may be associated with a mucus plug in an airway or, occasionally, the spontaneous collapse of a lobe but contrary to theoretical predictions, there appears to be no firm evidence that asthma predisposes to barotrauma.

Again, rather than continue with a review of published medical wisdom, it may be more profitable to summarise the guidance offered by some diving Authorities. There is little disagreement.

THE UK HEALTH & SAFETY EXECUTIVE (FOR WORKING DIVERS)

Asthma is normally a contraindication to diving. A requirement for regular bronchodilator therapy is a contraindication to diving. However, individuals with mild asthma:

> whose lung function remains normal for most of the time and there is no reduction of exercise capacity or evidence of exercise or cold-induced bronchospasm;
> and they have been asymptomatic for a considerable period of time;

may be considered fit to dive even if they require regular prophylactic medication to control symptoms.

Individuals with asthma require specialist referral. That is likely to include bronchial testing using cold, exercise or hypertonic saline. Persons assessed with a possible diagnosis of asthma are likely to be found either fully fit or unfit. It is unlikely that a certificate of fitness with a restriction on diving activity (for example depth) would be appropriate.

UK SPORT DIVING MEDICAL COMMITTEE (UKSDMC)

There is little if any evidence that the mild controlled asthmatic who follows the guidelines below is at more risk. Asthmatics may dive if they have allergic asthma but not if they have cold, exercise or emotion induced asthma. Only well-controlled asthmatics may dive. Asthmatics should not dive if he or she has needed a therapeutic bronchodilator in the last 48 hours or has had any other chest symptoms.

The asthmatic should not need more than occasional bronchodilators, i.e. daily usage would be a disqualifying factor, but inhaled steroids/cromoglycate/nedocromil are permissible. During the diving season he or she should take twice daily peak flows. A deviation of 10% from best values should exclude diving until within 10% of best values for at least 48 hours before diving. A β_2 agonist may be taken before diving as a preventative but not to relieve bronchospasm at the time.

The medical examiner should perform an exercise test such as the 18 in (43 cm) step test for three minutes, or running outside (not a bicycle ergometer) to increase the heart rate to 80% (210 minus age). A decrease in PEFR (peak expiratory flow rate) of 15% at three minutes post-exercise should be taken as evidence of exercise-induced bronchoconstriction and hence disbars. The patient should be off all bronchodilators for 24 hours before the test.

THE SPUMS DIVING MEDICAL

Any abnormal findings should be fully investigated. Such investigations should include provocation testing if any doubt concerning the possibility of bronchial hyperreactivity exists. Particular attention must be paid to any condition that might cause retention and trapping of expanding gas in any part of the lungs during decompression (e.g. asthma).

The following conditions may disqualify: (iv) Any evidence of obstructive airways disease e.g. current asthma, chronic bronchitis, allergic bronchospasm.

In cases of doubt, specialist medical opinion should be sought. Such opinion should include provocation testing if any doubt concerning the possibility of bronchial hyperreactivity exists.

THE RSTC GUIDELINES

Any process or lesion that impedes airflow from the lung places the diver at risk for pulmonary overinflation with alveolar rupture and the possibility of cerebral air embolisation. Asthma (reactive airway disease), COPD (chronic obstructive pulmonary disease) cystic or cavitating lung diseases all may lead to air trapping. Spirometery, provocative tests such as methacholine challenge and other studies to detect air trapping should be carried out to establish to the examining physician's satisfaction that the diver is not at risk.

Relative Contraindications:

> History of prior asthma or reactive airway disease (RAD)*.
> History of exercise/cold induced bronchospasm (EIB)*.
> Restrictive Disease**.

Absolute Contraindications:

> Active RAD (asthma), EIB, COPD or history of them and abnormal PFTs (Pulmonary function tests) or positive challenge.
> Restrictive diseases with exercise impairment.

Note

* Air Trapping must be excluded.
** Exercise Testing necessary

THE CALIFORNIA THORACIC SOCIETY

Until better data are available, the following guidelines should be considered. Prospective dive applicants should be screened for the presence of asthma by history and physical examination.

A remote past history of asthma alone should not preclude an individual from diving.

Candidates with a more recent history of asthma or those with intermittent asthma should be required to have normal spirometry at rest and in response to exercise before being certified to dive.

Candidates with mild persistent asthma on medications should be required to have normal spirometry at rest and in response to exercise.

The patient has to assume responsibility to refrain from diving when asthma symptoms are present.

Conclusions

On the whole these various approaches are reasonably similar to those of the UK Sport Diving Medical Committee (and I have no association with them) which provides the most practical guidance. But could it be universally accepted?

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Professor David H Elliott has been a guest speaker at a number of SPUMS Annual Scientific Meetings. He is Co-Editor of THE PHYSIOLOGY AND MEDICINE OF DIVING, which was first published in 1969, with the most recent edition in 1993 and is also the civilian consultant in diving medicine to the Royal Navy. His address is 40 Petworth Road, Haslemere, Surrey GU27 2HX, United Kingdom. Fax + 44-1428-658-678. E-mail <106101.1722@compuserve.com>.

AUDIENCE PARTICIPATION

Cathy Meehan (Cairns)

Do you have a protocol for the exercise challenge test? In Cairns, it has been my practice to do an exercise challenge test and then follow that with a hypertonic saline challenge. Do you think there is any point in doing that? Do you think exercise will pick up everyone or do you think that the two is a good way to test for everything?

David Elliott

I know nothing about the hypertonic saline challenge test. However there is nothing to stop you doing it as an extra. After you have sufficient numbers who have done both tests you would be able to tell me the answer. Exercise is not meant to be absolutely gut-busting. As far as I am concerned climbing stairs or a quick walk around the block is suitable. I would like Jürg Wendling, who has the responsibility of pulling this together for all the European countries, to give his comments.

Jürg Wendling (Switzerland)

I think it is an unresolved question because there are so many ideas that there is no consensus yet. The European Diving Technology Committee, which is a 17 nation committee, has tried to define, for the European Standards, a submaximal exercise test. We want to avoid a direct measurement of VO_2max and use an indirect calculation of the VO_2max. Any test running around the block will not be acceptable. However any other test which has a reference to VO_2max can be used. The result should be written down in the VO_2max space and indicate the reference of that particular test. The Standard will be published on the Web when we have finished at the end of the year, so it will be readily accessible to everybody.

David Elliott

Jürg, how many minutes after exercise do you test lung function? And did you say that the Step test was not acceptable?

Jürg Wendling (Switzerland)

Most of the doctors I know use a step test as doing some steps and then when the candidate is tired, they take the measurements. I do not think that acceptable. However a standardised step test, such as the British Army Step test is acceptable.[1]

David Elliott

The problem with exercise, is that there are three reasons for doing exercise in a medical assessment. One is obviously cardiological, one is for testing people with asthma and the third one is for physical fitness. And we naively thought when we got together in Edinburgh in 1994, we might be able to bring all these exercise tests together.[2] But no, I think each particular question has to have its own exercise, but yes, there is a standardised step test under the physical assessment of fitness. But in the UK we tend to use VO_2 for commercial divers, as being the appropriate assessment.

Jürg Wendling (Switzerland)

The agency prescription of assessment, with a peak flow measurement immediately after six minutes exercise, repeated every five minutes, is a standard largely accepted by pneumonologists. In Switzerland they say that they would prefer to have full spirometry, not just the peak flow. Full spirometry gives more appropriate size measurements but the peak flow is easier to take.

David Elliott

Can I add one sobering thought to all this. Who pays? The trouble is, most working divers are actually self employed so they do not want to have all the wonderful tests which we would like them to have. If the working diver is in salaried employment, that is alright as the employer will pay. This really does need to be part of our thoughts.

Bill Brogan (Perth)

David, in your definition of recreational diving you mentioned that diving below 40 m is not permitted, and those that did so were idiots. Then you went on to mention wreck diving. Now what do you mean by wreck diving? Is there a depth limit on wreck diving?

David Elliott

I do know that a lot of people do it successfully, but one has to draw a borderline somewhere when you are collecting statistics. As far as wreck diving is concerned, or overhead diving, there are training programs and that is well defined. The first part of your question was whether or not 40 m is an appropriate depth. As far as the working diver is concerned, 50 m is the maximum depth, at least in Europe, with I think still the exception of France where they go to 55 or 60 m on compressed air. In the Royal Navy, we used to do 180 foot (54 m) dives routinely and 240 foot (72 m) dives occasionally on air. A trained person, who has worked up to it, can do it, but we are talking about the recreational field. Recreational divers have died on deep air dives, even those with adequate air. Usually they have not dived to those depths before. Those are the people I am worried about. Some people want to go into wrecks, others want to look at fish and some want to do these things below 50 m. Unfortunately some are merely going for the badge "I've dived deeper than you". They are the people one has got to beware of.

Bill Brogan (Perth)

I disagree with that, because I have done about 400 odd dives to depths between 40 and 60 m in the last 11 years at places like Truk Lagoon and Bikini and in New Guinea, and so have many thousands of other people who have derived great pleasure from their deep dives. I have not had a problem nor have I seen other people have problems and it is quite a large group, if you take that number of dives. I have had problems with cold water, rough conditions on the surface and stupidity, mine and other people's, but not pure depth.

David Elliott

230 feet is approximately 70 m and I have certainly seen people go unconscious when swimming at that depth. I have actually watched them with my own eyes. Not everybody is as experienced as you are. There are idiots who merely want to beat everybody else in the depth and more of them will be lost.

Bill Brogan (Perth)

I know, but I am talking at a specific group which is a very big industry in the Pacific and it has always concerned me a bit that SPUMS seems to ban them.

David Elliott

Well there are other ways of doing those kinds of dives. If you use Heliox or Trimix then you would not have the narcosis problem and should not have the CO_2 build up problems and things like that. So I think, Bill, that you should move on from being a compressed air diver.

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PRACTICAL SOLUTIONS FOR DIVERS WITH RESTRICTED FITNESS TO DIVE

Jürg Wendling

Key Words

Children, disabled diver, fitness to dive, medical conditions and problems, standards.

Introduction

The medical assessment of fitness to dive is a preventive action with the idea of improving the safety of diving. For different diving practices the criteria may vary to some degree, but there are common risks which have to be respected by everyone. Table 1 shows the fitness criteria for recreational divers. The particular point is that sports (recreational) divers go diving because they want to and they accept responsibility for their actions. The safety concept however is based on the buddy principle, thus a fit diver has to be able to observe and to help his buddy.

TABLE 1

CRITERIA FOR FITNESS TO DIVE FOR RECREATIONAL DIVERS

Ability to swim
Ability to communicate
Ability to manage self-responsibility
Exclusion of diseases that can provoke unconsciousness or disorientation
Exclusion of diseases that could provoke panic
Exclusion of diseases that could provoke barotrauma
Exclusion of diseases that may be worsened by diving

Persons with some disabilities do not usually fulfil these conditions. Are exceptions possible? Many physically disabled people have learned to dive and have improved their quality of life by enjoying the floating feeling of neutral buoyancy and the ease of movement under water. The question is not whether it is possible for the handicapped to dive, but what is the role of the medical examiner of divers for those people. As handicapped divers are not fit for unrestricted diving, the certificate must state that they may dive only when participating in a handicapped diving program.

The separate programs for different kinds of disabilities are shown in Table 2. From this analytical point of view children and diabetics also have to follow these guidelines, as their “disabilities” are insufficient management of self-responsibility in children and incomplete control of blood sugar level in diabetics (metabolic handicap).

Programs available

Several handicapped divers’ organisations support training and diving activities of the handicapped. They usually offer a training program for instructors and helpers, a system of training adapted to the needs of divers and special certificates, as well as information and meeting points for interested persons.

In Europe the main organisations are the Handicapped Divers Association (HDA), the Handicapped Scuba Association (HSA; www.hsascuba.com), International Association for Handicapped Divers (IAHD www.iahd.org), but there are others which are locally based.

TABLE 2

SPECIFIC APPROACH TO PARTICULAR HANDICAPS

IMPARED ABILITY TO

Swim
Physically handicapped program.

Communicate
Program for the deaf.
Program for the mentally handicapped?

Manage self-responsibility
Children’s diving program.

Control blood sugar
Diabetics program.

All organisations distinguish three certification levels:

Level I Disabled persons who are difficult to train, but may reach, as end point, an independent autonomous diving capacity and being able to help their buddy.
Level II Disabled divers who are able to dive without help, but not in all water conditions. They are usually unable to help their buddy.
Level III Handicapped persons which need continuous assistance from helpers.

The situation in Switzerland, and probably in the neighbouring countries as well, is marked by highly motivated diving instructors training some disabled people to a particular level certificate, but then leaving the divers on their own. A level I diver will join the non-handicapped divers once he has got the normal certificate. Other disabled people, especially level III divers, will need competent helpers for every dive. However these are difficult to find. It is unfortunate that handicapped divers do not easily find help from other diving organisations. Because they assess their candidates themselves, medical examiners of divers have very little contact with the handicapped diving organisations. It remains to be established how far the liability of the diving doctor goes in these cases. Divers with a disability are dissatisfied with the current system and feel discriminated against by not having a normal certificate, which would enable them to hire equipment and participate in diving trips.

Practical solutions

DIABETIC DIVERS

The Swiss Society for Underwater and Hyperbaric Medicine (SUHMS) has defined an algorithm for defining the conditions under which a diabetic person may dive.[1] Unstable diabetics on insulin and those with organic complications are unfit, while the rare maturity onset diabetes of the young allows unrestricted recreational diving activity. Diabetics, whether requiring insulin or not, with stable and uncomplicated diabetes may dive, but under special restrictions. The certificate contains a remark: "No decompression, less than 30 m, medically supervised log-book, next re-assessment in 3 months, supervised dives only".

TABLE 3

GUIDELINES FOR DIABETIC DIVERS
(adapted from Lerch)[2]

Reduce risk
Regular diving practice
Skills and knowledge of specific procedures
(handicapped diving program for diabetics)

Prevent complications
Good hydration before diving
(minimum of 2 l of liquid in the 2 hours before a dive)
Raised blood sugar
(> 9 mmol/l [160 mg/dl])
Dive to less than 30 m
(Nitrogen narcosis mimics the hypoglycaemic state)
Dive within the no-decompression limits
(emergency ascent is always possible)

Enhance safety during the dive
Glucose paste and glucagon easily available under water
Equipment for normobaric, 100% oxygen at surface
Buddy must be an experienced diver, informed and trained in the emergency treatment of a diabetic diver

Monitoring/supervision
Blood sugar testing should be done at 60 and 30 minutes and, importantly, just before the dive. Testing should be done immediately after the dive and 12 hours later
Special logbook (monitor every dive!)
Annual fit to dive examination should include specific assessment of logbook contents

The prospective diver contacts a handicapped divers office, where he or she receives a brochure and a log-book and is directed to one of the trained medical examiners of divers of the SUHMS. The doctor introduces the diver to the medical aspects of the diabetics safety plan. The guidelines are set out in table 3. A more detailed version is available at <www.suhms.org>. The diver then undergoes a normal diving course, where the instructor has to be informed and introduced into the technical aspects of the diabetics safety plan.

The diver logs all relevant data according to the guidelines, being supervised by the instructor and by the doctor as required. After having achieved the diving certificate a consultation with the diving doctor is needed to check the logbook and assess the trainee's understanding of the guidelines. The reassessment interval is set to 12 months and diving with an informed buddy permitted.

DIVING FOR CHILDREN

An extensive risk assessment concerning children was performed by Ducassé and Izard in 1987 for the French Divers Federation (Fédération Française d'Études et de Sports Sous-Marins or FFESSM).[3] A summary is given in table 4. The late maturation of the lungs and CNS are contraindications to using scuba gear in children under 8 years. Typical childish behaviour and insufficient ability to manage self-responsibility are the reasons for not attesting unrestricted fitness to dive. Between age 8-14 the following restrictions are written on the certificate: "only for introductory dives with an experienced buddy (children's training program)".

TABLE 4

SPECIFIC RISKS FOR CHILDREN
(From Ducassé and Izard 1987)[3]

Alveolar growth ends at about 8 years of age.
Lung compliance continues to develop until 18 years.
(Risk of barotrauma)
Risk of panting and inadequate ventilation leading to hypoxia at less than 8 years.
Frequent occurrence of otitis media.
Muscular function of Eustachian tube not fully developed in children.
(Risk of middle ear barotrauma)
High surface/weight ratio.
(Risk of hypothermia)
Limited ability to learn mathematics and physics before age of 8.
Emotional lability.
(Risk of sudden change of behaviour)
Searching behaviour.
(Risk of trying things out at inappropriate times)
Insufficient ability to face self-responsibility.
(Risk of not following instruction correctly)

The specialised training program of the FFESSM[4] consists of a series of introductory dives with emphasis on communication and knowledge of fauna and flora. At the end of a diving week the child is evaluated by the instructor on the basis of his observations and may get a sticker in bronze, silver or gold according to the level of experience (table 5), and eventually a special qualification ("buddy

TABLE 5

FFESSM TRAINING LEVELS FOR CHILDREN'S DIVING

Bronze

Can dress and undress.
Can clear ears, use regulator, swim in the blue.
Knows how to approach surface, some animals, some underwater signs.

Silver

Can clear ears, take off and replace mask.
Orientation, can get back to starting point.
Knows how to surface in different conditions, more animals and algae, all underwater signs.

Gold

Can care for equipment and contribute to group security.
Has improved diving techniques.
Knows creatures and their behaviour, and some ecology.
Knows theory of buoyancy, why to clear ears, why to expire during ascent.

diver", "small boats", "big boats", "BC jacket"). There are no tests and no lectures.

The guidelines for safe practice are summarised in table 6. The key for good supervision is a personal diving passport and a medical "livret". The passport contains the medical certificate (initial and reassessments at 6-12 months), training certificate, certificate of special qualifications, the log of all dives with the instructor's comments. The "livret médical" includes the guidelines for fitness to dive assessment and the informed consent declarations for each training progression (signature of child, parent, instructor and doctor) valid for 6 months only. This is extended to 12 months from age 12).

A detailed study of the "sharpened" diving medical assessment of children shows that besides the usual examining standards the FFESSM added 4 points:

1. Determination of growth percentiles
2. A rather uncommon stress test (Ruffier)
3. An ENT special examination with audiogram and tympanogram and teaching of ear equilibration procedures
4. Estimation of psychological development (see Table 7).

ECG, X-rays and lung function tests are performed only for special indications.

The lower age limit for World Underwater Federation (Confédération Mondiale des Activités Subaquatiques or CMAS) basic diver training is 14 years, the age at which children may use motorised vehicles in traffic in many countries. Exceptionally children, who have obtained all the above mentioned diving experience and competencies, may do the basic course at the age of 12 if the child, parents, diving instructor and doctor approve.

TABLE 6

FFESSM (=CMAS) STANDARDS FOR CHILDREN'S DIVING

Reduce risk
"Sharpened" fitness to dive assessment
Informed consent (child, parents, physician, diving instructor)

Prevent problems by modifying equipment to fit
Snorkel
Cylinders
Buoyancy jackets, buttons, valves
Exposure suit
Regulator provides assisted breathing

Enhance safety during dive
No lectures and licence oriented training (stress)
Buddy with special training (M* to m5, M** to 10m)
Limited depth (immediate ascent possible)
Time limits
Temperature limits
< 12°C No diving
12°C Not more than 10 minutes
> 12°C Not more than 25 minutes
< 25°C must wear full wet suit

Monitoring/supervision
Special log book
Special medical record book

Note
M* CMAS One Star instructor,
M** CMAS Two star Instructor.

TABLE 7

PSYCHOLOGICAL ASSESSMENT OF CHILDREN
(from "Livret médical")

Consideration should be given to
School history
General "impression" of the examining doctor
General "impression" of diving instructor (after the course is over)
General statement of Club doctor
Statement of parents

PHYSICALLY HANDICAPPED

Unfortunately practical solutions are scarce for the physically handicapped. In the Swiss Paraplegics Centre diving is a part of the rehabilitation sports, but for other wheel chair-dependent divers there are no particular structures available. In the long term these divers must not be sequestrated from the normal diving community, but integrated.

A good example is the diving section of the Sports University of Paderborn in Germany.[5] Sports students train together with a few disabled people and take them for excursions to as far as the Spanish coast.

The physician's role is reduced to the fitness to dive assessment which should be adapted to the training possibilities of the disabled (see table 8). The training agencies have a diving doctor as a backup for unexpected new problems.

TABLE 8

HANDICAPPED DIVERS' FITNESS TO DIVE

Unfit

If locomotion, communication or self-control are not continuously assured

If there is a danger of drowning

If unable to understand instructions

Restricted fitness

Informed consent, handicapped divers have to be informed about their specific risks.

Novices start at level III and progress to their final level.

Level III	"only for handicapped diving program"
Level II	"only with experienced and specifically trained buddy"
Level I	"time restrictions, avoid currents and exertion, special log book"

MENTALLY HANDICAPPED

There have been efforts in France[6] and Germany[7] to offer diving to this kind of disabled. However, we believe that there are absolute medical contraindications to this kind of diving (emotional instability, inability to understand theory, impaired communication). The behaviour of the mentally handicapped is much less foreseeable than in children.

DEAFNESS

Deaf people are physically and mentally fit, but extremely difficult to train. Once trained they have even better communication than non-handicapped divers if their buddy is also deaf. Their medical assessment needs special experience in the communication methods of the deaf.[8]

Conclusions

Diving doctors must be aware of their responsibility. They should avoid discriminating against handicapped persons as far as possible and also avoid the risk of provoking diving accidents by signing certifications as a favour.

We should establish a team approach, because each specialist has different experience and views, and many ideas are very provisional as they are not evidence based.

Underwater and Hyperbaric Medical Societies must use their authority and create centres of competence, or if possible excellence, in order to demonstrate a clear concept of minimal medical standards in spite of the different, competing training organisations. An acknowledged monitoring system (logbook) should be part of the fitness to dive assessment.

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HEALTH STATUS OF RECREATIONAL SCUBA DIVERS IN WESTERN AUSTRALIA

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Key Words

Ascent, equipment, fitness to dive, medical conditions and problems, low air.

Abstract

Background

Scuba diving is a physically demanding activity. Physical fitness is required to meet the routine demands of the aquatic environment, and to cope with unexpected environmental or equipment related (technical) problems. "Fitness to dive" is currently assessed by pre-training medical screening and the achievement of a minimum swimming distance. The health and physical fitness of diving trainees, however, has not been well defined. Similarly, the prevalence of diving related health and technical problems is not known.

Aims

To characterise the general health and fitness of recreational scuba divers and to identify any diving related health or technical problems.

Methods

Detailed health and diving questionnaires were mailed to 63 experienced divers and to 919 randomly selected subjects who had recently completed a PADI accredited diving course.

Results

The overall questionnaire response rate was 55%. 72% of respondents were male and 28% female, with mean age of 27 years (range 12-66). The divers' mean body mass index (BMI) was 23.5 (range 16-40), with 24% being overweight or obese (BMI>25). Current smokers made up 11.6% with 16.9% being ex-smokers. Most divers undertook regular exercise (88% >2 hours weekly), but only 26% swam regularly. Conditions which contraindicate diving (asthma, epilepsy or diabetes) were present in 10.4%. Minor dive related symptoms such as ear and headache were experienced by 52% of subjects. Dive-related technical problems (eg swimming difficulties, low-on-air, emergency ascent) had been experienced by 37% of respondents.

Discussion

While most recently trained divers are in good health, a significant proportion are either overweight and/or do not exercise regularly. Current medical screening is not effective at excluding people considered medically unfit for diving. Despite undertaking accredited training programs, many divers had experienced avoidable technical problems when diving. Given the prevalence of these problems, the relative lack of 'water fitness' of most divers is of particular concern.

Introduction

Scuba diving is a physically demanding activity. Diving fitness can be defined on a number of levels; strength, endurance and psychological factors.[1] Strength is very specific to the activity being undertaken and requires ongoing training to maintain. Regular swimming, preferably with scuba fins, is required to retain diving strength. Endurance is a cardiovascular phenomenon and relatively non-specific; i.e. it can be maintained by regular aerobic exercise of any form. Diving fitness also needs to consider both the physical demands of normal, comfort level diving and the sudden unanticipated demands that occasionally occur. Many divers have experienced unexpected changes in sea conditions or gear failures that suddenly necessitate a greater level of physical exertion to resolve. At the present time, scuba diving trainees undergo a simple swim test. They have to swim 200 m and they have to tread water for a couple of minutes. The energy requirement of different activities can be compared by a measure of workload, the metabolic equivalent (MET). To swim 200 m at one's own pace, requires only 6-7 METs. Treading water is more strenuous and requires 7-9 METs. Most people have to be moderately fit to achieve that, but certainly not very fit. In contrast, a diver in full gear requires a near-maximal exertion of 13 METs to swim at one knot.[1] Unless very fit, most people cannot exercise aerobically at this level. Anaerobic exercise can only be maintained for a minute or so before the diver becomes exhausted and slows down or stops.

A variety of medical conditions can also potentially affect diving fitness. In accordance with Australian Standard 4005.1,[2] all prospective scuba divers are required to undergo medical screening and participate in an accredited dive-training program. However, the efficacy of this strategy in detecting these medical contra-indications to diving has not been determined.

The scuba training process aims to teach divers to anticipate and avoid adverse environmental conditions, to detect gear problems before diving and how to cope with unexpected failures that arise during diving activity. The efficacy of this approach and the prevalence of such problems are, similarly, unknown.

Thus, we sort to characterise the general health and physical fitness of recently trained recreational scuba divers and to identify and quantify any diving related health or technical problems.

Methods

A total of 982 scuba divers from two discrete populations were studied to assess the reliability of applying results to the general Western Australian scuba diving population and for the purpose of comparing recently trained divers with more experienced divers. One group was 919 divers trained by the Professional Association of Diving Instructors Australia (PADI).[3] These divers were randomly selected from people who have completed a PADI accredited scuba diving course in Western Australia between January 1998 and June 1999. A further 63 divers were randomly selected from the University of Western Australia (UWA) Dive Club membership list.

Participants were mailed a detailed questionnaire which included questions about the general health and fitness of participants and problems they had encountered while diving. A covering letter was sent with all questionnaires, requesting divers' participation in the study and stating that all information provided was confidential and would not be available on an individual basis to the diving agencies. Questionnaires were returned directly to the UWA Department of Public Health. Non-respondents were sent a follow up letter and a second copy of the questionnaire one month after the initial mail out. A statistician from the University of Western Australia, Department of Public Health performed all data analysis, using the Statistical Package for the Social Sciences (SPSS). Statistical comparison between groups was by non-parametric chi-squared test, with $p<0.05$ being taken as significant.

Results

Forty questionnaires were returned without reaching the addressee. Most of these were international tourists that had listed their dive operator's or a hotel's address on dive training registration forms. The overall response rate in the remainder was 54.7% (515 of 942 possible respondents). The actual respondents were 477 (92.7%) PADI enrolled divers and 38 (7.3%) UWA divers. The response rate and findings were comparable between the two groups as 243 PADI divers responded (51%) as did 23 UWA divers (60.5%) (p not significant).

Overall, 343 (72%) of respondents were male and 134 (28%) were female. The mean age was 27 years, with a median age of 24 and a range from 12 to 66 years (Figure 1). There were 20 divers (4.2%) aged more than 50 years and 51 (10.7%) aged less than 16 years. Fifty five (11.6%) divers were current smokers. This is much lower than the general population prevalence of 24%.[4] Eighty one divers (17%) were ex-smokers. Self-reported height and weight were used to categorise 466 divers by body mass index (BMI) (Figure 2). Obesity (BMI>30) was present in 23 (4.9%) divers and 89 (19.1)% were overweight (BMI>25); of the overweight subjects 44 (9.4%) were borderline overweight (BMI 25-27) and 45 (9.7%) clearly overweight (BMI 27-30).

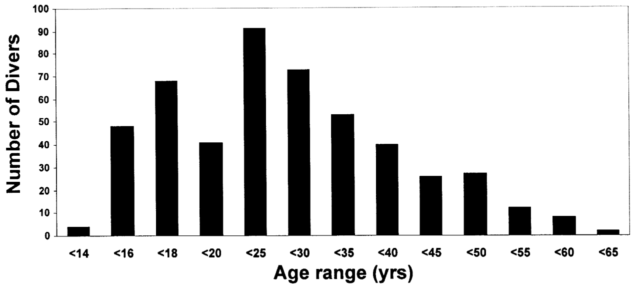

Figure 1. Number of divers in each age group.

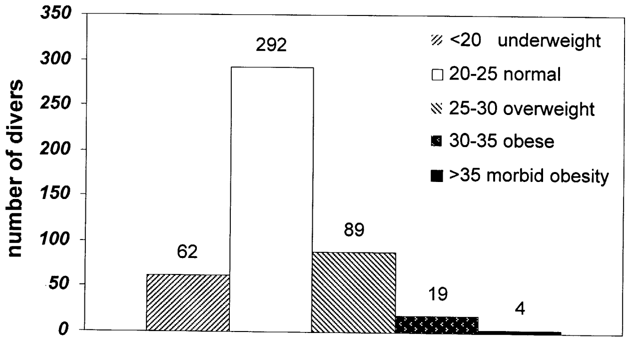

Figure 2. Body mass index of divers

Most divers (454 or 95.2%) had completed their basic dive training in Australia, and the majority (445 or 94%) had done basic diving courses since 1992, when the current Australian Standard for recreational diving training was introduced.[2] The divers' experience varied greatly, with 362 (75.9%) having done fewer than 20 dives since their training course; this included the majority of the recently trained divers. A further 87 (18.3%) had done between 20 and 100 dives and 28 (5.9%) having over 100 dives.

Divers were asked to estimate the average number of hours they spent doing various types of exercise each week. Exercise was then categorised, according to predefined criteria, as aerobic (including walking, jogging, team sports, cycling and others), isometric exercise (weight training) and water related activities (swimming and diving). The amount of exercise undertaken each week in each of the exercise categories is shown in Figure 3. Although most (420 or 88%) divers exercised regularly for more than 2 hours of aerobic exercise weekly) only 124 (26%) did two or more hours of water related activity each week.

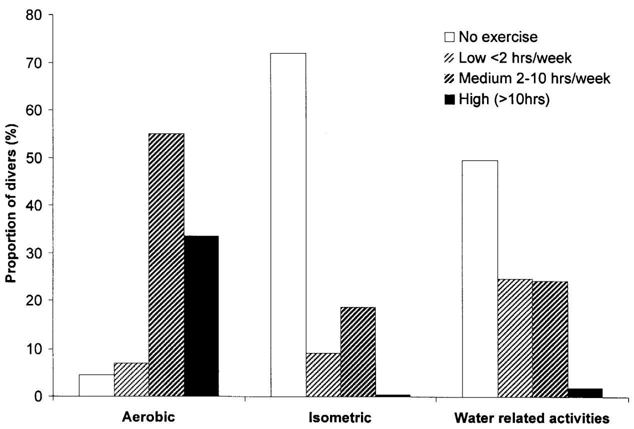

Figure 3. Levels of exercise

Completion of the Recreational Scuba Training Council questionnaire (RSTC) is an obligatory requirement before undertaking any PADI dive course.[3] Any positive response to this screening questionnaire then mandates formal medical assessment. The RSTC was the only pre-dive assessment completed by 51 (10.8%) of the respondents. Of those who had a formal health evaluation, the majority 417 (87.54% of all divers) had full dive medicals, including lung function tests. A further 19 (4%) divers reported having additional assessment by a medical specialist prior to undertaking dive training. Only 9 divers (1.9%) reported having no formal health assessment.

Medical conditions that are considered contra-indications to diving (AS4005.1)[2] such as current asthma, epilepsy or diabetes were present in 50 (10.5%) of subjects.[4] Most of these had undergone full dive medicals. A number of divers with these conditions commented how easy it was to avoid detection by a combination of misrepresentation of their medical history and/or pre-medication (e.g. bronchodilators) before the dive medical. Table 1 outlines the self-reported medical co-morbidities of the divers (more than one condition may have been present in each subject).

Other conditions reported by divers included orthopaedic problems, thyroid disease, haemochromatosis, congenital complete heart block, right bundle branch block and a colostomy bag. One diver reported progressive and near complete visual loss since passing his diving medical, yet he continued to dive.

TABLE 1

PREVALENCE OF MEDICAL CONDITIONS IN DIVERS IN WESTERN AUSTRALIA

Condition	Number	%
Current asthma as defined by AS 4005.1	46	9.7%
Chronic bronchitis/Emphysema	3	0.6%
Diabetes mellitus	1	0.2%
Epilepsy	5	1.0%
Ischaemic heart disease	1	0.2%
Hypertension	20	4.2%

Health problems during or immediately following diving were noted by 248 (52%) of the divers. The most prevalent were ear problems and headache, most likely due to problems with pressure equalisation and CO_2 retention in novice divers, respectively.[5-7] Significant symptoms such as dyspnoea, wheeze, chest pain or syncope occurred in 32 (6.8%) of divers.

One or more technical problems had been experienced by 177 (37.1%) divers (Table 2). This included a large number of divers (91 or 19%) who had become unexpectedly low on air, and 20 (4%) who had needed to ascend urgently because of perceived failure of air supply.

TABLE 2

PREVALENCE OF UNEXPECTED PROBLEMS WHILE DIVING

Problem	Number	%
Low on air	91	19.0%
Emergency ascent	20	3.7%
Unexpected difficulty swimming	113	23.7%
Equipment failure	32	6.8%

Each diver may have experienced more than one event

There were few significant differences between the recently trained PADI divers and the more experienced UWA cohort. The UWA divers were all older than 20 years, were more likely to have completed further dive training ($p<0.005$) and had completed a greater average number of dives ($p<0.0005$). These divers also experienced a greater number of technical and health problems, however, this finding is confounded by the difference in the number of dives.

Discussion

Safe diving requires adequate fitness levels in all participants. In this study, fitness was determined by assessing exercise, smoking, and BMI. Most divers undertook some form of aerobic exercise, but there was only a small proportion of divers who undertook regular water related activities. This could indicate the swimming fitness of this cohort of divers was sub-optimal. The study was conducted during late summer and the autumn months. We asked divers to indicate the amount of regular exercise they partook when they were diving. Even so, we may have under-estimated swimming fitness by surveying towards the cooler months of the year.

The prevalence of current smoking in divers was 11.6%, which is significantly lower than the general population prevalence of 24% ($p<0.01$).[8] A significant number (23) of divers were obese or very overweight (45), a total of 14.6% with BMI>27, conditions which maybe associated with impaired fitness.

Current medical screening is not effective at excluding people considered unfit for diving. Our data shows that divers with potentially lethal disease can escape detection under current screening guidelines. One diver had epilepsy with the most recent seizure only 6 months previously, despite taking regular anti-convulsant medication, and he has continued to dive subsequently. There is little doubt that a seizure underwater may well be fatal.

Another weakness of the current entry-level screening is that many subjects will continue to dive for years after their initial assessment and may subsequently develop significant disease. This is becoming more relevant as the mean age of both prospective and certified divers increases; already 5% of divers are older than 50 years. The importance of discussing the effects of any new medical conditions on their fitness to dive should be emphasised in training programs. Periodic health reviews, particularly of “older” divers would also potentially allow the detection of new health problems such as ischaemic heart disease.

This study highlights that, despite undertaking accredited training programs, many divers had experienced avoidable technical problems. Many of these are issues that instructor organisations would assume to have been effectively covered by dive training. The high prevalence of unexpected swimming difficulties emphasises the need for a high “survival” level of fitness. The large number of divers who had experienced unexpected low air or needed emergency ascent was greater than expected. Such scenarios could easily lead to panic situations, and this re-enforces the psychological aspect of diving fitness.[1] This may be particularly relevant when considering the 11% of divers who were less than 16 years or age.

It is possible that our survey respondents are not representative of recently trained scuba divers. Only 55% of people responded to the questionnaire, however, there is little reason to suspect any systematic bias in these respondents. With regard to the sample size, accurate figures for the total number of divers trained in the time period surveyed are not available, however commercial estimates are in the order of 10,000 individuals in Western Australia. The survey population approached represents 9% of this number and is statistically robust. Similarly, the study population is likely to be representative of the broader Australian recreational scuba diving community. Although a number of different dive agencies operate in Australia, PADI is the largest and is thought to train 80% of all divers. Overall, there were only small differences between the recent (PADI) trainees and the more experienced (UWA) divers. The increased number of problems is consistent with the greater number of dives; proportionally, there were fewer problems per dive in the UWA group, in keeping with their greater diving experience. The similarity of results in these samples supports the contention that these findings can be generalised to the broader Australian recreational diving population.

Conclusions

While most recently trained divers are in good health, a significant proportion are either overweight and/or do not exercise regularly. Current medical screening is not effective at excluding people considered medically unfit for diving. There is a definite need to re-evaluate the current screening methods, and to promote continued health surveillance in divers. Despite undertaking accredited training programs, many divers had experienced avoidable technical problems while diving. Given the prevalence of these problems, the relative lack of “swimming fitness” of most divers is of particular concern.

Acknowledgments

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The study was conceived by Dr Paul Langton who presented the paper in Fiji. The questionnaire design and data collection were by Rebecca Cresp, Carolyn Grove and Emma Lalor, in conjunction with Liora Valinsky. The project was performed as a component of the Public Health unit in fifth year medicine at UWA, and was co-supervised by Paul Langton and Liora Valinsky.

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AUDIENCE PARTICIPATION

David Taylor (Melbourne)

I am interested in what you have done as we did a similar study. I have concerns with some of the design of your project, particularly the selection of your candidates. You sent out questionnaires to I think 982 people, most of whom had recently been qualified. Now that and the fact that most of them had done fewer than 50 dives, suggests to me that this paper is a glimpse of the profile of young divers. We know that possibly up to 60% of this group might have stopped diving within a year of finishing their training. Were your responders representative of people like us who have dived for many years, the maintained diving population if you like.

Secondly a 55% response rate is probably about as good as you are going to get. It is very difficult to do better, but there is quite a potential for significant selection bias. I wonder whether you could comment whether the response rate is partly due to the fact that a lot of the divers who did not respond had actually given up diving since their course, or whether they were in fact ashamed to answer such a questionnaire.

Paul Langton

Firstly we wanted to get a broad picture of who was taking up diving. We had also tried to look at those subjects who continue to dive. We approached a number of local dive clubs but few if any maintained mailing lists; those that did were not happy to give us confidential access those mailing lists. Thus, unfortunately we had no good way of accessing a large group of active divers. We were fortunate in gaining the cooperation of the University dive club to look at their small number of divers.

Secondly, with respect to the question of responder bias, we looked carefully at all the variables and compared the experienced UWA to the recently trained divers. Although the UWA respondents was a relatively small group, the only variable they were consistently different on, was the number of dives, as you would expect. They were a little older, but they had experienced similar percentage of technical problems. They had similar health problems. It is true, that it is not a great snapshot of the current divers but within the limitations of what we could do, it is not bad. With regard to the response rate, 55% was much better than we expected. We tried to address the problem of potential responder bias by a non-responder survey. We picked, at random, a small number of people who had not responded and spent a some effort trying to contact them by phone and get them to complete a (limited) survey. The non-responder sample, when they did finally respond, had quite similar characteristics, certainly from our main outcome measures, which were actually asthma related. Our 55% sample of the original population is approximately 9% of the recently trained divers in Western Australia. That is actually quite a statistically robust proportion of the population. There are a number of other surveys that have been done world wide, mostly through the Diver Alert Network (DAN) organisation, which have been sampling only 1 to 2% of their populations.[9]

Aubrey Seknow (Melbourne)

As a diving medical examiner I am always aware of the obesity of some of the candidates that come in. Would you set a limit as to what BMI you would say to the person, well you are not fit to dive?

Paul Langton

There are theoretical risks and perhaps a little bit of data to suggest that obese divers are more prone to decompression related illness. I do not see that as the major issue though. I think it is more related to fitness because of the obviously inverse relationship between obesity and fitness. A lot of our divers are unfit and I think obese divers are more likely to have problems if trying to swim at high level if they encounter problems underwater. I think if a fat diver came to me and wanted to become a fit individual to take up diving, I would encourage them to get swimming fit. Now it is very likely that they would lose some weight as well, but I would argue that they need to be swimming fit and maintain that level of fitness as they continue to dive.

Aubrey Seknow (Melbourne)

Can you put a number on it? If the BMI is 35, would you then say no to them until they come back to you with a BMI that is more acceptable?

Paul Langton

I would not actually set a cut off. I think looking around some of the boats today, you would see a few people with BMI substantially above 30 who can dive without any problems. 35 is really morbid obesity and I would try and dissuade them from diving but I am not in a routine dive medical practice so perhaps others can better answer your question.

Vanessa Haller (Victoria)

I was surprised that asthma was not among the perceived medical problems. If someone does not say they have diabetes and I do not detect anything to suggest they may have diabetes, I do not explain to them the risk of diabetes and diving. I think this is likely to be the norm, so those having medicals would probably not have an idea of the risks of certain medical conditions.

Paul Langton

I agree fully. The asthma results I have taken out intentionally, as they will be presented in more detail subsequently. In fact we did even more on asthma than on the other medical and technical problems potentially affecting divers.

Diabetes should be picked up by prospective divers being honest and sometimes they are not. It should also be picked up by people admitting what medications they are on, but the dishonest ones are clever enough to fib about their medications as well. It is worth reminding ourselves that up to 50% of late-onset diabetes is undiagnosed, so some simple screening tests in the older dive candidate would be reasonable.

I seem to recall, at least when I did a diving course, that the instructors did mention the potential diving problems of diabetics. I am not sure whether this information is in the current course contents. Respondents were very, very clever in giving us comments on how they managed to avoid being detected with their various conditions.

Fiona Sharp (Perth)

A lot of the divers in your survey said they had swimming difficulties. I know a lot of simple drowning deaths have been due to people panicking. How does panic relate to the reported swimming difficulties?

Paul Langton

I think panic was a very big factor in some of the swimming difficulties reported by the divers. As they were a relatively inexperienced diving group, swimming difficulties may have reflected as much panic as anything. But if one is not fit, and one gets into an unusual situation you are more likely to panic. It is difficult to dissect out the factors, but I agree, panic is a very big factor.

Jürg Wendling (Switzerland)

I think we would probably all agree that a person with the very high body mass index or other risk is not fully fit for unrestricted diving. In Switzerland we have restricted fitness which is not as fit as being declared fit for unrestricted diving. We have problems in managing with these restrictions.

First of all we have to explain to the candidate where his problems are and where he has some restriction. In the Swiss guidelines, for instance, we have recommendations to give them advice not to go diving in rough conditions or for other things. I think there is no reason for a depth limit, but there is a reason to recommend no decompression dives. For instance for the asthmatic, if he has any symptom he must go up immediately. This is not unrestricted fitness for all categories because we do not know what they will do next. The problem is, what shall we write on the certificate? Is it just an informed consent? Should we have this countersigned by the candidate in our protocol or should we write this on the certification. I do not know the answer.

Paul Langton

I think that system is reasonable in some circumstances. However, although we can say do not dive if the water conditions are rough, over 20% of the divers had encountered unexpected swimming problems. Also, almost 20% had encountered unexpected problems with gear failure or running low on air. The prevalence of problems is so high that I think it is difficult just to recommend that an individual only dives in nice easy conditions and makes sure their tank is full and that they surface before the tank is empty.

The reality is that is not going to happen. All the recently trained divers, having done a PADI course, will have been educated about how they should dive. And many of them are, in fact, still diving with relatively well supervised dive clubs with dive masters etc, and there were still a lot of unexpected problems.

A REVIEW OF THE EFFECTIVENESS OF THE RESORT STYLE MEDICAL DECLARATION IN QUEENSLAND

Chris Coxon

Note

Chris Coxon is a Senior Inspector with the Department of Employment, Training and Industrial Relations, Division of Workplace Health and Safety, of the Queensland Government. He is based in Cairns. He has worked extensively in the recreational diving industry as a PADI Instructor and had an intimate knowledge of industry practice across north Queensland.

The opinions offered in this paper are those of the author and do not represent the views or policy of the Department of Employment, Training and Industrial Relations.

Key Words

Medical standards, recreational diving.

Abstract

Resort diving, being an introductory scuba experience or introductory educational diving program conducted to a recreational scuba training organisation's standards, probably forms the single largest sector of the Queensland diving industry in terms of numbers of participants.

Resort dives take place in open water environments to a maximum depth of 12 m, usually for 20-40 minutes, in groups of a maximum of four participants to one instructor or six participants to one instructor and one certified assistant. The dives are, typically, immediately preceded by a short period of theory and in-water instruction. Participants fill in a medical declaration and there are age restrictions.

There has not been a notified fatal resort diving incident in Queensland since two were recorded in 1993. This contrasts with all other sectors of the recreational diving industry in the same period.

Following the 1993 incidents, legislation governing recreational diving in Queensland was reviewed and the Code of Practice for Recreational Diving and Recreational Snorkelling was gazetted in 1995 with increased focus on resort diving standards. In the intervening period, education and enforcement of these standards was expanded with the number of Workplace Health and Safety Inspectors working with the diving industry rising from two to five. The latest review of standards is the enactment of the Compressed Air Recreational Diving and Recreational Snorkelling Industry Code of Practice and Regulation 1999. Currently Queensland is the only state in Australia with this type of legislation.

Throughout this period the key role of the medical fitness declaration for resort divers has been acknowledged by operators, training agencies, regulators and the diving medical fraternity. However the resort diving medical declaration has also been widely criticised as ineffective.

A study of declarations from four Cairns-based day trip dive operators reveals levels of identification of medical conditions similar to those found by medical practitioners with regard to the more extensive open water course style medical questionnaire. Coupled with the apparent low fatal incident rate, a case can be made for the overall effectiveness of this system in Queensland.

Resort Diving

Resort Diving in Queensland is dominated by two training agency programs, the Scuba Schools International (SSI) Introductory Diving Experience and the Professional Association of Diving Instructors (PADI) Discover Scuba Diving Program. The sobriquet "resort diving" seems to have stemmed from the initial popularity of this style of diving on island resorts. The programs typically aim to give a one off experience to introduce a person to compressed air diving.

Both agency programs are similar, with several companies offering both in an interchangeable manner. Table 1 shows certain aspects of the courses which are stipulated in either the Queensland Government's Workplace Health and Safety Regulation Amendment (No.2) 1999 or Compressed Air Recreational Diving and Recreational Snorkelling Industry Code of Practice (1999).[1,2]

The resort dive program typically consists of four stages. The first is to sign up and evaluate potential participants. The role of the medical declaration in this process will be discussed in more detail.

Secondly, participants attend a theory session, usually lasting from between 20 to 40 minutes. In the PADI system this includes the compulsory use of a flip chart which is available in several languages. There is also an eight question true/false style questionnaire at the end of this presentation. The SSI system grants more flexibility to the instructor to determine the extent of instruction required. Although in some cases this session is conducted at some time prior to the dive taking place, it is more typical for this to occur as a vessel proceeds to the reef or upon its arrival.

Thirdly there is a water skills session. As with the theory session there is a discrepancy between the agencies,

TABLE 1

ISSUES ADDRESSED REGARDING RESORT DIVING IN THE QUEENSLAND WORKPLACE HEALTH AND SAFETY AMENDMENT REGULATION (NO.2) 1999 AND THE INDUSTRY CODE OF PRACTICE FOR COMPRESSED AIR RECREATIONAL DIVING AND RECREATIONAL SNORKELLING

Regulatory Elements (Mandatory)	Code Elements (Advisory)
Medical declaration	In water supervision methods
Dive safety log	Appropriate skills and knowledge of divers
In water supervision ratios	Instruction and advice to non-English speaking divers.
	Equipment for diving
	Diving depths

with PADI opting for set skills requirement and SSI leaving it more towards the instructor's discretion, with a few mandatory elements. This may take place in a variety of settings offering confined water conditions, such as a resort pool, off a beach, on a platform, bar or rope arrangement hung from a vessel, or even from custom built "moon pools" which have become a standard feature on most reef pontoons. Typically this session lasts between two and 15 minutes.

Finally there is the dive itself. Here the agencies revert to a similar standard and the regulatory involvement is highest. Dives are restricted to a maximum depth of 12 m although most dives take place in about six m. The sites selected are normally used on a daily basis and despite sometimes less than perfect conditions, are usually well known to the instructors. Many sites have been modified, for example with guiding ropes or bars, to ease the control of the group. Many operators used certified assistants, such as divemasters (PADI) or dive controllers (SSI) to raise ratio numbers and provide extra supervision. In recent years the advent of a viable video retail industry and increased use of "diver training for work" programs have helped increase the numbers of qualified, or semi-qualified, persons escorting a group of resort divers. Some companies advocate a simple "all dives are hand-held policy" and most restrict the distance travelled by the divers to about 30 m from the starting point. The time spent underwater is usually between 20 and 40 minutes.

TABLE 2

RESORT COURSES IN QUEENSLAND, FROM A STUDY INTO THE NUMBER OF DIVES CONDUCTED ON THE GREAT BARRIER REEF IN 1994.

Cairns	83,000
Townsville	4,500
Whitsundays	34,000
Capricorn Bunker	5,500
SE Queensland (non-GBRMPA permits)	2,500
Total	**129,500**

The scope of resort diving in North Queensland

There is a dearth of good and recent data on how many people dive in Queensland, how many dives they do and what categories they fall into. The Great Barrier Reef Marine Park Authority (GBRMPA) studied the number of dives (Table 2) in its various areas for 1994.[3]

The same study concluded that a total of 1,290,500 dives were done in total, making resort diving approximately 10% of the total. It also concluded that 60% of all Queensland diving took place between Lizard Island and Innisfail.

In 1994 the average cost of a resort dive was $65, thereby generating an overall earning of $5,395,000. The average cost in 1999 has risen to approximately $80.[4]

These figures were constructed on the number of dives, not the number of divers. One diver undertaking an open water course will undertake a minimum of 4 dives. A certified diver on a 4 day dive trip will usually do about 12 dives. However, typically, the resort diver does a single dive only. Applying these figures to the Cairns region suggests that, in the same period, there were 5,500 open water certifications (22,000 dives) and 60,000 certified divers (720,000 dives). Thus it would appear that resort divers constitute the single largest group of divers (83,000) although their exposure to the risks of diving are limited by their, typically, single dive experience.

Locally gathered figures for 1999 concluded that there were 125,581 resort dives in the Cairns Region in 1999. This represents an approximate 50% growth in 5 years. Anecdotal evidence suggests that this rate of growth for resort diving far surpasses other sectors of the recreational diving industry.

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The resort diving market is quite sectoral, both geographically and amongst operators. However its low entry hurdles and mass marketing possibilities make it the mainstay of an increasing number of diving operations ranging from back-packer vessels to the largest reef pontoon operators.[5]

The incidents

As discussed above, there is limited data available for comparative comment on rates of diving incidents.

Instead discussion often focuses on the anecdotal nature of particular incidents which can only be of little value in an overall assessment of the efficacy of the various control measures used to minimise the risks associated with this type of diving.[6]

All workplaces in Queensland are required to notify the Division of Workplace Health and Safety of certain categories of workplace incident. These include fatalities and hospitalisations.

Compliance with these notification requirements may not be complete, but are best with the most significant incidents i.e. fatalities.

Anecdotal evidence suggests that there are many lower level incidents, such as ear and sinus barotrauma that go unrecorded.[7] Nonetheless Table 3 shows that resort diving fatality statistics are amongst the lowest levels in the recreational diving industry and that there has not been a fatal incident in Queensland since 1994.

In each of the three resort diving fatalities the person became separated from their instructor.

None of the incidents recorded a known medical precondition as a significant contributory factor although one showed a severe myocardial infarction on post mortem.

There is widely held belief amongst recreational diving operators that two main factors contribute to this low incident rate, these being close in-water supervision and the pre-dive screening provided by the resort dive medical declaration.

The resort dive medical declaration

The current resort dive medical declaration has had a chequered history. In Queensland this document stemmed from an original developed by Dr Bob Thomas for remote location use (the original resort concept).[8] However, once in use, diver employer groups such as the Queensland Dive Tourism and Travel Association (QDTAA) and later Dive Queensland picked it up as a medical screen. It can be found in both PADI and SSI agency standards and has appeared firstly as a both an advisory and most recently a regulatory element in Workplace Health and Safety Legislation.[1]

The layout has changed somewhat over the years, both in terms of individual questions and the format.

TABLE 3

RECREATIONAL DIVING AND SNORKELLING FATALITIES APRIL 1993- 31 DECEMBER 1999, QUEENSLAND. SOURCE: DIVISION OF WORKPLACE HEALTH AND SAFETY INSPECTION AND ADVISORY SERVICES DATABASE

	Resort	Training	Certified	Workers	Total Divers	Snorkellers
93	1	1	2	1	5	3
94	2	0	1	0	3	1
95	0	1	2	0	3	1
96	0	0	1	0	1	9
97	0	0	1	0	1	13
98	0	1	4	1	6	2
99	0	1	1	0	2	5
Sub total	3	4	12	2		
Total					**21**	**34**

Originally it was in a questionnaire style but is now a declaration.

The form consists of three sections. Firstly are the "have you ever had" statements, then "Are you currently suffering from" and finally selected individual questions. The language is relatively non-medical in its terminology and the declaration is available in 12 languages from the Division of Workplace Health and Safety.

The purpose of the declaration is not to exclude a person from diving per se. Instead it is to exclude a person from a resort diving program until a medical practitioner has a chance to query them on the issue. Simply a "Yes" to any question on the declaration renders the participant unable to dive without a medical practitioner's approval.

Critics of this process may point to its prescriptive and arbitrary nature. Undoubtedly it is both of these and many persons who may, after proper consultation with a diving medical practitioner, be allowed to dive are restricted from undertaking a resort dive. However, as a tool to be used by essentially medically untrained persons, diving instructors, who seek clear, if not always medically valid delineation, the advantages of such a process should be clear.

Many operators have developed a relationship with a diving medical practitioner to allow queries or borderline cases to be reviewed, usually via a radio or telephone consultation. Despite the cautious responses from most medical practitioners involved,[9] it remains a valuable part of the process.

The value of this is most commonly seen as a strategy to minimise the likelihood of a person lying. Assuming that a person completing the declaration wishes to undertake the resort dive, there may be a compulsion for the person to conceal a medical issue raised by the declaration. This type of problem must bedevil any sort of screening process for any condition not readily picked up by an examination. Where a medical practitioner is portrayed as the final arbitrator, there is less compulsion to lie on the original form presented to the dive instructor.

The ethical standards of the individual operator and instructor are the final hurdle for this process. Particularly where pay rates are linked to the numbers of dives undertaken, there may be an incentive to ignore, avoid, alter or dissuade the correct filling in of the declaration. In this area the prescriptive nature of the Workplace Health and Safety Regulation and penalties attached must serve as a reminder to all operators of the importance to follow the spirit as well as the letter of the declaration.

Since 1989, the Division of Workplace Health and Safety has mounted successful prosecutions of operators over resort diving incidents and has increased its enforcement, education and monitoring role across Queensland by expanding the original force of two diving Inspectors to five.

Both training agencies also maintain quality assurance and education strategies to maintain compliance with their particular standards.

The Study

To maintain a level of confidence in the resort dive medical declaration as a screening tool for prospective participants, it would be reasonable to compare the identification rate and type of condition that it identified with the other similar screening process in the recreational diving industry. This is the AS4005.1 medical questionnaire given to prospective open water course students by a diving medical practitioner.

Four Cairns-based dive operators were approached who agreed to partake in the study. All operated day trips to reef sites off Cairns and resort diving formed the major part of their diving business. Each operator paid their dive instructors with an incentive commission based on the numbers of divers taken and for repeat dives.

Each operator was asked to provide a complete selection of completed of medical declarations. All of the operators had policies to keep all completed declarations. However it was related that staff occasionally threw declarations disclosing a medical condition away on board. Others had to be discarded in the study where there was insufficient or confusing information on the form.

An indication of a medical condition does not necessarily imply that the person did not dive. However this was usually the case. The review process by the instructor, often including a radio or telephone consultation with a medical practitioner, would be the final arbitrator. This was not a mechanism to cast dive instructors in the role of medical examiner, but more usually the case to clarify an issue or misunderstanding. For example it is common that a person will indicate a medication with a brand name without any clear knowledge of what it is for. Similarly some issues do not translate well. The Mandarin for ear surgery is frequently taken to include ear piercing by prospective participants.

The results of the study are shown, by operator and condition, in Table 4.

The operators differed in one major respect. Two of the operators offered a generalised reef trip with diving, snorkelling, glass bottom boat tours etc (Numbers 1 and 2). They distributed dive medical declarations to all customers on boarding. This was done primarily as a marketing tool so that all clients on board could be potential resort dive customers. It served a safety function in that enabled the crew to be aware of the medical conditions of other types of customers, including certified divers and snorkellers, as well. The declarations were then reviewed with those deemed as fit to dive and of the correct age moving automatically to the theory lesson part of the day. Once this was completed all customers, unless they actively "opted out", were grouped into dive groups and allotted a time. In this dive all divers were required to perform the necessary skills in confined water. It was at this moment that the customer was required to acknowledge, with a signal, that they wished to proceed with the dive itself, and consequently pay for the experience.

The reality is that it is usual, for any group of four allocated to a particular dive, that at least one and occasionally all four limit their dive experience to the confined water experience and do not proceed away from the vessel. However as a marketing tool it is typical for

TABLE 4

CONDITIONS INDICATED ON THE DIVE MEDICAL DECLARATIONS OF FOUR CAIRNS DAY DIVE TRIP OPERATORS

	Operators					Totals %
	1	**2**	**3**	**4**	**All**	
Total declarations	**2,051**	**536**	**660**	**141**	**3,388**	
Incomplete/unclear	**19**	**21**	**9**	**6**	**55**	
Total available for study	**2,032**	**515**	**651**	**135**	**3,333**	
Total indicating medical conditions	**179**	**40**	**39**	**8**	**266**	**100%**
% indicating medical conditions	**9%**	**8%**	**6%**	**6%**	**8%**	
Medical conditions						
PULMONARY						
Asthma or Wheezing	98	22	19	4	143	53.8%
Chronic Bronchitis or persistent chest complaint	4	0	0	0	4	1.5%
Collapsed lung (Pneumothorax)	2	0	0	0	2	0.9%
TB or other long term lung disease	0	0	0	0	0	0.0%
Breathlessness	1	0	0	0	1	0.4%
CARDIOVASCULAR						
Chest Surgery	2	0	1	0	3	1.2%
Heart disease of any kind	4	2	0	0	6	2.3%
High blood pressure	18	3	2	0	23	8.6%
LIABLE TO ALTER CONSCIOUS STATE						
Diabetes mellitus	6	1	0	0	7	2.6%
Epilepsy	2	1	0	0	3	1.2%
Fainting, seizures, blackouts	0	1	0	1	2	0.9%
EARS AND SINUS						
Chronic sinus conditions	1	1	0	0	2	0.9%
Ear surgery	3	0	0	0	3	1.2%
Recurrent ear problems when flying	6	0	1	0	7	2.6%
Chronic ear discharge or infection	6	1	2	0	9	3.4%
Perforated eardrum	4	1	0	0	5	1.9%
OTHERS						
Brain, spinal cord or nervous disorder	1	0	1	0	2	0.9%
Other illness or operation within the last month	4	1	0	1	6	2.3%
Currently taking medicine or drug (excluding oral contraceptive)	13	5	5	1	24	9.0%
Alcohol within last 8 hours	3	1	0	0	4	1.5%
Pregnant	1	0	1	0	2	0.9%
Combined disorders	0	0	7	1	8	3.0%

vessels operating this type of system to take approximately 60% of their customers on a resort dive.

The other two operators (Numbers 3 and 4) used an “opt in” type of system. The resort dive program was promoted on the vessel using a variety of media with interested persons requested to approach the dive staff. This promotion usually would include face to face promotion with one or more diver instructors moving through the vessel. Once a person had approached the dive workers, they were then requested to complete the dive medical declaration. There would often be a pre-screening process, particularly when the style of declaration was a specially printed version, such as that produced by PADI as a part of the Discover Scuba Diving Program. This would involve the instructor talking to a person before requesting them to complete a medical declaration. Medical conditions may be discovered in this process and hence no declaration completed.

The day would then proceed with the theory session, division into groups, in water skills and then the dive. The dropout rate for this process tends to be much lower but typically the overall participation rate on a vessel is lower, typically around the 20% rate.

Both systems, and also questionnaires completed for diving medical practitioners, all suffer from a further pre-screening process that may take place formally, for example with booking agents advising persons regarding medical conditions when a trip is booked. This also takes place informally, particularly in the more developed information networks of backpacker-type participants, where information and advice (often incorrect!) is passed from person to person regarding this process.

This has two outcomes. Firstly it means that persons with listed conditions do not attempt to participate in a resort dive. Secondly it better prepares a person to lie or ignore questions about a particular condition.

Discussion

In his examination of the relative importance of different parts of the open water diving medical in identifying fitness to dive and the detection of asthma, Dr John Parker showed that, in his sample group, 9.8% were failed as fit to dive[10,11] In his break up of the four stages of the medical examination process, the questionnaire, the interview with the diver, the physical examination and investigations, he indicated that 48% of the failed group were anticipated through the questionnaire. This represents 5.2% of the whole examined population. If this is combined with the second stage of his examination, the total failed during these two processes represent 6.8% of the examined population.

The detection rates for the resort dive medical declaration provide detection percentages consistent or marginally higher than those in Dr Parker’s study. This may lend some credibility to the capacity of the screening process of the resort dive medical declaration. However, the 3.9% of the failures identified by Dr Parker through examination and investigation are unable to be detected by the resort dive medical declaration.

This discrepancy should only matter if there is a difference in the outcome regarding diving incidents stemming from acknowledged medical conditions that materially contributed to an incident. For this to be accurately determined there would have to be experimental

TABLE 5

ADVANTAGES AND DISADVANTAGES OF THE RESORT DIVE MEDICAL DECLARATION SYSTEM AND THE OPEN WATER STYLE MEDICAL EXAMINATION BY A DIVING MEDICAL PRACTITIONER

Advantages	Disadvantages
<u>Resort Dive Medical Declaration</u>	
Quick	Limited scope
Simple	Administered by persons of limited medical training
Cheap	Subject to external operational/ fiscal pressures
Less reliant on medically trained persons and equipment	Arbitrary
Current	
<u>Open Water Style Medical Examination</u>	
More comprehensive	Lengthy
Diving medical practitioner	Usually one-off check
Examination and investigations	Expensive
Qualitative outcomes eg conditional certificates	Reliant on medically trained persons and equipment
	Subject to external operational/fiscal pressures

measurement against a control group, which is ethically unlikely to take place, or a comparable difference between the two main medical screening systems and particular incidents. As the overall numbers of documented incidents are so low and the rates of participation inaccurately known, quantitative comparisons are of limited value.

Instead it is probably of more use to acknowledge the relative effectiveness of both systems and consider their relative merits and disadvantages (see Table 5)

Conclusions

The resort dive medical declaration provides a widely used system of screening potential participants for a popular but limited diving experience. Despite limited anecdotal evidence based on particular incidents, it is possible to demonstrate with some confidence that the screening process identifies similar numbers of medical conditions of concern as the similar questionnaire part of the open water style medical examination.[10,11] Within a regulatory framework provided under the Workplace Health and Safety Act 1995 in Queensland to enforce compliance levels on operators, this system appears to manage the risks posed by pre-existing and acknowledged medical conditions to this group of divers.

Acknowledgments

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GLEANINGS FROM MEDICAL JOURNALS

Cigarette smoking and transcutaneous oxygen tensions: a case report

Strauss MB, Winant DM, Strauss AG and Hart GB.
Undersea Hyper Med 2000; 27 (1): 43-46

We report the effects of acute smoking cessation on transcutaneous oxygen ($PtcO_2$) measurements in room air and with hyperbaric oxygen (HBO_2) of an extremity at risk for amputation. The reports on cigarette smoking and $PtcO_2$ do not discuss acute smoking cessation. $PtcO_2$ measured 46 h after smoking cessation increased 10% while breathing room air and 34% with HBO_2, as compared to measurements made before smoking cessation.

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Key Words
Hyperbaric research, medical conditions and problems, oxygen, reprinted.

ARTICLES OF INTEREST REPRINTED FROM OTHER JOURNALS

ARE REBREATHERS SAFE?

John Q Trigger

Key Words
Accidents, deaths, equipment, rebreathing, reprinted.

Diving magazines are full of ads and hoopla about rebreathers, trying to get the sport diving community to make them their next big purchase. However, rebreathers are extremely expensive (like five figures!), and a spate of recent deaths has given them the image of being complex and dangerous.

Many divers know little about rebreathers beyond their basic function: the ability of some units to purge carbon dioxide from recycled air and to eliminate exhaled bubbles, making them a boon to photographers and those who want to approach big fish.

Rebreathers are not new. Because of their quiet operation, stealthy lack of bubbles, and the long dive times they enable, rebreathers have been used by the military for years, including extensive use in WW II. Civilian use includes underwater photography, above-ground mine rescue, and underwater scientific expeditions such as cave exploration. Their encroachment into the recreational market has been recent, although several live-aboards and a few resorts now rent them after giving divers a short training course. In places like Cocos Island, their lack of bubbles helps divers approach the big pelagics.

Rebreathers have made few inroads into the U S sports diving market. While they were on centre stage at the Diving Equipment and Marketing Association shows in 1997 and 1998, at the 1999 New Orleans show their promotion had been greatly reduced.

In the UK, safety concerns are so severe that in 1998 the British Sub-Aqua Club (www.bsac.com) announced it was prohibiting its 50,000 members from using rebreathers on BSAC dives. Although the BSAC subsequently modified its stand to enable the use of semi-closed circuit rebreathers, the use of closed-circuit rebreathers within the BSAC is still (1999) prohibited.

According to DAN's Joel Dovenbarger, DAN is aware of only two rebreather deaths in the US, one in Washington state last year (1998) and the highly-publicised death of 72-year-old Nobel-prize-winning physicist Henry W Kendell during the Wakulla 2 cave exploration in February 1999. The circumstances of Kendell's death certainly sparked rebreather controversy. Kendell was diving alone, in clear violation of both Wakulla's rules and Florida state parks regulations. After his body was recovered, the team doctor issued a report that a valve on Kendell's Cis-Lunar MK-5 rebreather was improperly adjusted, which caused him to black out due to lack of oxygen. Later, the Florida State Medical Examiner determined that Kendell had suffered a fatal gastrointestinal haemorrhage. Subsequently, the Wakulla 2 Expedition issued a statement that Kendell "died from natural causes and his unfortunate death bore no relationship to either the predive procedures that he followed that day or the dive equipment that he used. [We regret] to have rushed to judgment."

However, the rash of 1998 British rebreather deaths are cause for concern. Besides the Cis-Lunar MK-5 death at Wakulla, according to industry sources there have been four rebreather deaths attributed to the Buddy Inspiration, six associated with Draeger (www.draegerdive.com) units and one linked to a Carleton Mk 16 rebreather. Not all final autopsy reports have been completed, and the BSAC says that it is not prepared "to comment speculatively on the cause of any of the individual rebreather fatalities". But one conclusion is obvious: according to Martin Parker, owner and managing director of AP Valves, which manufacturers the Buddy Inspiration rebreather, as of February 23, 1999, the statistics stood at 4 Buddy Inspiration deaths out of 4,000 Inspiration rebreather hours dived. Whatever the cause, statistically this is an incredibly high rate.

Manufacturers such as Carleton (www.carltech-marine.com) and Inspiration defend their products but are not permitted to comment on the deaths until after the autopsy reports have been filed. However, industry spokesmen did tell *Undercurrent* that the Royal Navy had informally reported that some of the deaths are due to natural causes, and these spokesmen also said that preliminary reports in other incidents pointed to "the user making fundamental mistakes with regard to basic equipment assembly, set up, or monitoring". Still, if deadly errors are this easy to make, shouldn't users have cause for concern ?

Rebreather models vary considerably. There are variations between computer or mechanically controlled units and single mix or multiple gas units as well as basic design differences between closed and semi-closed circuit rebreathers. (Closed circuit units totally recirculate the breathing gases, keeping the proportions of the gases in balance by employing a sensor to add oxygen when it falls below the specified level and using a scrubbing material to absorb and remove excess carbon dioxide. They eliminate exhaled bubbles except on ascent, when they release the expanding gases to stabilise pressure on the breathing loop. Semi-closed circuit units, on the other hand, only recirculate part of the exhaled gas and discharge the rest with each breath. Oxygen levels are maintained by a fixed supply of compressed gas each minute. However, increased exercise can induce anoxia when the oxygen supply becomes inadequate.)

Units have a wide scope of possible mechanical problems ranging from flooding the breathing loop to maladjustments in the sensors that control the gas mix. Maintenance is involved and pricey, especially with models that incorporate oxygen sensors. The training required to use rebreathers safely is far more extensive than, say, training for Nitrox certification. Because of the wide variation between models, there are substantial differences in training programs. Charges of inadequate training and cavalier attitudes toward rebreather usage have been bandied about extensively in explanation of the recent deaths.

Rebreathers have also been associated with a wide range of possible medical problems, any one of which can precipitate a serious dive emergency. Sudden depth changes can stymie rebreather electronics: a quick ascent, especially one where a diver is working against a strong current, can result in oxygen dropping below safe levels. An abrupt descent can cause the opposite problem. There are added risks of hyperventilation and carbon dioxide build up as well as unique decompression sickness considerations for closed circuit and semi-closed circuit systems. Oxygen toxicity (convulsions) is possible at any depth.

While official confirmations of cause of death have not been released in many incidents, some unconfirmed reports have pointed toward natural causes, operator error and inadequate backup systems. The fact that accidents seem to occur at different stages of the dive, some on the bottom, some on ascent and some on descent, makes it hard to spot a trend, although in some instances the suspected cause of death has been oxygen poisoning. Unconfirmed reports regarding problems with units recovered after fatal or near fatal accidents have also been varied, with reports mentioning recovered units in which the oxygen was turned off, units which did not have an open-circuit bail-out fitted and units which were not in "dive mode" when the diver entered the water, a situation that reportedly would make it impossible for the user to control the oxygen level.

Many deaths have reportedly involved divers with extensive opencircuit scuba experience but only minimal rebreather training and experience. AP Valves, manufacturer of the Buddy Inspiration (<www.apvalves.com>), has reportedly begun offering additional free training to all owners. Unfortunately, the question of how much training is enough has yet to be definitively addressed by the industry. Manufacturers require training when units are purchased, but there are no industry-wide training requirements and little agreement about either how much training is necessary or what constitutes safe rebreather design. Issues of how much redundancy to build into units, what sensors and displays should be included, and whether control systems should be computerised or manual have been left up to manufacturers and purchasers.

Cost is certainly a factor. For example, it is hard to fault the triple redundancy built into the CisLunar MK-5P and the company's training requirements are extensive (to purchase the unit, they require a 7 day basic training course that qualifies divers to use their MK-5P to a maximum depth of 165 ft [50 m]), but the $17,500 price tag, which does not include the cost of training, is hard to swallow. (For more info on CisLunar, see <www.cis-lunar.com>.)

While some may view the BSAC response to the UK deaths as alarmist, it is certainly a fledgling effort to set initial industry-wide standards, albeit conservative ones. The BSAC's current position on rebreather use permits only semi-closed circuit rebreathers using Nitrox (no pure oxygen rebreathers are permitted); users must carry an open circuit bail-out and dives cannot exceed 40 m. The BSAC's recommendations for rebreather users on non-BSAC dives are less stringent and appear aimed at the identified problems: get comprehensive training; follow manufacturer's recommendations for preparation, maintenance, servicing, and operation; gain progressive shallow-water experience before attempting deeper dives; stay above 50 m; use only air, oxygen, or Nitrox; and do not dive alone.

Experienced divers have spent years buying new pieces of equipment and sticking them on their backs, but using rebreathers takes more than a little getting used to. Because buoyancy and exhalation are so different from open-circuit scuba, there's enough of an "unlearning curve" that some instructors actually claim that novice divers may have an advantage in mastering rebreather use. Given the units' complexity, the deaths of several experienced divers, and such extensive differences between rebreather models that you cannot switch from one to another without additional training, there is plenty of reason for caution. In fact, that is a concession that even manufacturers are making. Martin Parker offers this succinct advice: "The diver needs to change his open-circuit thinking and remember one thing — you do not breathe from the loop unless you know what you are breathing".

Diver Barry Lee Brisco offered this summary of the problem from September 1998's "Rebreather Forum 2.0" organised by Michael Menduno in Redondo Beach, California:

"At the top of the agenda was the fact that although extensive training is mandatory when a rebreather is purchased, there are no industry-wide training standards in place, [a situation] reminiscent of the fledgling dive industry forty years ago .... Training standards are complicated by the fact that rebreathers vary significantly in design. This is in contrast to open circuit scuba, where from the diver's point of view, one regulator is used like another: air on, purge and go. Try that with a rebreather you have not been trained on and you are more than likely to end up a fatality statistic."

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