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SPUMS

Children in Diving

Blood sugar levels in diabetics during HBO_2
Travel medicine: Post-travel illness
The technical lowdown on rebreathers
Diving and hyperbaric medicine in South Africa

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OBJECTS OF THE SOCIETY

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

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Membership is open to all medical practitioners.
Associate membership is open to all those who are not medical practitioners but are interested in the aims of the Society, and/or those engaged in research in underwater medicine and related subjects.
Membership application forms can be downloaded from the Society's Web Site at *http://www.SPUMS.org.au*

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The Society's financial year is January to December, the same as the Journal year.
The 2003 and 2004 subscriptions will be Full Members A$132.00 and Associate Members A$66.00, including GST in Australia. All those outside Australia will be charged the same amounts as the GST component to partly cover the cost of having the Journal delivered to them by Air Mail. These fees must be paid in full.

The Editor's offering

Whether or not young children should be allowed to scuba dive has been debated for many years. Recently, as a result of various enquiries, the Society's President wrote a letter to the *Medical Journal of Australia*, in which she stated "SPUMS continues to recommend a minimum age of 14 years for all entry-level scuba activities involving open-water dives...". At the 2002 SPUMS ASM she presented the rationale for this position.

Vandenhoven and his Belgian colleagues now provide useful prospective data for the eight- to14-year-old age group from a moderate-sized prospective study. This study is, in fact, a decade old. Clearly, the recreational diving industry, particularly in Europe, have known of this work and have had good training programmes in place for many years, partly based on this experience. It is regrettable that such studies have not been published sooner in the medical literature to better inform those practising diving medicine.

Reproduced with these papers is a review written specifically for instructors by committee member Simon Mitchell, himself an advanced diving instructor, to give an idea of what information is out there for the recreational diving community. Drew Richardson provides the training-agency perspective with the assistance of DAN America, and the new PADI book on children in diving is reviewed. Weighing up the pros and cons, Anita Cvitanovich, a paediatrician, and Paul Langton, a cardiologist, provide an invited editorial that takes a developmental approach to the issues.

In the light of all this, perhaps the Society needs to review again its position on children, or risk being labelled a dinosaur as the recreational diving industry simply leaves the medical profession in its wake. Whether we as physicians like it or not, scuba kids are here to stay. By providing in this issue new data and several different perspectives, it is hoped that members feel they can enter into serious debate and are better equipped to deal with the next 10-year-old child who comes in for a diving medical.

Clearly, informed medical input to children's diving programmes is essential. Secondly, the paediatric case report shows what can go wrong if the tightly controlled parameters set by the training agencies are ignored by supervising adults. Finally, this writer remains convinced that a strong emphasis on snorkelling skills is needed, and that not enough time is spent on these skills either for children or adult divers.

Increasing numbers of diabetics are presenting for hyperbaric oxygen therapy (HBO_2) for peripheral ulcers. It has been known for some years that falls in blood sugar levels occur in diabetics during HBO_2, for reasons that remain uncertain. Trytko and Bennett present data that show this is not predictable from patient to patient, nor from day to day in any one patient, but is more likely to be extreme in insulin-dependent than non-insulin-dependent diabetics. Does the unpredictable nature of these changes also have implications for diabetics who wish to scuba dive?

Trish Batchelor continues her travel-medicine series with a review of the diverse problems that may present after return home. She focuses particularly on fever and diarrhoea. It is important to exclude malaria urgently in the febrile post-travel patient. As in most medical practice, a good history is the key to diagnosis and successful treatment when faced with the huge range of potential conditions that may be acquired abroad. The advantages of DEET-containing insect repellents, of which Dr Batchelor is a strong advocate, are confirmed in a recent study from the *New England Journal of Medicine*.

Technical diving, that is air diving beyond 40 m and all mixed gas diving using open, semi-closed, or closed circuit scuba, has taken off in a big way in the northern hemisphere. Accompanying it has been a high injury and fatality rate and a series of publications, like Chowdhury's *The Last Dive*, that tend to extol its macho qualities. Since the same trend in recreational diving is likely to be seen in Australasia in the near future, it is important that diving physicians understand the principles of these techniques. Steve Goble provides succinct descriptions of how two of the archetypal semi-closed and closed circuit rigs work, and the potential problems inherent in their use. The news item from *Diver* magazine, describing an August weekend in England, with several deaths and "all the chambers on the South Coast full", could be the stuff of the future in this part of the world as divers continue to stretch the boundaries of their underwater adventures.

Occasionally, South African physicians, of whom several are SPUMS members, have attended our conferences, and Frans Cronje's article shows that diving medicine is active there. Perhaps the current Committee should explore means of enhancing contact between the two societies, to their mutual benefit.

There have been a number of complaints in the last year that the 'Instructions to Authors' are not clear enough. In this issue these have been revised and re-organised in an attempt to meet these concerns. From 2004 these will be completely revised and expanded, and placed on the Society's web site rather than taking space in the Journal. We hope these changes will assist authors.

As mentioned in the last editorial, the Journal is seeking good colour pictures with a diving medicine interest for the front cover. We encourage readers to submit their efforts.

Michael Davis

Cover page photo of three young divers courtesy of Terry Cummins, Sydney, with the parents' permission.

Original articles

Blood sugar changes in diabetic patients undergoing hyperbaric oxygen therapy

Barbara Trytko and Michael H Bennett

Key words
Diabetes, hyperbaric oxygen, blood sugar levels

Abstract
(Trytko B, Bennett MH. Blood sugar changes in diabetic patients undergoing hyperbaric oxygen therapy. *SPUMS J* 2003; 33(2); 62-69)

Introduction: We have conducted a prospective, single-cohort observational study of blood sugar levels (BSL) before and after hyperbaric oxygen therapy (HBO_2) in diabetic patients.

Methods: BSL was measured immediately before and after HBO_2 for between four and 15 consecutive treatments in each individual. Primary analysis compared the mean change in BSL for each patient. Secondarily, we analysed the change for each individual treatment. Glycosylated haemoglobin (HbA1c) was measured before the first treatment, and then after ten treatments, to determine any alterations in diabetic control over the trial period.

Results: Twenty-seven patients were studied over a total of 237 treatment episodes. The mean change in the BSL after a single HBO_2 session was a reduction of 2.04 mmol.l^{-1} (95% confidence limits (CL) 1.49 to 2.58, $p < 0.0001$). Problematic reductions in BSL occurred more often in patients requiring insulin than in those not requiring insulin. The number of treatment sessions in which the BSL drop was >4.0 mmol.l^{-1} and/or intervention was required was 44/133 (33%) in the insulin group and 17/104 (16%) in the non-insulin group ($\chi^2 = 8.6$, DF = 1, $p = 0.003$). Eleven HBO_2 sessions were associated with symptomatic hypoglycaemia requiring glucose administration while in the hyperbaric chamber; nine in insulin-requiring subjects, two in non-insulin-requiring. There was a small, non-significant mean reduction in HbA1c of 0.22 % ($p = 0.06$) over the course of treatment.

Conclusions: HBO_2 reduces BSL in both non-insulin-requiring and insulin-requiring diabetics. Diabetic control overall is unchanged over a course of ten treatments. Problematic hypoglycaemia is more common in patients requiring insulin. We recommend daily monitoring of BSL prior to HBO_2 and prophylactic glucose in some form if the BSL is <8 mmol.l^{-1}.

Introduction

As evidence emerges to support the efficacy of hyperbaric oxygen therapy (HBO_2) for the treatment of the diabetic foot, diabetic patients are coming to constitute a significant proportion of those treated in hyperbaric facilities worldwide.[1–3]

Some authors have shown significant reductions in blood sugar level (BSL) in these patients during HBO_2,[4,5] while others suggest we should expect none.[6,7] The numbers of diabetic patients reported to date are small, and most published work has been restricted to those diabetics requiring regular insulin administration. Furthermore, if there is a significant relationship between HBO_2 and BSL, it remains unclear whether changes in BSL are variable in the population but predictable in the individual, or variable both for the individual and the population.

The ability to identify those patients most prone to problematic reductions in BSL would greatly assist clinical management and potentially eliminate unnecessary testing in patients identified as not at risk.

The mechanism by which HBO_2 might result in a reduction in BSL remains unclear though several possibilities have been proposed.[8–11] Whatever the mechanism, the clinical implications of any fall in BSL are important because early hypoglycaemia may be masked in the chamber by other physiological responses to HBO_2 or may be mistaken for oxygen toxicity.

We considered that further clinical investigation was required to quantify any fall in BSL in our own practice and to assist in the development of a rational protocol for the routine treatment of both insulin-requiring and non-insulin-requiring diabetics during HBO_2.

Consequently, we have conducted a prospective observational study of BSL before and after each hyperbaric treatment session in diabetics presenting for HBO_2, along with an estimation of glycosylated haemoglobin (HbA1c) concentrations before and after a course of HBO_2.

Subjects and methods

The study was approved by the Ethics Committee of the

TABLE 1. DEMOGRAPHIC DATA FOR PARTICIPATING SUBJECTS

	Insulin-requiring	Non-insulin-requiring	All diabetics
Age in years (mean)	35–79 (63.4)	39–83 (62.1)	35–83 (62.9)
Duration of diabetes in years (mean)	7–44 (22.1)	0.2–25 (6.0)	0.2–44 (15.4)
Male:Female	12:1	10:4	22:5

Prince of Wales Hospital (Randwick, Australia) and was conducted in accordance with NHMRC guidelines. All diabetic patients presenting to the Prince of Wales Hospital Department of Diving and Hyperbaric Medicine over a period of 12 months from January 1999 to January 2000 were considered for inclusion, and all consenting patients were enrolled in the study if they were over 18 years old and accepted for HBO_2.

BSL was measured using Medisense^R Precision QID^{TM} glucometer (Abbott, MA, USA) immediately before and after HBO_2 for 10 consecutive sessions where possible. This instrument is commonly employed for serial estimations of BSL in diabetic inpatients and has been demonstrated to show acceptable accuracy and high concordance between operators (correlation coefficient 0.98).[12] We performed a preliminary study in non-diabetic control subjects and confirmed reliability in our clinical setting (unpublished data). Capillary blood was collected via finger prick in all patients no more than 15 minutes before HBO_2 and repeated no more than 15 minutes following HBO_2. Standard measurement procedure was used according to the manufacturer's instructions.

In a subset of five subjects (17 pairs of readings), BSL was estimated twice on non-treatment days at the same times as the pre- and post-HBO_2 samples in order to compare any alterations in BSL independent of HBO_2. HbA1c was measured in all patients prior to commencing the course of HBO_2 and again following the tenth treatment.

In order to identify any difference in the relationship of HBO_2 and BSL in different types of diabetes, we also compared changes in insulin-requiring and non-insulin-requiring diabetics. Finally, we investigated the quality of BSL control by comparison of HbA1c levels before and after ten treatment sessions.

STATISTICAL ANALYSIS

No sample size calculations were performed prior to commencing the data collection. Differences in mean BSL between groups were compared using Students *t*-test and for each individual using the paired *t*-test. Differences in proportions were compared using χ^2 analysis of 2 x 2 tables and any differences in daily BSL were investigated using one-way ANOVA with adjustment for multiple comparisons using the treatment number (from 1 to 10) as the within-group factor. Simple linear regression was used to investigate any relationship between initial BSL and post-treatment BSL. Results will be given as mean or proportion with 95% confidence limits (CL).

Results

All eligible patients consented to the study, and 27 patients undertook a total of 237 individual sessions of HBO_2 during the study period. Demographic data are shown in Table 1.

Thirteen patients required regular insulin administration prior to enrolment, while 14 did not. Of those who did not require insulin, eight were on regular oral hypoglycaemic agents (metformin, glibenclamide, gliclazide either singly or in combination) and six were controlled with diet alone. All patients were referred for the treatment of diabetic wounds in the lower extremities except one insulin-requiring patient treated for acute visual loss and two non-insulin-requiring patients with retinal artery occlusion. Twenty-three patients completed a minimum of nine sessions of HBO_2, while one insulin-requiring patient completed five sessions and three non-insulin-requiring patients completed four, four and six sessions respectively.

The range of BSLs before and after treatment for each patient is summarized in Table 2. The mean pre-HBO_2 BSL for insulin-requiring patients was 9.7 $mmol.l^{-1}$, while the mean BSL for non-insulin-requiring diabetics was 9.1 $mmol.l^{-1}$. This difference was not significant ($p = 0.14$). There was a mean reduction in BSL for each individual subject after HBO_2 of 2.04 $mmol.l^{-1}$ (95% CL 1.49 to 2.58, $p < 0.0001$). The mean reduction in BSL in insulin-requiring diabetics was 2.61 $mmol.l^{-1}$ (95% CL 3.5 to 1.68, $p < 0.0001$), and in non-insulin-requiring diabetics 1.5 $mmol.l^{-1}$ (95% CL 2.06 to 0.93, $p < 0.0001$). This difference between diabetic types was also statistically significant ($p = 0.03$).

The number of treatment sessions in which the BSL drop was >4.0 $mmol.l^{-1}$ and/or intervention with glucose was required was 61/237 (26%). Of these, 44/133 (33%) were in the insulin-requiring group and 17/104 (16%) in the non-insulin-requiring group. This difference in the

TABLE 2. BLOOD SUGAR LEVEL (BSL) BEFORE AND AFTER HBO_2 IN ALL PATIENTS

Patient and insulin requirement		BSL range ($mmol.l^{-1}$) before HBO_2	BSL range ($mmol.l^{-1}$) after HBO_2	BSL range ($mmol.l^{-1}$) change during HBO_2
1	Insulin	8.0-14.9	5.4-10.8	-1.3 to -6.6
2	Non-insulin	6.7-12.9	6.0-8.9	+1.1 to -6.1
3	Non-insulin	5.0-13.7	4.1-15.0	+4.8 to -3.9
4	Insulin	4.5-17.2	4.0-12.4	+2.1 to -5.1*
5	Non-insulin	4.1-15.4	2.7-12.4	+1.4 to -4.7
6	Non-insulin	5.5-13.7	4.6-12	+2.2 to -2.2
7	Non-insulin	6.1-9.6	3.7-7.6	+0.1 to -3.8
8	Insulin	9.1-13.8	7.1-13.2	+2.1 to -5.0
9	Insulin	3.7-10.1	2.9-7.4	+0.3 to -4.1
10	Insulin	5.4-14.5	5.8-14.9	+0.7 to -4.9
11	Insulin	4.5-20.1	1.4-16.9	+0.3 to -9.8*
12	Non-insulin	3.6-12.3	4.8-12.9	+9.3 to -2.8*
13	Insulin	6.4-13.1	4.3-8.9	+0.4 to -5.4
14	Insulin	4.5-10.2	2.6-8.5	+2.3 to -3.2*
15	Insulin	5.4-18.1	4.4-10.6	-0.2 to -7.5
16	Insulin	3.6-14.7	5.3-16.6	+6.2 to -4.7*
17	Non-insulin	5.4-12.4	3.4-7.9	-1.4 to -4.7
18	Insulin	5.4-11.7	2.7-7.5	-0.8 to -6.6*
19	Non-insulin	8.6-15.7	4.7-12.4	+2.3 to -5.7
20	Non-insulin	7.2-10.0	7.3-10.1	+2.9 to -1.5
21	Non-insulin	4.8-10.7	3.3-7.3	+2.1 to -4.6
22	Non-insulin	6.0-10.1	4.4-9.7	+3.7 to -5.7
23	Insulin	5.8-12.2	4.6-8.3	+1.0 to -3.7
24	Insulin	5.4-11.8	3.1-7.9	-0.3 to -6.1
25	Non-insulin	5.6-8.1	4.0-5.4	-0.4 to -3.8
26	Non-insulin	8.0-15.0	8.1-11.0	+3.0 to -4.0
27	Non insulin	7.4-13.5	7.3-11.4	+4.0 to -5.2

*Patient required glucodin and sugar for hypoglycaemia during treatment

proportion of sessions associated with significant hypoglycaemia was statistically significant (χ^2 = 8.6, DF = 1, p = 0.003).

While subjects underwent a total of 237 treatment sessions, 11 individual sessions were excluded from further analysis because glucose was administered during the hyperbaric session to treat symptomatic hypoglycaemia (nine episodes in insulin-requiring subjects and two in non-insulin-requiring subjects). The mean change in BSL in the remaining 226 treatments was 2.13 $mmol.l^{-1}$ (95% CL 1.82 to 2.44, p <0.0001), similar to the overall mean. The changes in BSL following these 226 episodes of HBO_2 are shown in Figure 1.

Of the 226 treatment sessions where in-chamber intervention to correct hypoglycaemia was not required, subjects with insulin-requiring diabetes accounted for 124 (55%). Of these, 112 (90%) were associated with a reduction in BSL that was measured post HBO_2. Seventy-one out of 124 (57%) sessions were associated with a reduction of >2 $mmol.l^{-1}$, 31/124 (25 %) with >4 $mmol.l^{-1}$, and 4/124 (3%) required treatment for hypoglycaemia. Non-insulin-requiring patients accounted for 102 (45%) of sessions. Of these, 80 (78%) were associated with a reduction in BSL, 13/102 (13%) had a BSL drop >4.0 $mmol.l^{-1}$, and 2/102 (2%) required intervention.

The relationship between the starting BSL and change over the course of a single HBO_2 session was investigated using correlation and regression (Figure 2). There was a significant relationship in that the higher the pre-HBO_2 BSL, the greater the reduction that can be expected following HBO_2 (correlation coefficient -0.45, p <0.0001). The relationship can be described by the regression equation:

Change in BSL ($mmol.l^{-1}$) = -0.37 x pre-treatment BSL ($mmol.l^{-1}$) +1.33

BSL was recorded in five patients (17 pairs of samples) on days during which no HBO_2 was administered. A reduction

FIGURE 1
CHANGE IN BLOOD SUGAR LEVEL (BSL) PRE- TO POST-HBO$_2$ SESSION IN 237 DIABETIC PATIENTS

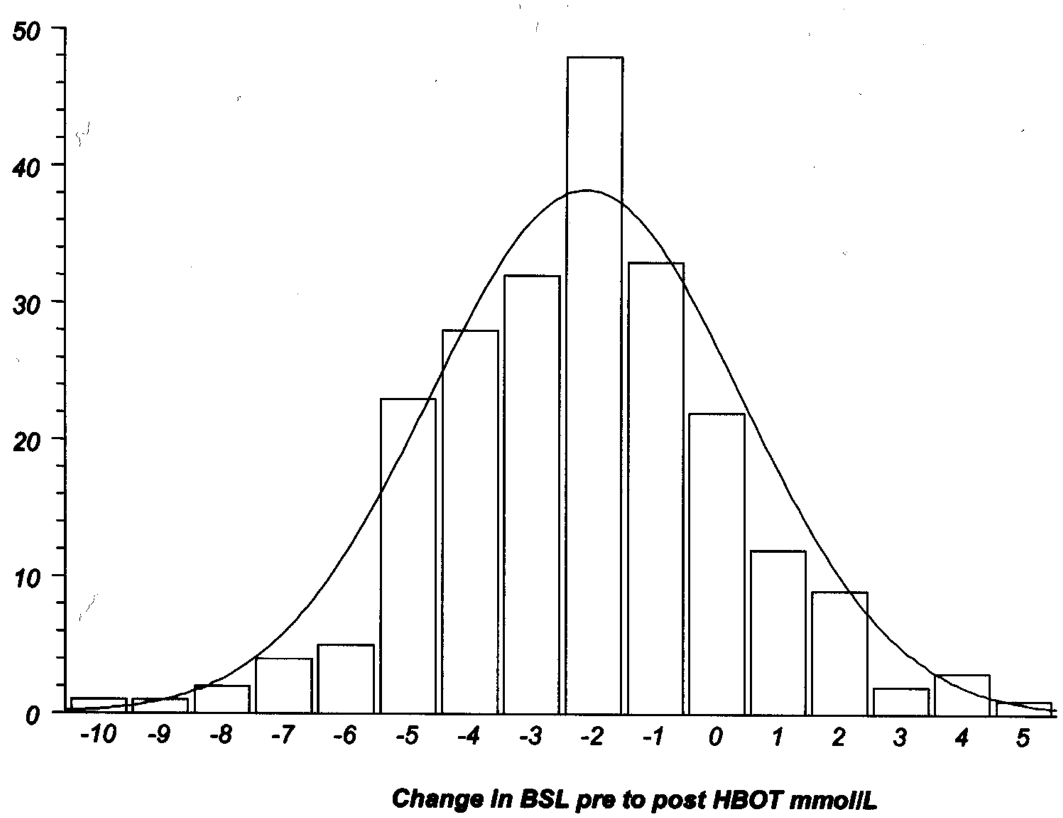
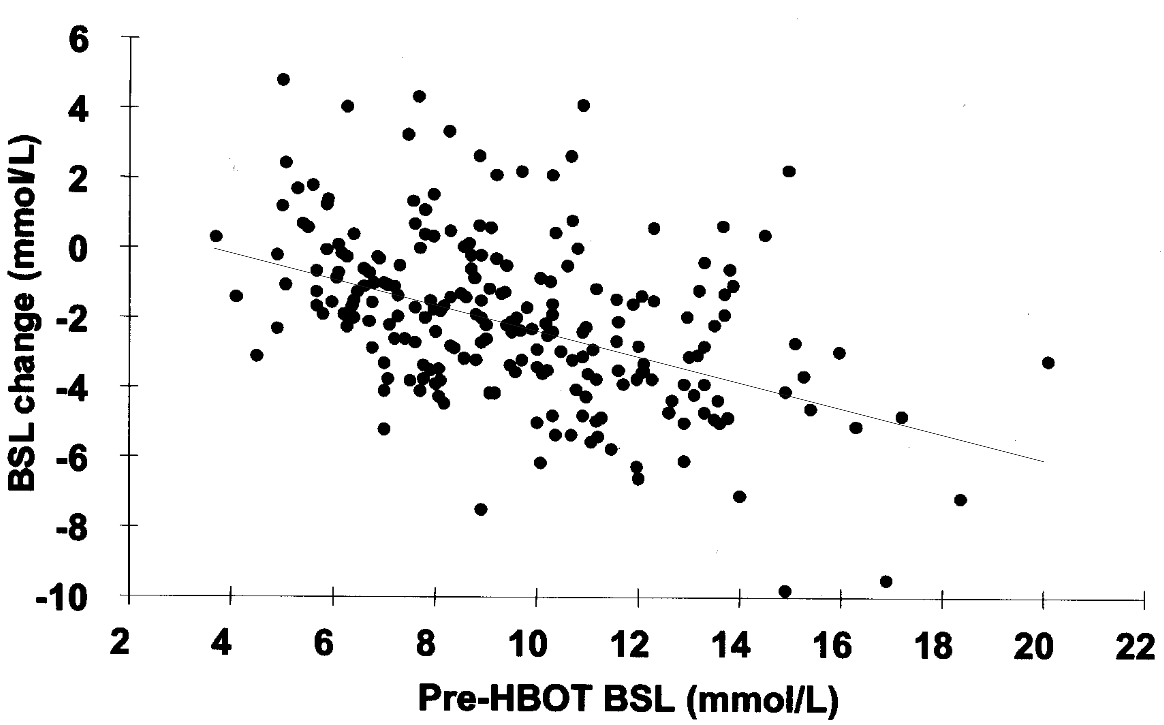


FIGURE 2
BLOOD SUGAR LEVEL (BSL) CHANGE PRE- TO POST-HBO$_2$ PLOTTED AGAINST THE PRE-HBO$_2$ BSL
(Correlation coefficient -0.45 , p <0.0001)



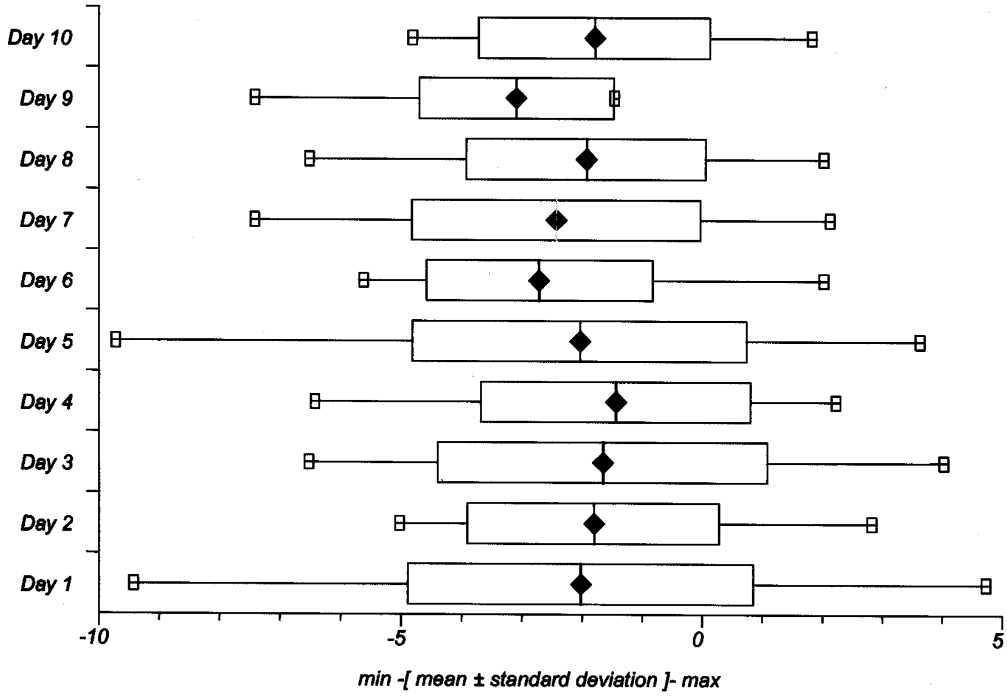


FIGURE 3
DAILY CHANGE IN BLOOD SUGAR LEVEL IN DIABETIC PATIENTS OVER THE STUDY PERIOD

in BSL was recorded in five (29%) sample pairs, two (12%) were >2 mmol.l^{-1}, while none were >4 mmol.l^{-1} or required intervention. The proportion of pairs showing a drop of >2 mmol.l^{-1} was significantly smaller in this group compared to the proportion associated with HBO_2 (11% versus 54%, $\chi^2 = 4.3$, $p = 0.04$).

The mean reduction in BSL following treatment did not significantly alter with treatment number during the course ($F = 0.94$, $p = 0.49$) (Figure 3). However, there was wide variability in the daily BSL measurements in each patient, and drops were unpredictable even in the same patient on consecutive days (Table 2).

Seventeen of the 23 patients who completed ten sessions of HBO_2 had HbA1c estimations following completion of the tenth session. Six patients were missed, four of whom were insulin-requiring and two non-insulin-requiring. In the 17 in whom the HbA1c was estimated, mean HbA1c prior to commencing HBO_2 was 7.78%, and there was a small, non-significant mean reduction in HbA1c of 0.22% (SD 0.43, 95% CL 0.01 to -0.44, $p = 0.06$) over the course of treatment.

Discussion

We have performed a prospective study into the effect of HBO_2 on the BSL in a population of 27 diabetics. There was a significant reduction in BSL in both insulin-requiring and non-insulin-requiring patients. The reductions in insulin-requiring patients were significantly greater and more often required active intervention.

Looking at each subject separately, we can predict an average drop in BSL during the course of a single HBO_2 exposure of about 2 mmol.l^{-1}, and our analysis predicts that 95% of diabetic patients will experience an average drop in BSL of between 1.5 and 2.6 mmol.l^{-1}. However, there is a greater variability in the changes in BSL following a single exposure. Furthermore, we cannot predict in which treatment an individual is more likely to experience a clinically significant problem. No patient with a pre-HBO_2 BSL greater than 8 mmol.l^{-1} required intervention for hypoglycaemia. Our figures are broadly in agreement with a previous small study in Australian patients.[4]

It might be suggested that we have detected a change in BSL that reflects normal variation over time in diabetics or, indeed, the normal population. Published work does confirm that BSL may vary by up to 2 mmol.l^{-1} postprandially in non-diabetic volunteers.[13] However, in these normal subjects there is an initial elevation after a meal, with the BSL returning to baseline over two hours. While testing non-diabetics might show a reduction in BSL during an HBO_2 session, such reductions would only be noted with treatment immediately after a meal, and from slightly elevated values down to normal. Symptomatic hypoglycaemia would be most unlikely. These hypotheses should be confirmed by further clinical investigations.

The published data on expected BSL variation over two hours in diabetics in the absence of a specific intervention are surprisingly sparse. To assess any such changes in our patient population, we examined the BSL over a two-hour period on non-treatment days in some of our study group. Compared with changes associated with HBO_2, reductions in BSL were smaller, less frequent and did not require intervention in this group. These results confirm that HBO_2 is associated with specific effects on BSL in diabetics. Further, if the reductions we report in this study were common to all diabetics, we would expect such changes to be well reported and to result in modifications to standard diabetic treatment protocols.

We chose to estimate BSLs with the Medisense^R Precision QID^{TM} glucometer as an accurate and expedient means of measuring BSLs in this patient population. This device was previously reported to be unreliable in the presence of high blood PO_2.[14] Each electrode contains the enzyme glucose oxidase, which catalyses the oxidation of glucose to produce gluconic acid. During the reaction, electrons are transferred to the electrode surface. The resulting current is measured by the sensor. This method was found to result in falsely low BSLs in the hyperbaric environment with high PO_2.[14] However, in late 1997 the measurement strips were modified specifically to function reliably under conditions of varying oxygen tension.[15] In addition, BSLs were measured in our patients once outside the chamber, at which time their PaO_2 would be approaching more normal physiologic levels.

The mechanisms by which HBO_2 might result in a reduction in BSL remain unclear. Possibilities include stimulation of residual insulin production,[8] suppression of glucose production by the liver,[9] improvement in tissue metabolism, and suppression of the glucagon response to a BSL fall.[10,11]

There is evidence to suggest increased insulin production is not a likely candidate.[4] This is certainly consistent with our findings, as there is a trend towards greater reductions in the BSL of patients who require insulin. If increased insulin production contributed to lower BSL in diabetics, we might expect the reverse to be true because non-insulin-requiring diabetics have better preserved insulin-manufacturing capability with which to respond.

Reduced glucose absorption and/or production secondary to the effects of hyperoxia on the cardiovascular system are a possibility. HBO_2 is known to cause vasoconstriction and a decrease in global cardiac output of up to 30%.[16] While the specific effect on splanchnic blood flow in humans is unknown, animal data have demonstrated a decrease.[17] Decreased flow could theoretically decrease gut absorption of nutrients, while decreased hepatic blood flow might affect gluconeogenesis and glycogenolysis.

Suppression of glucose production by the liver was proposed as the chief mechanism for hypogylycaemia in one Russian paper. However, the patients were tested before and after a full course of HBO_2, and the proposed mechanism of decreased hepatic production was not fully elucidated.[9] In the non-diabetic population with normal regulation of insulin production, a decrease in blood glucose will trigger a decrease in insulin production and the release of glucagon and catecholamines. However, suppression of the glucagon response to hypoglycaemia is well described in diabetics and the catecholamine response is similarly blunted.[18] This means that a decrease in glucose production or absorption would result in a significant decrease in BSL, particularly in the presence of exogenous hypoglycaemic agents.

Increased glucose utilization secondary to up regulation of oxidative pathways might explain the reduction in BSL, and there is some experimental evidence that this may be so, at least over a course of HBO_2. In a study involving 120 diabetic patients, Kakhnovskii measured glucose, lactate, pyruvate, malate dehydrogenase and lactate dehydrogenase over 15–18 days utilizing HBO_2 at 1.7 ATA (173 kPa), and demonstrated a link between increased tissue metabolism and increased glycolysis.[11] Efuni produced similar results in another series.[19] These studies also demonstrate that with the increase in oxidative capability there is a concomitant induction of enzymes in the gluconeogenic pathways, thus reducing the net effect on BSL over time.

HbA1c is an indicator of longer-term glucose control. It is formed following irreversible, non-enzymatic glycation of the haemoglobin A beta chain and is directly proportional to the ambient glucose concentration. In our subjects, HbA1c levels did not significantly change over the course of ten sessions of HBO_2. Although the absolute figures suggest there may be a small decrease, the measured reduction would not be clinically significant.

A larger study measuring HbA1c at the end of a longer period of HBO_2 may confirm this finding. If correct, this would be consistent with the premise that there was no significant change in the adequacy of diabetic control over this period and therefore no evidence for induction of metabolic pathways that may contribute to hypoglycaemia. The literature confirms that a change in HbAIc should be measurable after this period of time with a change in therapy or in BSL control.[20]

A novel mechanism not previously discussed in the literature involves the possible effect of hyperoxia on the carotid bodies. The carotid bodies are known to be responsive to oxygen tension and recent animal data suggest that they may have a significant role in the regulation of blood glucose. In a dog model in which the carotid bodies were removed, for example, Koyama reported significant impairment in glucagon release and a hypoglycaemic response to infusion of insulin.[21] It is possible that HBO_2 may affect carotid body function and alter the response to hypoglycaemia via this mechanism.

We are not aware of any studies specifically involving HBO_2 and the glucagon response to hypoglycaemia. In fact, as noted above, glucagon release in response to hypoglycaemia is lost early in insulin-requiring diabetic disease and therefore may not be of any significance in our patients.[18]

Growth hormone and cortisol also have important regulatory effects in glucose metabolism.[22] While Longoni looked at urinary cortisol levels in diabetic patients undergoing HBO_2 and found no changes, no-one has comprehensively examined growth hormone or cortisol responses in diabetic patients receiving HBO_2.[5] Inhibition of these hormones may possibly contribute to hypoglycaemia in patients with impaired glucose regulation.

Perhaps the most likely mechanism for hypoglycaemia is an increase in the insulin receptor sensitivity in response to HBO_2. Non-insulin-requiring diabetic patients have lower numbers of insulin receptors and tend to have resistance to insulin, whereas insulin-requiring diabetics have a higher number of insulin receptors and maintain sensitivity.[23] This would explain the greater drop in insulin-requiring diabetics compared to non-insulin-requiring diabetics. Despite a literature search we were unable to find previous work in regard to insulin receptors and the effects of HBO_2.

Our results show that, on average, diabetics having HBO_2 will drop their BSL by about 2 $mmol.l^{-1}$ during each treatment. However, there is considerable variability in this response, both between subjects and between treatment sessions in a single subject. Non-insulin-requiring diabetic patients are more predictable in their response than insulin-requiring diabetic patients and are less likely to drop their BSL sufficiently to require treatment.

We recommend all diabetics eat a meal within two hours of HBO_2 if possible and that a BSL estimation be performed prior to each treatment. Patients with insulin-requiring diabetes in whom the BSL is <8.0 $mmol.l^{-1}$ or with non-insulin-requiring diabetes with a BSL <6.0 $mmol.l^{-1}$ should be given glucose prior to entering the chamber. We continue to monitor our experience with these recommendations, but suggest that under this regimen symptomatic hypoglycaemia is very unlikely. It would be useful to confirm this suggestion in a subsequent larger study.

Regardless of aetiology, our study has demonstrated that important changes in BSL can occur in any diabetic patient undergoing HBO_2. Such changes cannot be predicted by previous response in an individual patient. Therefore, we advocate that BSL estimation should be mandatory in all diabetic patients prior to each HBO_2 session.

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Children and diving: medical aspects. Eight years' sports medical follow-up of the first scuba diving club for children in Belgium

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Key words
Scuba diving, children, medicals/diving, incidents, accidents, ENT

Abstract
(Vandenhoven G, Collard F, Schamp E. Children and diving: medical aspects. Eight years' sports medical follow-up of the first scuba diving club for children in Belgium. *SPUMS J* 2003; 33: 70-73)
Evaluation of prospective paediatric divers has been based largely on opinion, with limited data. Two hundred and thirty four children aged six to 13 years wishing to scuba dive were enrolled in a prospective study of diving medical evaluation between 1985 and 1992. Medical evaluations, including pulmonary function testing, and resting and exercise ECGs were performed annually by one physician. An electroencephalogram (EEG) was performed as part of the initial examination. Twenty-nine children (12.4%) were excluded: 12 (5.1%) did not complete the initial medical assessment, 12 (5.1%) had abnormal EEG patterns, four (1.7%) were asthmatic and one had sickle cell anaemia. In the remaining 205 children, Eustachian tube dysfunction (12.2%), wax build-up in the external ear canal (5.4%) and otitis externa (3.9%) were the commonest problems during the pool training. All these incidents were minor. Five accidents (2.4% of qualified divers) occurred during the swimming pool sessions, all with full recovery. Four of these were tympanic membrane perforations, two in the same child, and all during the first year of the programme. One potentially life-threatening accident was a breathhold hypoxic syncope in a twelve-year-old. No incidents or accidents occurred during the 2216 open water dives completed in the study. The average follow-up was five years. No subsequent developmental problems, with special focus on growth, pubertal development and hearing, were seen. This study provides evidence that scuba diving may be successfully and safely undertaken in the eight- to 14-year age group provided it is undertaken in a tightly controlled environment.

Introduction

The involvement of children in underwater activities started growing in the mid-1980s. Diving instructors and physicians were faced with the need to develop programmes for the training of young divers in optimal conditions that balanced children's satisfaction with maximizing their safety. Guidelines for the medical assessment of adult divers were well established. However, courses sponsored by national certifying agencies introduced new minimum age limits of 12 to 14 years. No suggested standards for evaluating prospective paediatric divers for diving course participation from this age were available at that time.

A review of the physiology and the most common problems associated with scuba diving in the paediatric age group proved to be based largely on medical opinion, as there were only limited data in the literature.[1–8] The growing popularity of recreational scuba diving resulted in a proportionately increasing number of paediatric subjects of all ages being referred to physicians for medical examination to determine their suitability for diving courses and active diving.

Therefore, we undertook a study to establish and assess a system of scuba diving initiation for children based on a children's diving club, Les Marmottes et Castors Palmés, Brussels, Belgium. This attempted to optimize communication between instructors, parents and a sports medicine specialist, and was focused on safety and the prevention of diving or other injuries.

Subjects and methods

All children interested in learning to scuba dive were entered into a prospective study of sport-diving medical evaluations over an eight-year period between 1985 and 1992. Written informed consent prior to study entry was obtained from the parent or guardian of each child. They underwent an annual sports medical evaluation including a complete physical examination with a special focus on ENT aspects. An audiogram, pulmonary function testing, including vital capacity and peak flow, plus resting and exercise electrocardiograms (ECG) were done. Children between six and eight years old had a bi-annual evaluation.

An electroencephalogram (EEG) was performed only as part of the initial medical examination. If an immature cerebral electrical pattern was found the EEG was repeated annually, or at least before open water diving, until a normal adult pattern was established. Children with a clinical diagnosis of asthma and/or abnormal pulmonary function testing underwent measurement of bronchial hyper-reactivity. All the medical evaluations, pulmonary function testing and resting and exercise ECGs were performed at a sports medical centre by one physician (GV). If additional medical investigations were required, the child was referred to the appropriate specialist, e.g., a chest physician for extended pulmonary function evaluations including measurement of bronchial hyper-reactivity, or a cardiologist for additional cardiovascular investigations. Modified adult guidelines for children based on the available literature and other medical data were used to determine participation in the pool diving course and then open water scuba activities.

The children participated in swimming pool sessions lasting up to one hour per week from September till June over the eight-year period of the study. The objectives of the indoor pool sessions were:

- introduction of the child to scuba diving and the equipment to be used;
- progressive acquisition of diving skills before open water experiences;
- regular training during the year independent of weather conditions; and
- preparation of the young diver for specific underwater activities like photography and archeology.

A variety of open water dives were organised during the year once children had acquired sufficient basic skills and a knowledge of the underwater environment. They also needed to be able to enter the water from and re-board the boat. These dives were limited to a maximum depth of 5 m for certified divers aged eight to 12 years old and 10 m for certified divers aged 12 to 14 years.

Results

Two hundred and thirty-four children between the ages of six and 13 years entered the study over an eight-year period. The average follow-up was five years with a range between one and eight years. Twenty nine children (12.4%) were disqualified on medical grounds from participating in open water diving, 12 (5.1%) because they did not complete the initial medical assessment. Of the remaining 17 children, 12 (5.1%) had abnormal EEG. patterns, four (1.7%) children were asthmatic with abnormal bronchial reactivity and one child had sickle cell anaemia (Table 1).

All children below the age of eight were disqualified from open water diving, mainly because they did not complete the initial medical assessment or due to immature EEG. patterns.

The remaining 205 children were assessed as medically fit to undertake diving training. They completed up to a maximum of 303 scuba diving training sessions in the swimming pool (average per child per year = 37, range 25–44). A total of 2216 open water dives were completed by children in the programme during the eight years (average dives per diver per year = 11, range 0–18 dives). None of the children undertook open water diving until the age of ten. Twelve open water diving trips were conducted with 20 to 29 children on each trip, each child completing four to seven dives per excursion.

TABLE 1
OUTCOME OF SPORTS MEDICAL EVALUATIONS FOR CHILDREN

		N	(%)
Number of children enrolling		234	
Age:	less than 8 years	12	(5.1)
	8 – 11 years	181	(77.4)
	12 – 13 years	41	(17.5)
Disqualified		29	(12.4)
•Incomplete examination (EEG and/or ECG)		12	(5.1)
•Abnormal EEG (irritable signs)		12	(5.1)
•Asthma		4	(1.7)
•Sickle cell anaemia		1	(0.4)
Approved for scuba training		205	(87.6)

Fifty four incidents (26.3% of qualified children) and five accidents (2.4% of qualified children) were reported during the eight years of pool training sessions. No incidents or accidents occurred during the open water dives.

The incidents most commonly encountered were related to the ear: Eustachian tube dysfunction (12.2%), wax build-up in the external ear canal (5.4%), and otitis externa (3.9%). There was only one case of otitis media (0.5%) related to diving and one epistaxis (0.5%) (Table 2). All these incidents were minor.

Five accidents (2.4% of qualified divers) were reported, all with full recovery. Four tympanic membrane perforations occurred, two of these in the same child, and all during the first year of the programme. After the implementation of a special training focus on techniques of ear clearing, no further perforations occurred in the next seven years. One potentially life-threatening accident was a breath-hold hypoxic syncope in a twelve-year-old child, due to hyperventilation before this exercise (Table 3). These five accidents occurred during the swimming pool sessions in the age group of eight to 12 years.

TABLE 2
INCIDENTS OCCURRING IN 205 CHILDREN AGED 8 – 14 YEARS DURING SWIMMING POOL SCUBA TRAINING

	Number	(%)
Eustachian tube dysfunction	25	(12.2)
Wax build-up external ear canal	11	(5.4)
Otitis externa	8	(3.9)
Mycosis (body)	7	(3.4)
Otitis media	1	(0.5)
Dental pain (caries)	1	(0.5)
Epistaxis (diving)	1	(0.5)

TABLE 3
ACCIDENTS OCCURRING IN 205 CHILDREN AGED 8 - 14 YEARS OLD DURING SWIMMING POOL SCUBA TRAINING

	N	(%)
Tympanic membrane perforation	4	(2.0)
Syncope during apnoea	1	(0.5)

During the follow-up period, no subsequent developmental problems, with special focus on growth, pubertal development and hearing, were identified in these children.

Non-medical dropout from this study was caused by children leaving the scuba diving school. This percentage was quite low – average of 25% per year – compared with adults who have up to 45% dropout per year at some schools in Belgium. The reasons for leaving were varied. Common reasons were children of European Community agents on duty in Brussels returning to their home country at the end of their two -year contract (14%); children moving to another district (31%); children experiencing family problems (divorces, death of one parent, financial difficulties, etc) (35%); changes of sporting activity (10%); and other reasons (lack of interest, parental fears about scuba diving, bad results at school, etc.). Follow up of children from the first two categories suggested they commonly continued their scuba diving in their home country or new location. All drop outs were compensated for by new entries to the diving school due to the high demand for scuba diving training for children.

Discussion

Respiratory, cardiovascular, ENT, musculoskeletal and thermoregulatory characteristics of children impact on their ability to cope with the underwater environment. Children have their own specific needs in diving and should not be considered simply as scaled-down adults.

Before the age of seven to eight, there are risks of dyspnoea, hypoxia and pulmonary barotrauma due to the immaturity of the lungs. Pulmonary maturation progresses with growth, and the number of pulmonary alveoli increases till the age of about eight years. Elasticity of the lungs continues to develop till about 12 years of age. Airway resistance is higher and passive expiration longer. As much as 30 % of the alveolar units demonstrate low ventilation-perfusion ratios before the age of seven due to early small airways closure, with a theoretical risk of air trapping and pulmonary barotrauma.

These ventilation-perfusion changes and a possible increased incidence of patent foramen ovale may modify inert gas washout in young children. However, the risk of damage to long bone development at the level of the epiphyses is low since this cartilaginous growth plate is well vascularised with a good blood flow,[3,9] and probably has a shorter inert gas washout period compared with adult bone. The osteo-articular risk in paediatric scuba divers is mainly linked to carrying heavy weights (tanks, etc.) with possible lesions to the ossification centres.

Increased heat loss in children compared with adults necessitates careful attention to thermal protection to avoid hypothermia during diving. Good hydration and changing out of the diving suit in a warm environment immediately after diving minimises the likelihood of hypothermia.

Children's psychological maturity, their ability to comprehend instructions and procedures and their behavioural responses, including evidence of anxiety, require careful evaluation. One should also be aware that during open water dives a child needs good visual reference points, such as the pool wall, the descent/ascent line or the reef or sea floor.

Medical clearance to dive was given only after an evaluation based on a team approach, doctors, parents and instructors, which took into account all these different factors. In this Belgian children's diving club this was centred around the sports medicine specialist in charge of the diving. We continue to evaluate children on at least an annual basis, and have now set a minimum age of eight years for participation.

Ear problems were far and away the most common incidents or accidents in these children. Special attention to ensuring each individual child understands and practises ear clearing both at the medical evaluation and during swimming pool training is essential to reduce the risk of tympanic membrane perforation. Provided this is done properly few problems arise in practice.

Breath-hold hypoxic syncope, a potentially life-threatening accident, can be avoided if apnoea is limited to a maximum of 30 seconds after the age of eight years and hyperventilation is prohibited before the age of 10 years and strictly limited until the age of 14 years.

Modified diving equipment and well-fitting diving suits are essential. Attention is needed to weight and size, changes in configuration to facilitate donning, use and comfort in the water and security of fit.

Education and training must be focused on and adapted to the individual child. Classification of children for training sessions is based on individual capabilities and their stage of physical development. For open water dives the environment has to be selected carefully, and is ideally warm, in clear water with no current, and has a limited depth profile and easy access. Supervision of the diving must be planned carefully (Table 4).

TABLE 4
BASIC REQUIREMENTS AND RULES FOR TEACHING CHILDREN TO SCUBA DIVE

Specific educated and trained team:	(Sports) doctors, instructors, parents	
Specific sports medical evaluation:	One per year or more	
Minimum age:	Eight years old	
Modified equipment:	Weight, size, form, security, facilitate donning	
Modified education and training programme:	Focused on the individual child	
Selected environment:	Clear, warm water, no current, easy access	
Minimum water temperature:	12ºC	
Limited depth:	8–14 years	initiation max. 3m
	8–12 years	certified max. 5m
	12–14 years	certified max. 10m
Maximum dive time:	10 min (12°C); 25 min (>12°C)	

Our experiences combined with other international data have been used to establish the Fédération Belge de Recherche et d'Activités Sous-marines/Belgische Federatie voor Onderwater Onderzoek en Sport (FEBRAS/BEFOS) and Confédération Mondiale des Activités Subaquatiques (CMAS) standards for children and diving.[10–13]

Conclusions

Periodic diving medical examinations based on modified guidelines for children and optimal communication between instructors, parents and the sports physician resulted in safe diving with a low incidence of problems in a children's diving club in Belgium over the eight-year period studied.

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Children and scuba diving

Editorial

Children and diving: a paediatric perspective

Anita Cvitanovich and Paul Langton

Diving is magical. Childhood is magical. Does it necessarily follow that the two should interact safely or well? Since the inception of scuba (self-contained underwater breathing apparatus), children of various ages have been involved in diving. Almost certainly, children of current SPUMS members number among them. That the progeny of elite divers such as Jacques Cousteau have been able to dive safely, however, should not be taken as a recommendation for the general public.

The Australian Standard (AS 4005.1) sets a minimum age of 14 years for basic open-water scuba training and certification.[1] What of alternative 'restricted' forms of scuba experience that are not covered by existing standards? The industry-wide minimum training standards for recreational diving have now been set to allow children under 15 years of age to learn to dive under adult supervision. This paper considers the developmental issues for children entering these programmes.

PADI have adopted a minimum age of 10 for Junior Scuba Certification, with supervision by a PADI professional, or Junior Open Water Certification with parental supervision. The basic requirements for certification are the same as for adult programmes, but within each level of certification there are strict limits of age, maximum depth and level of supervision during diving. In addition, there are programmes for snorkelling and SASY (supplied-air snorkelling) from five years old, and Bubblemaker and PADI Seal Team from eight years old.[2] These activities are marketed with an emphasis on fun.

The minimum age requirements for different levels of activity in addition to other limitations are aimed at minimizing potential risks and are based on widely held expectations of a child's intellectual, physical and psychological development. What must be recognised, however, is that a child's developmental age is not always the same as their chronological age. All children develop in a similar sequence but at differing rates.

There are many developmental theories based to varying degrees on nature versus nurture, social, environmental and genetic factors. It is not appropriate to go into detail, but essentially these constructs study how a child learns and gains skills, looking at their physical, cognitive, social and emotional development. For most children (but not all), the different areas of development progress together, rather than independently, but it may be that physical growth for example does not equate with emotional maturity. While it is true that these widely held expectations are appropriately based on broad age ranges at which developmental stages are achieved, readiness to dive should not be assessed simply on the basis of chronological age. What is required is that these more complex cognitive and psychosocial factors be considered at each stage through a child's diving instruction. Ideally, failure to meet the developmental expectations in any one of these areas should mean the child is not certified until the appropriate level can be achieved.

Physiologically, there are obvious differences between a growing child and an adult. The suggested age and maximum depth limitations are in place to minimize potential risks. It must, however, be acknowledged that there are limited published data on diving physiology in (human) children. The adequacy of these restrictions is therefore largely speculative. Similarly, there are very few outcome data against which to judge the current limitations. Industry-based figures from groups such as Confédération Mondiale des Activités Subaquatiques (CMAS) and PADI are of some reassurance, but are likely to suffer from under-reporting.[3]

Supervision by an adult, whether parent, guardian or divemaster, needs to be exactly that – close supervision, not just the presence of an adult 'buddy' nearby. Children have a shorter attention span than adults, are more distractible and are more likely to wander off to varying depths, attracted by something magical. They may be less reliable in monitoring their own or their buddy's air supply and depth (it is not unheard of for adults to behave in the same way). Children can be less consistent in problem solving, particularly when put under stress.

It is important, therefore, that they have a true understanding of the issues, for example, of depths, pressure and volume changes and how air supply is affected. They may not otherwise take the time or think clearly underwater to be able to modify a dive plan accordingly. Whilst the theory is taught as an integral part of dive training, and is practised in the training environment, a high level of judgment and maturity is still required for the junior diver to be able to apply this knowledge in the wide range of scenarios likely to be encountered whilst diving. Ideally, the supervising adult should be ready to address these issues, particularly in an 'at risk' situation when a child is more prone to react by reflex. In danger, they will almost invariably look to an accompanying 'adult'.

As a dive buddy then, how much of this responsibility should we expect a child to be able to take upon themselves if a dive incident occurs? The child must be competent to the point of their own safety in a worst-case scenario, i.e., if the adult buddy becomes unresponsive for whatever reason. Again, diving instruction addresses these issues but, as with some adults, this may not be consistently applied underwater. Behaviour is difficult to predict, particularly in the 10–15 year age group. There are many incidents of children acting to save the life of an adult. Most examples, however, occur on land when any initial period of panic usually occurs in a more forgiving environment than that present underwater.

Many parents allow their children to participate in sports of their own choosing. Participation in diving requires the consent of the parent (or guardian) as well as that of the child. Informed consent from a child, even as they approach 15 years of age, can be a difficult issue. They are more likely to consider only the immediate self-directed benefits and enjoyment and, depending on how the facts are presented, the immediate dangers. They are less likely to give thought to long-term consequences. It is important that a parent recognises that in giving consent for any 'minor' to dive they take the risks and responsibilities entirely upon themselves. Whilst injuries during diving appear to be less frequent compared with those sustained by children in some contact sports, they are generally more severe. Parents need to clearly understand that there is a small but well-documented risk of death or permanent disability, and that such adverse outcomes can occur during the dive training process.[4,5] A small, prospective 'theoretical' risk will almost certainly be viewed differently with the benefit of retrospectivity.

Few would argue the potential joys and benefits of diving. It opens children up to a world of travel, geography, underwater interests, colour and beauty. Achievement and enjoyment boost self-esteem and confidence, which may have a positive impact upon schooling and social skills. It is an activity that for most children will be family oriented, something they can share and build upon with their parents and siblings.

The various cognitive, developmental and physical fitness issues need to be carefully considered in assessing the suitability of each child to participate in a given level of dive activity. Diving is certainly magical but it is more complex than simply meeting the minimum requirements for one's certification, donning the gear and getting into the water.

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Key words
Editorials, children, scuba diving

Decompression sickness in a 14-year-old diver

Michael Davis

Key words
Decompression illness, scuba diving, children

Abstract
(Davis FM. Decompression sickness in a 14-year-old diver. *SPUMS J* 2003; 33: 75-76)
A 14-year-old boy was boat diving with three adults on a remote off-shore reef when, on entering the water, he was swept off the reef by the current, losing contact with his dive buddy. He reached the bottom at 63.8 m seawater depth. Unable to inflate his buoyancy compensator or to fin off the bottom, as he was considerably overweighted at this depth, he ditched his weight belt and made a swimming ascent. He was soon unable to control his ascent rate. He rapidly developed neurological and musculo-skeletal symptoms of decompression illness after reaching the surface requiring a complex evacuation to a recompression facility. Following a 30 m helium-oxygen treatment and a week of daily hyperbaric oxygen treatments, he made a complete recovery. This case illustrates the potential disparity between diving training agency guidelines for children and what may happen in actual diving practice.

The following case report is presented to remind readers of the dangers that children who have been taught to scuba dive may face underwater if the diving environment is not rigorously controlled by the supervising adults. His diving accident is reported with his mother's kind permission.

Case report

During a diving trip to a remote area of southern New Zealand, a 14-year-old Open Water diver suffered an uncontrolled rapid ascent from a depth of 63.8 m. He was diving with his elder (in his late 20s) brother and two other adults. This was his fifth dive over a two-day period, two of the previous dives having been in excess of 30 m. The dive site was on a reef several kilometres off shore, which on entry into the water he missed in the current, finding himself instead alone in deep, dark water. He was unable to inflate his buoyancy compensator or to swim off the bottom. He had the presence of mind to drop his weight belt in order to get to the surface but then was unable to control his ascent rate.

He rapidly developed neurological and musculo-skeletal symptoms of decompression illness (DCI), and on return to shore the emergency services were called but took some time to reach him. When first seen, he appeared shocked and delirious. He was evacuated by ambulance, then helicopter, another ambulance and finally by pressurised, fixed-wing aircraft over the Southern Alps to the nearest recompression chamber several hundred kilometres away. During this time, he was maintained on high-flow oxygen and intravenous saline.

On arrival at the chamber, he was complaining of moderately severe pain in the left knee, but was not aware of any other problems. On examination, he was fully conscious and there were no signs of circulatory shock or respiratory distress. Neurological examination showed weakness of all muscle groups in the left arm, most particularly in the distal muscles, and almost certainly similar weakness in the left leg, but this could not be assessed adequately because of his knee pain. He was hyper-reflexic generally, with down-going plantars. There was hesitancy and past-pointing with finger-nose test on the right, but the left appeared normal and he had a borderline sharpened Romberg's test with a best time of 25 seconds.

Hyperbaric therapy was commenced and he was reassessed after two oxygen periods at 2.8 bar (286 kPa). At this stage there had been minimal improvement in his neurological signs, though his left-knee pain was much better. The decision was made to proceed to a 30 m helium treatment (RNZN Table lA). This was completed without event and with significant improvement. At the end, power on the left side was normal, he had no pain in his left knee and, in addition, bladder sensation and function were normal. Secondary deterioration occurred following this first treatment, and he then commenced on daily hyperbaric treatments at 2.4 to 2.8 bar (245–286 kPa) each lasting two hours, to a total of seven treatments. He continued to make steady progress and at discharge no neurological signs were present.

Discussion

This incident had a number of potential implications for this boy and his family. First, our general advice to sport divers suffering neurological DCI is that they should never dive again. However, our view was rather coloured by the fact that his own presence of mind in the absence of responsible adult supervision underwater undoubtedly saved his life. There are few inexperienced adult sport divers who would have the presence of mind to ditch their weight belt at over 200 feet in the dark, narcotised and confused, let alone a 14-year-old schoolboy. We advised the family that he could return to diving when he was 16 years old.

Second, his father had died recently, and this accident was a severe shock for his mother who was clearly in a distressed state. It was felt both of them would need support over the ensuing months. Post-traumatic stress problems are not uncommon in divers following this type of injury and we were concerned that the boy could well be quite susceptible to behavioural and schooling problems. However, these apparently did not eventuate.

Finally, this accident reflects badly on the supposedly responsible adults with him. His brother's view was that he would rather have him doing adventurous sports than hanging around street corners sniffing glue. Whilst one applauds the general sentiment, nevertheless divers must modify their diving activities to meet the needs of a growing child. There were gross errors in the conduct of diving activities where this 14-year-old was concerned.

The recreational diving training agencies, such as the Professional Association of Diving Instructors and Scuba Schools International, have well-designed training programmes, clear recommendations regarding limitations on young children's diving and defined levels of supervision. However, it is the general diving public that determines whether these criteria are conscientiously put into practice or not. The analogy with speeding or drink driving is obvious. Such frailty in the human psyche is certainly not programmable into any training programme or recommendations. Thus, the decision regarding the training of children to scuba dive remains one for each parent or guardian and their child to make together.

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Assessing children's fitness for scuba diving

Robyn M Walker

To the Editor, Medical Journal of Australia:

The South Pacific Underwater Medicine Society (SPUMS) recommends that, before starting scuba-diving activities, all candidates undertake a medical assessment by a doctor trained in diving medicine. SPUMS recommends a minimum age of 14 years for all entry-level scuba activities, as does Australian Standard 4005.1.[1] This recommendation is based on the belief that younger children do not have the emotional maturity and confidence to safely manage underwater emergencies. Such emergencies, which may include running out of air, being separated from your buddy, being caught in a strong current, and equipment malfunction, can all result in panic.[2,3] A diver who panics will typically make a rapid ascent to the surface, risking life-threatening pulmonary barotrauma and decompression illness.[2]

Commercial scuba diving instructor agencies are introducing a number of introductory activities for children as young as eight years.

SPUMS urges caution in assessing young children as fit to dive. Medical practitioners making these assessments should clearly understand the nature of the activity to be undertaken, the equipment to be used and the nature of the environment in which the training is to occur. They should also understand the nature of the certification to be awarded. The presence of at least one legal guardian during this assessment is desirable to ensure that the risks are fully understood and to ensure the desire for the child to undertake the activity is not that of the parents alone.

An individual may meet the criteria laid down in a standard or understand and accept the risks of an aquatic sport. However, it is not clear that a young child is mature enough to make this informed choice.[4] Clearly, some 14-year-olds also lack sufficient maturity, and an experienced diving physician will advise them to delay their open-water certification course until greater maturity is demonstrated. Alternatively, some children younger than 14 years may be completely safe in undertaking a highly structured, one-on-one, supervised scuba experience in a swimming pool. However, it should be understood that trialling scuba equipment in a swimming pool has resulted in significant morbidity.

SPUMS continues to recommend a minimum age of 14 years for all entry-level scuba activities involving open-water dives, and recommends caution in assessing younger children for all other scuba experiences.

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ERRATUM

In SPUMS Journal Volume 33 Number 1, March 2003, page 46, Dr Robyn Walker's surname was incorrectly printed. The correct reference for this case report is:

Davis M, **Walker** R. Decompression illness in a tropical resort. *SPUMS J* 2003; 33: 46-48

The Editor apologises for this error.

SPUMS Members' News

Drew Richardson, a full member of the Society by election, was recently awarded Doctor of Education of the Nova Southeastern University. His dissertation is entitled:

> "*Development of a web-based distance education course for scuba divers with an implementation and evaluation plan*"

How old is old enough?

Robyn M Walker

Key words
Scuba diving, children, medicals/diving

Abstract
(Walker RM. How old is old enough? *SPUMS J* 2003; 33: 78-80)
Recreational diving training agencies are increasingly introducing young adults and children to self-contained underwater breathing apparatus (scuba) activities. This paper reviews the SPUMS position as at 2002 and its rationale on diving fitness and minimum age for diving.

Recreational diving training agencies are increasingly introducing young adults and children to self-contained underwater breathing apparatus (scuba) activities. In response to a number of enquiries from SPUMS members who requested advice in respect to fitness to dive and minimum age, a position statement, reprinted on the preceding page, was published in the *Medical Journal of Australia*.[1]

This paper provides the rationale for that position.

TABLE 1
PADI COURSES FOR 8- TO 15-YEAR-OLD CHILDREN

Supplied Air Snorkelling
Snorkel with a personal flotation device with a scuba tank and regulator attached
Need to be 10 years old and dive with a parent, guardian or PADI professional

PADI Bubblemaker
Pool diving with an instructor in confined water less than 2 metres sea water (msw)
Direct supervision of a PADI assistant instructor or above
Designed for 8- to 9-year-old children

PADI Seal Team
Learn the basis of safe diving and explore different aqua missions – wreck, navigation, buoyancy, underwater photography, environmental awareness
Designed for young divers 8 years and older

PADI Junior Open Water Diver
Certified to dive in open water under the direct supervision of a qualified adult diver
10–11 years – must dive with a certified parent, guardian or PADI professional
12–14 years – must dive with a certified adult
15 years – may upgrade to open water certification with a maximum depth of 12 msw

Current situation

SPUMS recommends that, before starting scuba diving activities, all candidates undertake a medical assessment by a doctor trained in diving medicine. SPUMS recommends a minimum age of 14 years for all entry-level scuba activities and that both the minor and their parent or guardian participate in the consultation to ensure the risks are fully understood. The Australian Standard AS 4005.1 – 2000 *Training and Certification of Recreational Divers - Minimum Entry level SCUBA Diving* also recommends a minimum age of 14 years. However, this standard specifically refers to those students who undertake the basic diving course and receive a qualification certifying them to dive in open water.

The British Sub-Aqua Club offers restricted certification courses to 12-year-old children and open water certificates at 14 years. The Scottish Sub-Aqua Club requires candidates to be 15 years or older. In the USA, the Recreational Scuba Training Council requires all participants to complete a questionnaire and anyone answering in the affirmative to any question is required to consult a medical practitioner. There is no requirement to consult a doctor if all questions are answered in the negative and there is no specified minimum age limitation.

Why is there concern?

Commercial organisations have developed and introduced scuba activities to children as young as eight years old. The courses conducted by the Professional Association of Diving Instructors (PADI) are listed in Table 1. Within Australia the AS 4005.1 does not apply to these courses and therefore no medical examination is required. The question has been asked that if a 14-year-old child requires a diving medical assessment, then why does an eight-year-old not need one?

How to assess a child's fitness to dive

When assessing medical fitness to dive in children under 14 the same basic rules that apply to adults will apply to children. For example, active asthma, juvenile onset diabetes and epilepsy will disqualify an individual from scuba diving. However, specific consideration should also be given to the assessment of physical, physiological and psychological maturity when assessing children's fitness to dive.

Children are not little adults. They are smaller, less powerful and may have difficulty coping with heavy scuba equipment, particularly on land. It is essential that exposure suits are appropriately sized, as children have a higher body surface area to weight ratio than adults and are more susceptible to cold and hypothermia. It is vital that buoyancy control devices (BCDs) are not oversized, as excess buoyancy may result in a rapid ascent and predispose to pulmonary barotrauma and cerebral arterial gas embolism (CAGE). Equipment should not be bought for the child to grow into and it needs to be regularly updated as the child grows.

All divers must be physically capable of dealing with the environment. Whilst conditions in a confined space such as a swimming pool are highly controlled, open water exposures may rapidly change. It is not unusual for weather conditions to change during a dive. Whilst you may enter during slack water, the tide may change and you exit battling a significant current. The child needs to be able to swim unassisted back to the boat or to the shore and be able to handle choppy surface conditions.

The buddy pair system exists so that if one of the dive pair experiences trouble their partner will be able to assist. Is it reasonable to expect a 10-year-old to effect a rescue, particularly if the affected individual is their parent or guardian?

Scuba diving requires a specific set of skills and physical coordination that may be poorly developed in the young. Demonstration of these skills in a highly controlled environment such as a swimming pool may not readily transfer to the open water environment.

Historically, concern has been expressed about the unknown effect of bubbles generated during decompression on unfused bony epiphyses. Many individuals continue to grow in stature until their late teens or early twenties when their long bone epiphyses fuse. Theoretically, bubbles formed during decompression could damage the active epiphyses resulting in early closure and retardation of growth resulting in reduced height. Although there are no animal or human data to support this claim it does remain a theoretical possibility. Inert gas dynamics are such that tissue or venous bubbles will not form in depths of 2 msw so this is not a consideration for the Bubblemaker programme.

As a consequence of the Eustachian tube not fully developing until approximately 12–13 years of age, children typically suffer more than do adults from middle ear infections. Therefore, children are at greater risk of suffering from middle- or inner-ear barotrauma. Some adults experience difficulty with the concept of ear equalization techniques and instructors and parents must be convinced the child comprehends the importance of this skill and is physically capable of performing it. Children also experience frequent upper respiratory tract infections with associated sinus and airway congestion and must not dive when so afflicted.

TABLE 2
SCUBA DEATHS IN CHILDREN REPORTED IN PROJECT STICKYBEAK[5]

Case 1 – 1973
16 years old, newly trained, separated from buddy
Found dead fully equipped in 8–10 ft water but no buoyancy vest
Cause of death reported as aspiration of vomit

Case 2 – 1975
15 years old, no scuba training
Separated from buddy
Body found in 15 ft water with a near-full tank

Case 3 – 1990
13 years old, diving with father, both inexperienced
Father found unconscious and suffered permanent mental impairment
Child found dead, all equipment in place except for tank and regulator, which were separated from each other

Case 4 – 1992
15 years old, separated from buddy whilst crayfishing
Found dead, no mask, tank empty
Presumed became lost in rock passages and unable to find way to surface

Parents need to be aware of the potential morbidity and mortality that can result as a consequence of pulmonary barotrauma. Boyle's Law explains why pressure and volume changes increase proportionately the closer you are to the surface, and episodes of CAGE have been reported during ascents from depths of only 2–3 msw.[2] A child breathing on scuba in a swimming pool only 2 m deep may not be at risk of decompression sickness but is certainly at risk of pulmonary barotrauma and CAGE if they do not exhale adequately when surfacing. In Australia, the incidence of asthma, with associated bronchoconstriction, air trapping, and reduced exercise tolerance, appears to be increasing although an unknown number of children will 'grow out' of their symptoms as they approach adulthood. Parents of children with asthma need to understand the possible consequences of exposing their child to a diving experience.

Children need to be sufficiently mature to understand the concepts of Boyle's Law, decompression theory and dive

TABLE 3
SCUBA FATALITIES IN CHILDREN (from refs 5, 6)

Case 1 – 1995
14 years old, died along with his father after diving to 40 msw to free an anchor

Case 2 – 1997
Untrained 12-year-old embolised and died after ascending while breathing from his father's tank

Case 3 –1997
14 years old, died after apparently running out of air while ascending from a dive to 30 msw with his father

Case 4 – 1997
15 years old, died from a CAGE following free ascent training during the first dive of a scuba class

Case 5 (New Zealand) – 1987
13 years old, died from a CAGE after panicking and making a rapid ascent from 12 m depth during an Open Water course

planning. They need to be psychologically mature enough to handle underwater emergencies and not respond by bursting into tears. Children often have a well-developed sense of adventure and a poorly developed sense of mortality. They are often easily distractible and excited by new experiences. Children often lack well-developed reasoning skills and may be slow to comprehend situational emergencies.

Available data

PADI issued 122,298 Junior Open Water Diver certifications between 1988 and 1998 with only one reported fatality.[4] The Confédération Mondiale des Activités Subaquatiques programme that is similar to the PADI Bubblemaker course has recorded nearly 1,000,000 exposures without serious injury.[3] Walker reports 15 deaths in divers under the age of 16 between 1972 and 1993.[4] Four of these were using scuba, one using hookah and 10 were breath-hold divers. Table 2 shows the details of the scuba deaths. Warren reports four deaths in children under 16 years old from 1995 to 1997 (Table 3).[5] There was only one scuba fatality under 16 years old in New Zealand between 1980 and 2000 (Table 3).[6]

SPUMS' position[1]

SPUMS urges caution in assessing young children as fit to dive. Medical practitioners who make these assessments must do so fully cognisant of the nature of the activity, the type of equipment to be used and the environment in which it is to take place. They should also understand the nature of the certification to be awarded. It is considered that the presence of at least one legal guardian during this assessment is desirable to ensure that the risks are fully understood and to ensure the desire for the child to undertake the activity is not that of the parent alone.

An individual may meet the criteria laid down in a standard or understand and accept the risks of such an aquatic sport. However, it is not clear that a young child is sufficiently mature to make this informed choice.[7] Clearly, some 14-year-olds also lack the maturity and an experienced diving physician will advise them to delay their open water certification course until this maturity is demonstrated. Alternatively, some children younger than 14 years may completely safely undertake a highly structured and one-on-one supervised scuba experience in a swimming pool. It should also be understood that trialling scuba in a swimming pool has resulted in significant morbidity.

SPUMS continues to recommend a minimum age of 14 years for all entry-level scuba activities involving open water dives and caution in the assessment of younger children for all other scuba experiences.

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Children in diving: how young is too young?

Simon Mitchell

For some years now PADI has offered a 'Junior Open Water Diver' programme for children aged 12–15 years. Graduates of this course are certified to dive in open water under the direct supervision of a qualified adult diver. More recently PADI has introduced its 'Bubblemaker' programme. This programme is provided for children aged 8–11 years and offers the opportunity to try scuba in confined water less than two metres under the direct supervision of an Assistant Instructor or above.

It was perhaps predictable that this attempt to introduce diving to younger persons would result in expressions of concern about safety from various quarters, including members of the medical community. Unfortunately, in the absence of published data describing the safety of diving in children, much of the commentary on this issue is based on speculation and emotion. Under these circumstances it is easy for discussants on both sides to lose perspective, and the debate may not necessarily generate the right answers. As both a diving physician and an experienced diving instructor I am well positioned to simultaneously appreciate both supportive and cynical views on children in diving. It follows that in this article I will review what is known (and not known) about the safety of diving for children, and present my own views on the issue.

Many of the basic rules and considerations that determine the appropriateness of diving for any candidate are common to both children and adults. For example, any of the medical problems that would reduce the safety of diving for an adult would also do so for a child. Specific concerns about children and diving arise from the myriad of physical, physiological, pathophysiological and psychological differences between adults and children and I will review some of those that are relevant to diving below. This type of discussion is complicated by the difficulty in strictly defining a 'child'. Many of the relevant characteristics evolve with age along a gradual continuum. The adult 'form' of different characteristics may be acquired at different ages, and there may be considerable variation between individuals in this regard. Generalisations must be made with caution.

Physical differences

Children are usually of smaller and less powerful stature than adults. Scuba gear is heavy and smaller children would find it very difficult to cope with wearing full scuba on land. Swimming with bulky scuba equipment also requires strength and stamina. Careful selection and configuration may ameliorate these problems and there is an ever-increasing range of options in sizes and styles of many items. Nevertheless, physical limitation can be an important safety issue in open water and it can be argued that children could easily find themselves in a situation where they have trouble coping. This is a critical consideration that in part predicates the requirement for certified adult supervision at Junior Open Water (JOW) level. Adults accompanying JOW divers must recognise their responsibility to avoid open water environments that may tax the less physically capable diver. Notwithstanding adult supervision, it is important that instructors teaching JOW divers carefully appraise each teenager's ability to cope with the physical demands of diving. Not all will 'make the grade' and instructors are the 'gate-keepers' in this regard. JOW diver candidates who find it physically difficult to cope must not be certified. It would be especially inappropriate at this level to simply counsel struggling students about their limitations and issue the certificate anyway.

Coordination and dexterity may be less well developed in children although by JOW diver age most children should be capable of learning diving skills to a standard comparable to that of adults. Psychological problems and limitations with mentation (see below) may be greater barriers to the achievement of adequate skill levels than physical limitations. Nevertheless, irrespective of the reason for any difficulty in achieving adequate skill levels, the instructor once again has a crucial role in ensuring appropriate achievement prior to certification.

Another physical difference between children and adults is the higher surface area to body weight ratio seen in children. For this reason, children will drop their core temperature more rapidly when immersed or exposed to wind in a wet wetsuit. They are therefore at greater risk of becoming hypothermic. Careful attention must be given to thermal protection, especially when diving in temperate environments. This is easier said than done. Teenagers at JOW level are growing rapidly and maintaining a wetsuit that fits adequately is a difficult and perhaps expensive task. Nevertheless, it is most certainly not an insurmountable problem; just one that needs attention.

Almost paradoxically, these concerns are less relevant to the younger Bubblemakers because they would only ever use scuba in confined water. Equipment could be carefully tailored to the small stature of the participants in this programme, and donned only when standing in the water to avoid the danger of falling while walking out of water. Achievement of excellence in skills is neither necessary nor even desirable. The aim of the programme is to provide an experience, not teach how to dive. Hypothermia is unlikely to ever be a problem in a confined water situation.

Physiological differences

One of the most obvious differences between children and adults is that children are growing. With reference to my previously specified threshold age of 15, it should be noted that growing does not stop in many teenagers until as late as 20 years. Changes in height occur mainly because of elongation of the long bones due to growth at their epiphyses. The epiphysis functions in a manner analogous to the operation of those large roading machines that move slowly forward laying down completed road behind them. The epiphysis is a complicated 'biological machine' that moves forward leaving 'completed' bone behind. At some point in the late teenage years the epiphyses are said to 'close' and bone elongation permanently ceases.

It has been suggested that epiphyseal tissue might be vulnerable to bubble formation during decompression. The obvious concern is that any such bubbling might damage the epiphysis, cause premature closure, and therefore inhibit growth. To my knowledge however, there are no data at all from animal or human studies that support this theory. Moreover, many thousands of dives are made by divers qualified to Open Water level and above who are between the ages of 15 and 20 years. I have not yet seen any clinical reports of apparent epiphyseal damage occurring in the cases of decompression illness that have occurred in this age group. I therefore believe there is insufficient evidence supporting this theory to justify altering our recommendations about diving in teenagers. Were we truly serious about this, we would not only discourage JOW divers, but also any diver less than 20. The issue is not really relevant to Bubblemakers since the inert gas exposure in two metres or less would be insufficient to cause bubble formation from dissolved inert gas in any tissue on ascent. Any concerns about this risk in JOWs or Open Water Divers less than 20 years can be largely addressed by ensuring conservative diving practice in this age group.

Eustachian tube function is critical for equalising pressure in the middle ears, and is often less developed in children up to age 12–13. This is one of the reasons why young children commonly suffer protracted ear infections. By JOW diver age, there should be little difficulty in teaching candidates to valsalva effectively. However, younger 'divers' in the Bubblemaker age range may be at greater risk of aural barotrauma. Even if it is assumed that Eustachian tube function is normal, it may be difficult to teach young children to reliably perform a Valsalva manoeuvre. This is one of the important factors underpinning the choice of two metres as the absolute maximum depth for this programme. Most experienced instructors teaching at Open Water level would agree that one of the problems inherent in teaching confined water sessions in two metres or less is that trainees often don't have to valsalva. Subsequently, problems with 'equalisation' may be unmasked in the deeper open water dives when the diver really needs to valsalva for the first time. Thus, it is likely that a descent to two metres would result in no aural barotrauma, even in the absence of an effective Valsalva manoeuvre. Any deeper however, and the risk would increase substantially. It follows that 'Bubblemaker experiences' should never take place in water deeper than the absolute maximum of two metres.

Pathophysiological differences

Just as there are some diseases which are more common in adulthood, so too are there illnesses that are more common in childhood. An important category in this regard is that of atopic diseases, including asthma, hayfever, and eczema. The argument that asthma may predispose the diver to pulmonary barotrauma and its potentially life threatening complications will be familiar to diving instructors. I would advise that children with a history of asthma are not admitted to Bubblemaker or JOW programmes. At least 50% of them will grow out of their asthma at or soon after puberty and the issue of diving can then be revisited at an age where they are eligible for an Open Water course. At older ages they will be better placed to understand the issues of risk and discretionary determinations of 'fitness to dive' that are necessary when dealing with previous or very mild asthmatics. Similarly, children with active hayfever should not be admitted to these programmes because hayfever may predispose to aural and sinus barotrauma. This is especially important for JOW divers who will venture into deeper water situations.

Psychological differences

In the debate over children and diving, few issues are more vexing than the differences between adults and children in psychology and mentation. Children are less able to assimilate technical information, unless it concerns computers it would seem! They may struggle with some of the more conceptually challenging aspects of diving theory. Attention and concentration are less developed in children and they are less able to stick to a plan. They are more impetuous than adult divers and if some underwater marvel captures their attention they are more likely to swim off to explore, and less likely to worry about where their buddy is.

Once again, these considerations have implications for both instructors and adults supervising JOW divers. Instructors should not certify those candidates who struggle more than normal with basic diving knowledge, who demonstrate a tendency to panic, or who demonstrate poor levels of attention, motivation, cooperation, or teamwork. Adults supervising JOW divers should not expect vigilant monitoring of dive parameters such as air consumption, time and depth by the junior diver. Nor should they assume that the JOW diver will obediently follow them to the letter of the buddy system. The purpose of the dive for the adult should be successful supervision of the JOW diver, not, for example, filling a catch bag with crayfish.

Since the Bubblemaker will never venture outside the highly controlled confined water situation, concerns over psychology and mentation are perhaps more relevant to the JOW diver. However, it has been argued that inattention and poor appreciation of risk may increase the risk of pulmonary barotrauma for the Bubblemaker. It is impossible to deny that divers of any age, Bubblemakers included, are at risk of pulmonary barotrauma and its life threatening complications even when diving in 2 m or less. This risk can be minimised by ensuring that the two-metre maximum depth is adhered to, and by close supervision of participating candidates by instructors.

Is it safe for children to dive?

Commentary such as that above in which various risks are enumerated and discussed inevitably make an activity sound horrendously dangerous! What is more, no one could argue that aural barotrauma or pulmonary barotrauma is never going to occur in a Bubblemaker. No one will suggest that it would be impossible for a JOW diver to become separated from his or her supervising adult and get into serious difficulty. Eventually, all of these events will occur. But qualitative discussion of potential problems misses the point. The important questions are 'What is the incidence of these potential complications?' and 'What incidence is unacceptable?'

Many parents allow their child to ride a bike to school every day knowing that each year many will be seriously injured in accidents. Thousands of children play hard contact sports like American football or rugby despite the well-understood risk of injury. Perhaps subconsciously, parents make risk-benefit decisions about their children's activities every day.

Diving should be no different in this regard. However, it is difficult to assess where the various diving activities on offer to the various age groups fall with regard to relative risk. Intuitively, I think that I would be more comfortable with my 10-year-old participating in a Bubblemaker experience than riding a bicycle on a public road and there are some data to support my perception of low relative risk. First, the Confédération Mondiale des Activités Subaquatiques (CMAS) has run a programme similar to Bubblemaker for years and now has records of close to 1,000,000 exposures without serious injury. In addition, PADI issued 122,298 JOW certifications between 1988 and 1998 and is aware of only one fatal accident involving a JOW diver. These admittedly crude data do indicate that the true risk of serious injury in these diving activities is very low. I must admit to more reservations about JOW divers than Bubblemakers, but provided both instructors and adult supervisors understand their responsibilities to the former, then these concerns are relatively minor. On the basis of my perceptions of relative risk, I believe that both the Bubblemaker and JOW diver programmes will provide a rewarding and comparatively safe introduction to diving.

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Children and diving: the recreational-diving training perspective

Drew Richardson

Abstract

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The provision of scuba experiences for children is drawing increased interest from many who look to scuba diving as a family activity. Dive industry professionals may independently decide if they wish to train families with children under 12 years old. The Professional Association of Diving Instructors (PADI) has made concerted efforts to provide information to assist affiliated instructors in making that decision, and prescribes standards and post-certification limitations based on minimum age requirements. This position statement overviews and identifies the issues involved in teaching children to scuba dive, including the risks in doing so from PADI's perspective and what to do to responsibly address these risks.

Introduction – the history of scuba diving in children

Training children to dive has a substantial history outside North America, particularly in Europe. For many years now, the Confédération Mondiale des Activités Subaquatiques (CMAS) has had a formal programme and training guidelines, as well as well-defined standards for teaching children as young as eight.[1–5] Prior to 1987, the Professional Association of Diving Instructors (PADI) and other certification organisations had no minimum age for certifying young divers. Teaching children younger than 12 was sanctioned on a performance-based approach throughout the 1960s, 1970s and 1980s for thousands of children.[6] Nearly 40 years ago children were diving into

Junior Frogman Programmes. The decades-old Jacques Cousteau film, *The Silent World*, shows young sons Phillipe and Jean-Michel diving with their father. There is indeed a developed base of empirical data and experience for children younger than age 12 getting a start in scuba diving.

Six reasons PADI introduced scuba programmes for children

There are six reasons PADI chose to add junior diver programmes for children aged 10 years:

SASY

Supplied Air Snorkelling for Youth (SASY) introduced new equipment and an unprecedented approach to offering safe, surface-based experiences to children as young as five.

BUBBLEMAKER

PADI introduced Bubblemaker to offer children as young as eight a safe and enjoyable scuba pool experience to a maximum depth of two metres. This was possible due to the development of child-specific diving equipment.

AN EMPIRICAL HISTORY OF SCUBA DIVING IN CHILDREN

Many PADI members asked PADI to change its minimum age requirement from 12 to 10 years. We did so only after evaluating the good safety record generated from the empirical data we reviewed from our own experiences in the 1960s, 1970s and 1980s training children younger than 12, as well as the data from other organisations during the same time period. In particular, CMAS has accumulated 20 years' experience of safely offering scuba training to children.[1] CMAS training programmes include compressed-air breathing in pool environments for children as young as four, and open-water scuba training and certification for children with a recommended, though not required, minimum age of eight. The Club Med resort system has similar programmes in many locations in the world, and has long been an advocate of children's dive programmes. With these data, we then developed a sequence of programming based on age and equipment, and we added strict pre- and post-certification limitations to courses like Junior Scuba Diver and Junior Open Water Diver based on minimum age requirements in terms of depth, supervision, ratios and control, along with other relevant safety factors.

RETURN TO PERFORMANCE-BASED TRAINING BY RECREATIONAL SCUBA TRAINING COUNCIL (RSTC)

When the dive industry settled on a minimum age of 12 for certification, PADI adopted this standard. The most recent PADI change came after the RSTC's vote to eliminate a minimum age in favour of performance-based training, and return the industry standard to its original wording.

SNUBA

Over the past ten years, SNUBA operations have allowed children as young as seven to participate in open-water experiences. SNUBA is a scuba/snorkelling adaptation where two divers can swim freely to a depth of six metres without a buoyancy control device or other equipment and breathe from a specially adapted regulator attached to a scuba cylinder floating at the surface. SNUBA operators report 3.5 million open-water exposures without incident (<http://www.scuba.com/questions.asp>).

FAMILY DIVING

We wished to provide families with an opportunity for a shared, non-contact adventure activity.

Special new restrictions and limitations

PADI has clear standards in place for teaching children to scuba dive, as well as limitations on dive certifications. Since the inception of the junior diver certification, divers under the age of 15 have always been required to dive under the direct supervision of a certified adult. Furthermore, this age group is restricted to a depth of no more than 18 metres, or 21 metres for Junior Advanced Open Water Divers.

Children under 12 have even greater restrictions placed on their certification. First, they are limited to a maximum depth of 12 metres. This ensures that junior divers are subjected to only minimal decompression stress, thereby addressing concerns raised over the unknown, and possibly increased, risk of decompression illness (DCI).

Another restriction of equal importance deals with the issue of supervision. While any certified adult diver might accompany Junior Open Water Divers aged between 12 and 15 after certification, that is not the case with those under the age of 12. These younger Junior Open Water Divers are required to dive with either a certified dive professional, Divemaster or higher, or a scuba-certified parent or guardian. No others, regardless of dive experience and training, qualify as supervisors.

Supervising children and instructor readiness

Teaching children to snorkel and scuba dive can be fun and rewarding, but places a new responsibility on instructors. It requires an adjustment to instructional techniques and supervisory procedures. After all, children are not little adults.

It is important to be comfortable teaching children before one does it. Teaching children is a choice. If an instructor has a personal interest in teaching children, but is not a parent and has had few opportunities to interact with them, it is recommended they team teach with someone skilled in teaching young people. Children often need more recognition, reassurance, praise and positive reinforcement than adults to remain focused and motivated. By being supportive and nurturing, an instructor can create a non-threatening environment conducive to learning and fun. Letting children know the instructor recognises and appreciates their efforts encourages them to keep trying. This takes personal commitment and a lot of energy. Some instructors may not feel comfortable with, nor want to take on, the added responsibility of dealing with younger students; that is fine in PADI's view.

Ten- and 11-year-old dive students

Without a doubt, there are 10-year-olds who do not qualify for dive training, and will not until they mature physically, emotionally and cognitively. Some children tend to be more physical and visual, while others may be less so. Because of their different rates of cognitive development, learning styles for children differ from those for adults. Scuba instructors need to be aware of these factors and may need to break a complex concept or task into simpler segments so children can grasp it more readily.

In the case of 10- and 11-year-olds, dive operators must be more attentive to the learning process than with adults. Likewise, when presented with the opportunity to train a physically challenged person, more personal attention, a review of dive-site selection and possibly special equipment configurations may be in order. These days, there are lots of choices out there for children in terms of smaller-sized dive equipment. Manufacturers like Aqualung, Scubapro and Oceanic are developing full-product lines for children, including child-sized wet suits and buoyancy compensators, as well as smaller tanks, masks, fins and mouthpieces for snorkels and regulators.

Medical issues regarding scuba diving in children

Speculation and controversy surround the discussion of the medical implications of allowing children to dive. After a thorough review of the medical literature on children and diving, the Diver Alert Network (DAN) concluded that insufficient clinical or scientific medical documentation exists to make any evidence-based judgment on the medical implications of allowing children to dive (unpublished data).

Under PADI standards, children are pre-screened for dive fitness under parental supervision via a dive-specific medical screen, and are required to be evaluated by a physician should anything on the screening form be answered in the affirmative.

The following commentary was prepared in consultation with the DAN staff physicians and other medical specialists at Duke University Medical Center. DAN conducted a Medline search from 1966, which revealed no papers dealing with how the physiological differences between adults and healthy children would alter the child's capability and risks associated with diving. Therefore, any recommendations made would be based on theoretical considerations taking into account what is known about normal growth and development, and the empirical evidence that exists where children younger than age 12 participated in scuba diving.

The following are the main issues that we consider must be addressed in considering children and scuba diving:

- Since a patent foramen ovale (PFO) is a risk factor in DCI, is there evidence of an increased incidence of PFO in children?
- Because of differences in neurological development, is there evidence that children are more susceptible to oxygen toxicity?
- Are growing bones in pre-pubertal children more susceptible to injury from DCI or silent bubbles?
- Are there any differences in the lung tissue or chest wall of children compared with adults that might make children more susceptible to pulmonary barotrauma?
- Given that young children have an increased incidence of asthma compared with adults, is diving more likely to trigger an asthmatic attack?
- Do children have an increased propensity for ear barotrauma?
- Are there special considerations needed to determine whether a child's thermal protection is adequate?
- Because large amounts of venous gas emboli (VGE) are thought to be associated with the development of DCI, is there evidence that children have a higher propensity to form VGE than adults?
- Are children whose central nervous system (CNS) is still developing more susceptible in general to DCI than adults?
- If children do get DCI, will it be of increased severity compared with adults as a result of an immature CNS?
- Do children have the strength and endurance to cope with emergencies?

The above are felt to be the most important medical and physiological considerations associated with children and diving. They do not, however, address behavioural or psychological issues, which may be equally if not more important than any medical and physiological considerations and should be addressed when considering the involvement of children in scuba diving.

Is there any evidence for an increased incidence of PFO in children?

DAN: One paper has looked at the incidence and age distribution of PFO in cadavers down to age 10.[7] An increased incidence of PFO in the 10–20 year group compared with other groups was noted. However, this incidence was based on only six cases, three with a patent PFO, out of a total of 705 (95% confidence intervals 11–88%). Thus, there is a suggestion of an increased incidence of PFO as age decreases below 20.

PADI: PFO is thought to be a risk factor in developing DCI. To avoid DCI concerns, PADI limited the depth for 10- and 11-year-olds to a maximum of 12 metres. According to the metric version of the Recreational Dive Planner the no-decompression limit for 12 metres is 147 minutes. Even in warm waters, recreational dives longer than one hour are unusual. This is a very generous safety margin and effectively precludes concerns about DCI.

Are children more susceptible to oxygen toxicity?

DAN: Clinical experience at Duke University showed no particular difference in susceptibility of children down to age eight to either pulmonary or CNS oxygen toxicity. Only a single paper was found that attempted to address the subject.[8] Bland showed that the effect of age on susceptibility to pulmonary oxygen toxicity was species specific; in some immaturity was protective, in others it was not.

PADI: The recreational dive community regards a maximum ppO_2 of 1.4 bar (142 kPa) as a conservative figure when discussing the possible onset of acute oxygen toxicity. PADI has not approved 10- and 11-year-old children for enriched air Nitrox, technical or deep diving courses. So, given that children will breathe compressed air only, they would need to dive to 60 metres before reaching a ppO_2 of 1.4 bar, well beyond the 12 metre limit. Pulmonary oxygen toxicity is not considered relevant to this discussion.

Are growing bones more susceptible to injury from DCI or silent bubbles?

DAN: In children up to age 18, long bones continue to grow from the epiphyseal region near each end. The epiphysis consists of mostly cartilage and has no blood supply, depending on diffusion of substances to and from adjacent vascularised tissue. If this area is injured then abnormal bone growth will result, such as one leg becoming shorter than the other. The main causes of injury to this region are weight-bearing sports activities such as skiing, rollerblading, ice-skating, football, etc. Accidental fractures are also common causes of injury to the epiphysis.

Joints are affected in musculoskeletal DCI, and avascular osteonecrosis has been associated with saturation diving and tunnel workers. The exact anatomical site of joint involvement is not known, and there is no published evidence suggesting that the epiphysis is more susceptible to DCI in children compared with adults. Children are unlikely to be exposed to the conditions most often associated with osteonecrosis in adults, but sport divers do occasionally develop osteonecrosis. Thus, we support time and depth restrictions for children. Restrictions have been imposed by organisations such as SSI, PADI and CMAS for children in confined and open-water environments.

PADI: There are no relevant experimental or clinical data, while data from clinical reports in cases of DCI in those aged 15–20 have not shown damage to the epiphysis. It is likely that exposures would have to be extreme, such as in caisson workers or saturation commercial divers, a scenario well outside the scope of recreational diving. The depth limits and limited decompression stress for junior divers add a considerable measure of safety. If this were an issue, it would apply to any diver younger than 20 years old.

Given its poor blood supply, the epiphysis is likely to behave as a 'slow' tissue (it 'on gasses' and 'off gasses' slowly). Slow tissues are more of a factor on long dives when there is plenty of time for tissues with poor blood supply to absorb nitrogen. Hence the enhanced osteonecrosis concerns for caisson workers and saturation divers. Given the depth restrictions and the short bottom times imposed on 10- and 11-year-olds, and the fact that scuba diving is a non-impact activity, risks to the epiphysis can be considered minimal.

Is there any difference in the lung tissue or chest wall that might make children more susceptible to pulmonary barotrauma?

DAN: Up to about age eight the pulmonary alveoli are still multiplying, pulmonary elasticity is decreased, and chest-wall compliance increased. This puts children eight years and younger at a theoretical increased risk of pulmonary barotrauma, although nothing was found in the published literature addressing this possibility. Based on this consideration, CMAS, PADI, SDI and SSI have recommended that children younger than age eight not scuba dive, with which DAN concurs. Given the variation in rates of growth and maturity it would even seem prudent to raise the minimum age closer to puberty, not less than 10 years old, to exclude any chance of children with immature lungs from diving. Organisations including SSI, SDI and PADI have all agreed.

PADI: This is the primary reason for the 10-year age limit.

Are children more likely to have an asthmatic attack while diving?

DAN: Risk factors that might provoke an asthmatic attack such as cold or exercise are present in the dry environment as well as underwater. However, the possibility of salt-water aspiration adds an additional risk factor. In addition, a child's reaction to an asthmatic attack underwater may involve a higher panic component than in an adult, putting them at increased risk of injury. There are no data to accept or refute these hypotheses.

PADI: Active asthma is a contraindication to diving, both for adults and children. This is a determination made by doctors and parents for 10- and 11-year-olds. If a 10- or 11-year-old child has active asthma, or if there is any doubt at all, the only possible recommendation is to avoid diving completely. This also applies to older children and adults.

Do children have an increased propensity for ear barotrauma?

DAN: Up to age eight, the Eustachian tube, which is responsible for equalizing the middle ear, is more tortuous than in adults. Hence, ear infections are more common in children. In a group of 234 Belgian children, aged six to 12 years, it was found that barotrauma and ear infections were the most common medical sequelae to diving.[9]

PADI: This is another reason for PADI's 10-year age limit and a very good reason to ensure that everyone in dive training programmes can equalize properly. It is worth pointing out that equalization of ears and mask is one of the first and most important skills any diver needs to master. Eustachian tube dysfunction is common in early childhood, so susceptibility to ear barotrauma is greater for children under age 12, when most children have achieved adult-level Eustachian tubes. It is important to make certain children can equalize properly in confined water before taking them on open-water dives.

Are there special considerations needed to determine whether thermal protection is adequate?

DAN: Children have a higher body surface area to volume ratio and smaller body mass than adults, which means under similar conditions with similar thermal protection they will cool faster. Special attention must be paid to ensure that children do not become hypothermic during diving. Exposure protection designed for children is recommended where warranted.

PADI: Make sure children have adequate thermal protection and monitor them closely for signs of chilling.

Do children have a higher propensity to form venous gas emboli (VGE) than adults?

DAN: No studies have been carried out comparing post-dive VGE incidence in children compared with adults.

Are children more susceptible to DCI than adults?

DAN: There are no published data that could be used to answer this question. However, organisations including PADI, SSI and SDI have all imposed depth and time restrictions to address this.

If children do get DCI, is it likely to be of increased severity compared with adults?

DAN: We have no published data to answer this question.

PADI: For this and the previous two questions, PADI refers back to the discussion regarding PFO relating to DCI. Given the restrictions placed on 10- and 11-year-old divers, this risk, from a practical standpoint, can be considered minimal.

Do children have the strength and endurance to cope with emergencies?

DAN: Children have less strength and endurance than adults. Whether it is sufficient to cope with emergencies, swim against currents, or board a boat under less than ideal conditions is unknown since the appropriate human-factor studies have not been carried out.

PADI: This question is not unique to 10- and 11-year-old children, PADI professionals have helped divers deal with this issue for years. Specific to this age group, however, is the requirement that they dive with a parent, guardian or PADI professional. PADI is defining the diving envelope within which these children may dive. An instructor must further define it based on local conditions. Philosophically, the very premise of the PADI Rescue Diver course reflects this issue in that there is never only one way to deal with an emergency or stressful situation.

Addressing this concern from a practical perspective begins with dive-site selection, ensuring the site is appropriate for the divers' age and experience levels. It is not reasonable nor prudent to expect children to simply tag along on dive trips designed for experienced adults. Dive professionals are encouraged to emphasise the importance of dive planning and sticking to that plan, and of supervision. That said, there are numerous instances of children younger than 10 making emergency assistance calls and helping adults in distress in other ways.

Summary of research evidence

Based on the above considerations, DAN considered the only data available that could be used to establish a minimum age for diving are based on pulmonary development. This suggests the possibility of and increased susceptibility to pulmonary barotrauma for pre-pubertal children, especially those less than 10 years old. There are no other data available that would assist in making this determination. It should also be noted that the empirical data and collective experience with scuba diving in children seem to be based on shallow-water, protected diving.

There is insufficient information to make any evidence-based medical judgment for or against involving children in scuba diving. As more children under the age of 12 dive, additional empirical data will gradually accumulate. However, in order for these data to be useful in making medically based decisions regarding children in diving it will have to be carefully collected, vetted, and analysed.

While the above represents DAN's best effort at looking at the problem, we realise there may be quality data available that have not yet been published. For as wide a perspective as possible, DAN invites anyone with substantive comments on DAN's assessment of the issues pertinent to children in diving to forward them to DAN (<www.danseap.org>). This issue will generate a wide range of opinions and, while these are useful, conclusions backed up by actual data or records are the most constructive.

Dive risks in perspective

Every day, thousands of parents enroll their children in sports such as soccer, rugby, American football, basketball, field hockey, skiing, gymnastics, skateboarding, bicycling, snowboarding, volleyball, wrestling, baseball, martial arts and other contact adventure sports and recreations. The incidence of morbidity and mortality in these activities is significant. For example, in the United States alone, emergency rooms treat more than 775,000 children under the age of 15 for contact-sports injuries each year. Trauma involving cervical and other spinal injuries, long-bone fractures and the like are regular occurrences in these sports. The risks and severity of the consequences of such activities are clear.

In comparison, scuba diving is a non-contact, non-impact soft activity experienced under closely controlled conditions requiring strict supervision, limited depth and careful instruction. Clearly, scuba is a reasonably safe activity with manageable risks, but is definitely not risk free. The major, potentially catastrophic dive-related risks for children include drowning, lung overexpansion injuries including arterial gas embolism, water aspiration and ear injury. These need to be managed through proper supervision and other precautions, such as reducing ratios and increased adult supervision. Both of these are vital requirements in PADI's junior diver programmes.

Ten- and 11-year-old dive buddies

A 10-year-old may not be able to assist a larger buddy such as a parent, for example, should an incident arise. However, some adult buddy teams may find themselves in similar situations, particularly when one diver is significantly smaller in stature and ability. When a physically challenged diver is teamed with an able-bodied one, or even when a neophyte diver is teamed with an experienced one, there are limitations on the team based on the weakest member. Yet, it works out in reality. This is because people tend to accept relevant limitations and accommodate them. These limitations are factored into the dive plan in terms of selecting an appropriate site based on depth and environmental conditions. Dive operators must be attentive to the limitations of their customers and select dive sites accordingly. Although Junior Scuba Divers and Junior Open Water Divers must fulfil the same certification requirements as an adult, the expectations faced by adult divers do not apply to divers with these certifications.

The implication of the differences between adult and junior divers has an important bearing on supervision. When an adult dives with a child, that adult may not have a buddy in the same sense as when diving with another adult, for example. On the other hand, there are anecdotes of children offering assistance to adults, children who call emergency services or even offer CPR in a medical emergency. The child mature enough to handle a dive certification course has demonstrated the ability to be responsible and to follow rules. It may follow that the same child may be astute enough to know how to inflate a buddy's BCD, then surface and call for help, or ditch a weight belt.

Children, their knowledge of safety and awareness of danger

Two published studies conducted to determine the extent to which children are aware of the dangers in several situations are of interest to training children how to safely scuba dive and indicate that eight- to 11-year-olds can understand and identify danger.

In the first study, thirty seven grade-three children (seven to nine years old) were tested by showing them drawings of children engaged in ten activities.[10] The students were asked what the children in the drawings were doing and how the children could get hurt. Depending on the drawing, 84–100% of the students identified the activities depicted appropriately, and 85–100% identified significant dangers in the situations depicted. The researchers concluded that, in general, the group of students tested appeared to be quite knowledgeable about the hazards represented in the set of drawings.

A second study investigated the ability of 64 children between five and 11 years old to select safe places to cross the road.[11] The children were presented with situations that were either extremely safe or manifestly dangerous and were asked to correctly identify these. All the experiments showed a similar pattern of results. Five- and seven-year-olds exhibited very poor skill in identifying dangerous road crossing sites. Nine-year-olds showed a higher level of ability and 11-year-olds showed good skill in these judgments. The results suggest that young children up to about nine years old do not have the ability to recognise a location as dangerous.

Although similar studies have not been performed with children for scuba diving, application and benefit for teaching scuba diving to children can be derived. The importance of utilizing all of the visual, audio and live-delivery media and information available for each diving programme, and thoroughly explaining the risks and dangers, can be inferred from these results. Thus, the child will be made aware of and identify the dangers and hazards associated with the given activity.

Social benefits

To a large extent, getting children interested in recreational diving takes them out of harm's way in a broader context in that it provides an active, rewarding recreation. It provides a focus that sets the stage for a healthy lifestyle away from drugs and other destructive pathways. It is also a means to bond families together with a common interest.

Evaluating motivation, knowledge and ability

How does an instructor evaluate motivation, readiness and ability in a child? It may be important to first assess motivation. Does the child really want to dive, or is there too much parental pressure? Parents should not pressure their children into training. Scuba diving is not an appropriate activity for a young person if that interest does not stem from a personal desire to learn.

Parents value programmes that are educational, interactive and activity based. PADI programmes allow children to learn about the underwater world and acquire new skills. Children learn to take responsibility for their actions and meet established goals, which builds confidence and pride. All of these benefits can build character and self-esteem. As for ability, instructors are obligated under PADI standards to conduct an assessment of knowledge and skill prior to making open-water dives. The point of pre-assessment is to give the instructor an opportunity to assess ability, strength, aptitude, readiness, emotional and psychological maturity, and attitude before progressing to the open water.

Safety and responsibility

Divers' health and safety are of paramount importance in the creation of every programme PADI has ever developed. Safety is integral to the long-term success of any business, including PADI. Many of us at PADI who develop standards changes are both instructors and parents. So consider this: we would not have introduced Bubblemaker, SASY, Junior Scuba Diver and Junior Open Water Diver programmes for children younger than 12 if we did not feel that decision was appropriate for our own children.

At a glance: PADI youth programmes

AGES FIVE AND OLDER:
May participate in Supplied Air Snorkelling for Youth (SASY) experiences. SASY allows youths to breathe from a regulator at the surface while wearing a flotation device in a pool environment.

AGES EIGHT AND OLDER:
May participate in PADI's Bubblemaker programme. This programme introduces participants to scuba diving in a pool or pool-like environment and has a maximum depth limit of two metres.

AGES 10 AND 11:
May participate in Discover Scuba and Discover Scuba Diving experience programmes, and can earn restricted certification as either a PADI Junior Scuba Diver or Junior Open Water Diver. PADI Junior Scuba Divers are limited to a maximum depth of 12 metres and may only dive with a PADI professional. PADI Junior Open Water Divers are also limited to 12 metres, and may dive with a PADI professional or a certified scuba-diver parent or guardian.

AGES 12 TO 15:
No recent changes. Divers in this age range earn junior certifications and can dive only when accompanied by a certified, adult scuba diver. During training, these divers are limited to 12 metres for the first two dives and 18 metres for dives three and four. Divers in this age group are limited to a maximum depth of 21 metres for all other PADI continuing-education courses.

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Book review

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This book is intended for diving instructors and parents. I am an instructor but not a parent. Therefore, I asked a local dive store what questions parents most commonly ask.

The sections are well laid out, with natural breaks, good summary points and clear photographs, making it very easy to read from cover to cover, or to use as a reference guide for a particular topic. The eight chapters cover the main theories of human development and medical issues, and provide practical advice on techniques to facilitate learning for the younger scuba diver. The book emphasises throughout the important partnership that must develop between the parent, child and instructor. For those who want more detail, particularly about child development, approximately 50 references and 10 web sites are listed. Initially, I wasn't taken with the cream-coloured pages and sepia photographs, however this trendy style grew on me.

The first chapter, 'Children of the sea', sets the scene that childhood is supposed to be magical, and full of discovery, wonder and adventure. Jean-Michel Cousteau, Lyn Morgan and Karl Shreeves present their perspectives on growing up with diving. Aside from this idyllic view, the risks associated with scuba diving are made very clear, and information and statistics are given that would help the anxious parent put the risks into perspective. This chapter also provokes thought around a child's readiness to learn.

Chapter Two introduces theories of intellectual development and the importance of matching the PADI diver programme with the child's stage of development. A long chapter, but interesting to understand how the various stages of development affect learning ability. It also has practical suggestions on how parents can support intellectual, physical and emotional development. It is worth reading the theories of Jean Piagets, referred to throughout the book.

The third chapter addresses the physical, physiological, pathophysiological and psychological differences between adults and children. Based on Dr Mitchell's paper, reproduced in this issue, it provides the non-medical person a succinct, balanced view on concerns about physical strength, motor skills ability, thermal considerations, bone growth, ear equalisation, and the impetuous nature of children with a potentially lower threshold for panic. Risk acceptance is put into perspective when diving conducted within appropriate limits and adult supervision is compared with other outdoor childhood activities. This is an excellent overview and a 'must read' section for instructors; also a balanced source of information for parents who raise any of these concerns. My only criticism is that I would have liked this chapter to include suggestions for further reading.

Chapters Four and Five provide practical suggestions for teaching and interacting with children on dive programmes. These chapters provided an excellent summary of the nine basic events of instruction, or conditions of learning, that optimise the teaching process. They also provide many tips on developing rapport, setting small goals, and building self-esteem and self-responsibility.

Not afraid to address the issue of child abuse, Chapter Six highlights the importance of professional conduct with appropriate interactions and supervision. It also provides the instructor with helpful guidelines on how to respond to a situation of suspected child abuse.

Chapter Seven cleverly intertwines the promotion of PADI centres, activities and continuing education courses with the fact that these are practical solutions to provide the young diver with continued experiences through organised activities. For parents, this chapter offers easy options to meet the child's enthusiasm for diving. For instructors there are some excellent ideas for underwater games and involvement in caring for the underwater environment.

Instructors should become familiar with the two case studies in the final chapter. These scenarios could be used to provide parents with insight into what is involved in a dive programme and also to emphasise the shared commitment that is necessary between the instructor, parent and child. They also help answer concerns about supervision, the most frequently mentioned subject in questions from parents.

In summary, this is a solid reference resource for instructors, and helps put risks and responsibilities into perspective for parents. It is bulging with practical suggestions to enhance child learning and is worth reading just for the ideas. A great deal of work has clearly gone into collating the book with input from highly credible contributors and the information is presented in a balanced and informative way.

Lynn Taylor

Key words
Book reviews, scuba diving, children

SPUMS Annual Scientific Meeting 2002

Post-travel illness

Trish Batchelor

Abstract

(Batchelor T. Post-travel illness. *SPUMS J* 2003; 33: 91-97)
An estimated 50 million people travel from industrialised countries to less developed areas of the world annually. Between 20% and 70% of these travellers will experience ill-health whilst abroad. Although most of these ailments are minor, between 1% and 5% of travellers will seek medical advice either whilst abroad or on their return home. Additionally, one should consider groups such as refugees and asylum seekers who will present to doctors in industrialised nations with diseases endemic to their home countries. In travellers, the most common health problems are diarrhoea, respiratory infections and skin conditions, relatively minor complaints that can be easily managed at the primary care level. One to three per cent of post-travel patients will be febrile and, if they have travelled to an area endemic for malaria, should be investigated as a matter of urgency to exclude potentially life-threatening *P. falciparum* infection. The range of possible diagnoses in a post-travel patient is diverse and can be daunting. Taking a thorough travel and exposure history and considering incubation times can result in a more workable differential diagnosis.

Introduction

An estimated 50 million people travel from the industrialised world to the less developed world each year. Between 20% and 70% of these travellers will develop illness related to their travels.[1] Whilst most of these ailments are minor, 1–5% of travellers will seek medical advice for their travel-related illness either whilst abroad or on their return home.[2] Thus, it is to be expected that doctors in Australia and NZ will frequently be consulted by patients who have acquired illness whilst travelling.

Post-travel patients are diverse, with each group having unique potential exposures. Apart from the leisure traveller, one should consider special groups such as humanitarian workers, missionaries, religous pilgrims, the military, international students, business people, long-term expatriates and their families, adventure travellers, those travelling for sex and so on. It is not just travellers from the industrialised world to the less developed world who should be considered when looking at post-travel problems. One should also consider those moving in the opposite direction; refugees, immigrants, asylum seekers and migrant workers may all present with illness endemic to their home country.

As in all fields of medicine, a thorough history will provide the majority of the information required to produce a workable differential diagnosis. In the case of post-travel presentation this is arguably even more important than usual, as the range of possible illness is so broad and diverse.

The recent outbreak of SARS has highlighted the role that international travel can play in the spread of emerging diseases. The world's population is now incredibly mobile – at any time a patient may walk into our clinics or emergency rooms having departed from any point on the globe within the last 24 to 48 hours.

Epidemiology

Data are increasingly being collected to analyse the epidemiology of travellers' illness. One American study conducted in a travel medicine clinic analysed data collected from 780 individuals who had travelled to less developed countries for a period of less than three months. Of this cohort, 64% reported illness during their travels, the most common complaints being diarrhoea (46%), respiratory

FIGURE 1
ILLNESS IN A USA POST-TRAVEL CLINIC (ref 3)

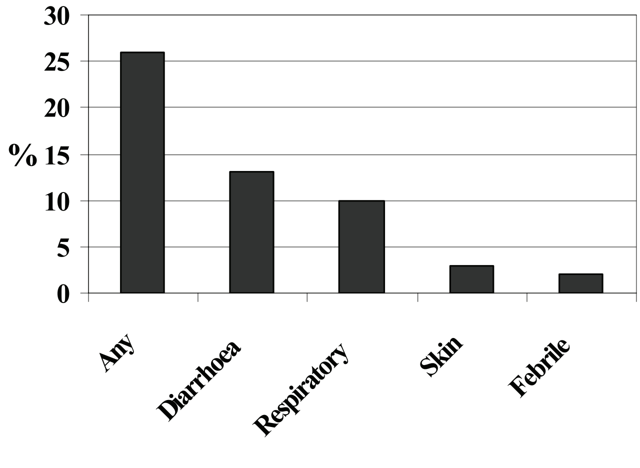

TABLE 1
10 MOST FREQUENT DIAGNOSES AT CIWEC TRAVEL MEDICINE CENTER, KATHMANDU, NEPAL

DIAGNOSIS	%
Acute bacterial diarrhoea	19
Acute respiratory infection	14
Skin condition (rash, infection, dermatitis)	5
Acute parasitic diarrhoea	5
Laceration, sprain, fracture	4
Healthy	3
Acute diarrhoea, unknown aetiology	2
Anxiety	2
Asthma	2
Animal bite/rabies post-exposure prophylaxis	2

TABLE 2
THE MINIMUM REQUIREMENTS FOR A POST-TRAVEL MEDICAL HISTORY

- Departure and return dates
- Countries and regions visited
- Illness whilst abroad
- Medications taken abroad
- Illness amongst fellow travellers
- Specific exposures: unsafe sex, swimming in fresh water or consumption of certain foodstuffs
- Pre-travel vaccinations: date(s) of administration
- Anti-malaria prophylaxis and compliance with prescribed regimen
- Detailed geographical history
- Activities undertaken
- Timescale of potential exposures

tract symptoms (26%) and skin problems (8%). Of the study group, 26% reported illness on their return home. Once again, the most common complaints were diarrhoea (13%), respiratory tract symptoms (10%) and skin problems (3%) (Figure 1).[3]

Similar figures are reported from the CIWEC Travel Medicine Center in Kathmandu, Nepal (P. Pandey, personal communication). This Western-run travellers' clinic sees approximately 6,000 patients annually and collects data on all patient visits. These unique data provide an excellent insight into the health problems of travellers whilst in a destination country. Of 8,900 travellers analysed, the most common complaints were acute bacterial diarrhoea (19%), acute respiratory infection (14%), skin conditions (5%), parasitic diarrhoea (5%), and injuries such as sprains, fractures and lacerations (4%), followed by a variety of other conditions (Table 1).

Thus, it is apparent that the majority of post-travel patients will present with relatively minor complaints that can be dealt with easily at the primary-care level. The febrile post-travel patient has more potential to be a medical emergency, but accounts for only 2–3% of ill travellers. Life-threatening conditions such as *Plasmodium falciparum* malaria must be excluded in these patients as a matter of urgency. An analysis of 232 febrile post-travel patients admitted to the Royal Melbourne Hospital showed malaria to be the most common diagnosis (27%), followed closely by respiratory tract infections (24%), then gastroenteritis (14%), dengue fever (8%), enteric fever (3%) and a variety of other conditions (Figure 2).[4]

FIGURE 2
FEBRILE POST-TRAVEL PATIENTS ADMITTED TO THE ROYAL MELBOURNE HOSPITAL (ref 4)

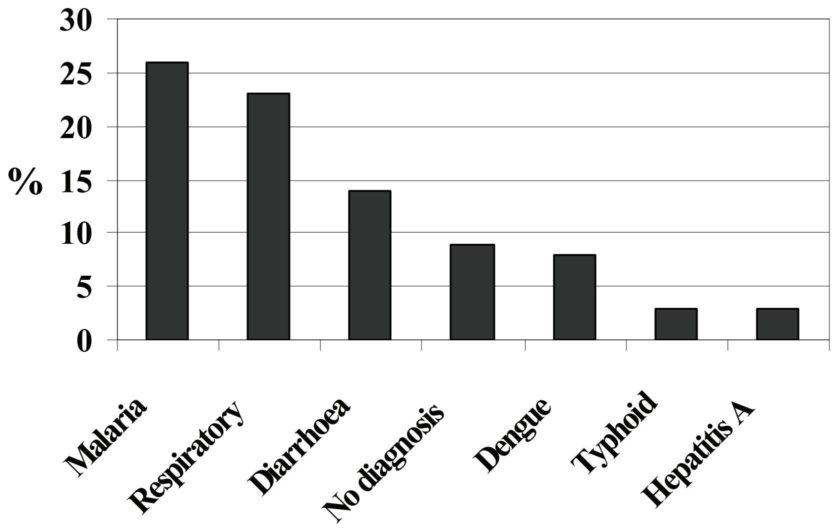

TABLE 3
TYPICAL INCUBATION TIMES FOR SELECTED TROPICAL DISEASES
(NB. This is not a comprehensive list)

SHORT (<10 days)
- Arboviral e.g., Japanese b encephalitis, dengue fever, yellow fever
- Bacterial diarrhoea
- Bacterial meningitis
- Haemorrhagic fevers e.g., Lassa, Marburg, Ebola
- Influenza
- Legionnaires' disease
- Leptospirosis
- Lyme disease
- Malaria
- Rabies
- SARS
- Streptococcal pharyngitis
- Typhoid and paratyphoid
- Typhus – African tick bite, flea-borne, scrub, Rocky Mountain spotted fever

MEDIUM (10–21 days)
- Amoebiasis
- Arboviral e.g., Murray Valley encephalitis, tick-borne encephalitis, Japanese b encephalitis
- Haemorrhagic fevers e.g., Congo-Crimean, Lassa, Marburg, Ebola
- Leptospirosis
- Lyme disease
- Malaria
- Measles
- Q fever
- Rabies
- Schistosomiasis (acute)
- Toxoplasmosis
- Trypanosomiasis
- Typhoid
- Typhus
- Hepatitis A (rarely)

LONG (>21 days)
- Amoebic liver abscess
- Brucellosis
- Filariasis
- Hepatitis, viral
- HIV
- Lyme disease
- Malaria
- Q fever
- Rabies
- Schistosomiasis (acute)
- Trypanosomiasis
- Tuberculosis
- Typhoid

Taking a post-travel history

Apart from the standard medical history, a travel history should be taken in as much detail as possible (Table 2). At a minimum this should include departure and return dates, all countries and regions visited, illnesses that occurred whilst abroad, medications taken abroad, illness amongst fellow travellers and specific exposures such as unsafe sex, swimming in fresh water or consumption of certain foodstuffs. Pre-travel vaccinations and their date of administration should be reviewed, as should the appropriateness of anti-malaria prophylaxis and patient compliance with the prescribed regimen.

A detailed geographical history will help exclude many potential pathogens and may also provide very specific clues. Activities undertaken can also offer specific clues. For instance, white-water rafting is associated with leptospirosis, walking safaris in southern Africa with African tick bite fever, and sexual contact with HIV. An accurate timescale of potential exposures and knowledge of incubation times are essential as these parameters may be used to exclude many aetiologies (Tables 3 and 4).

A thorough examination with a particular emphasis on temperature, lymphadenopathy, skin, chest, liver and spleen is imperative and may add further clues. Baseline investigations for a febrile patient should include: full blood count (FBC), three malaria smears, antigen testing, liver function tests, urea, electrolytes, blood culture, urinalysis, chest X-ray, stool and serum for relevant serology.

Fever in the post-travel patient

Febrile travellers must be assessed with urgency, in particular to exclude potentially life-threatening *P. falciparum* malaria. The 'big four' illnesses to exclude in the febrile traveller are malaria, dengue fever, enteric fever and hepatitis. The list of potential diagnoses is extensive and will not be covered in this review. A recent review article by Schwartz provides a timely methodological approach for the evaluation of fever in the returned traveller.[5]

MALARIA

Malaria has been covered in detail in a previous article in this series and will not be discussed again.[6] It is, however, important to emphasise that malaria remains the most frequently diagnosed disease in the febrile traveller and may be rapidly fatal.[4] The fever pattern in malaria is variable and may not be continuous, and the absence of fever at the time of evaluation should not exclude the possibility of malaria. At least three negative malaria smears read by a competent pathologist over a period of 48 hours are required to exclude the diagnosis. Most would agree that all patients with *P. falciparum* should be admitted to hospital for treatment as their clinical status may deteriorate rapidly.

DENGUE FEVER

Dengue fever is increasingly being recognised as a risk to travellers. Dengue viruses are the most common cause of arboviral disease in the world and are estimated to cause 50–100 million cases of dengue fever annually.[7]

The principal vector of dengue, *Aedes aegypti*, is found throughout the world between the latitudes of 35^{O} North and South. It is a highly efficient vector and over the past 60 years the incidence, distribution and clinical severity of dengue has increased dramatically.[7] An analysis of European travellers who had contracted dengue abroad showed that over 50% of cases were acquired in Asia. Thailand and India in particular are high-risk destinations.[8] Of patients admitted to the Royal Melbourne Hospital with dengue, 61% acquired their illness in Thailand.[4]

Dengue has a short incubation period of four to seven days and in the classical presentation common symptoms include the abrupt onset of high fever, severe headache, retro-orbital pain, myalgias, arthralgias and sometimes a maculopapular rash. Laboratory findings commonly associated with dengue include neutropenia, lymphocytosis, and thrombocytopenia.[7] Diagnosis is by virus isolation or positive serology. There is no specific treatment available for dengue. Patients should be watched for signs of dengue haemorrhagic fever (DHF), the more severe manifestation of the illness. DHF is primarily a disease of children under 15 in hyperendemic areas, characterised by haemorrhagic manifestations and a platelet count of less than 100,000.[7]

ENTERIC FEVER

Enteric fever is the clinical syndrome caused by *Salmonella typhi* (typhoid fever) or 'paratyphi' Salmonella species (paratyphoid fever). The dominant symptoms are sustained fever and headache. Patients have constipation, abdominal pain, and a dry cough. Leukopenia and thrombocytopenia may be present on FBC. The most common destination for acquiring the illness is the Indian subcontinent (India and Nepal), which now has increasing species of quinolone-resistant *Salmonella*. Eighty per cent of the cases of typhoid fever treated at the CIWEC Travel Medicine Center in Kathmandu, Nepal, this year have been resistant to ciprofloxacin (W. Cave, personal communication). Interestingly, older drugs such as co-trimoxazole are being found to treat the illness successfully. Diagnosis is made by culture. Blood culture is approximately 50% sensitive, whilst bone marrow is more reliable and offers approximately 90% sensitivity. Without treatment, the case fatality rate of enteric fever is 10%. This is reduced to less than 1% with appropriate antibiotic therapy.

HEPATITIS

Theoretically, hepatitis A should no longer be a cause of fever in travellers since the advent of a highly effective vaccine. It is therefore disturbing to see that hepatitis A still accounted for 3% of the patients in the Royal Melbourne Hospital series. This reflects a failure of travellers to seek appropriate advice pre-travel, or of healthcare providers to offer adequate pre-travel vaccination advice.

Hepatitis E is endemic in Nepal and there is currently no vaccine available. Like hepatitis A, it is food and water borne and presents clinically in a manner indistinguishable from hepatitis A. Hepatitis E is a particularly serious disease in pregnant women resulting in a 30% maternal and fetal mortality rate if contracted in the final trimester. A vaccine trial is currently underway in Kathmandu; unblinding of the results will occur in May of this year. Interestingly, this study has been conducted in members of the Royal Nepalese Army and has shown an incidence rate of 5% in the study population (R. Scott, personal communication). The diagnosis is made on serology and should be considered in all cases of hepatitis in travellers, particularly in those to the Indian subcontinent. Treatment is supportive.

TABLE 4
SPECIFIC EXPOSURES FOR SELECTED TRAVEL-RELATED DISEASES

Untreated water	Hepatitis A and E, bacterial diarrhoea, cholera
Unpasteurised dairy products	Brucellosis, Q fever
Undercooked meat	Cestodes, trichinosis, bacterial diarrhoea
Animal contact/bites	Rabies, Q fever, typhus, echinococcosis, leptospirosis
Mosquitoes	Malaria, dengue fever, yellow fever, arboviruses
Sand flies	Leishmaniasis
Tsetse flies	Trypanosomiasis
Ticks	Rickettsial disease
Fleas	Murine typhus, plague
Freshwater exposure	Schistosomiasis, leptospirosis
Barefoot exposure	Strongyloidiasis, cutaneous larva migrans
Sexual contact	HIV, other STDs
IV drug use/tattoos/transfusions	HIV, hepatitis B and C, malaria
Sick contacts	Meningitis, TB

Diarrhoea

Acute traveller's diarrhoea has previously been discussed in these review articles.[9] Chronic diarrhoea (diarrhoea of greater than two weeks' duration) is more likely to present to the doctor evaluating a post-travel patient. Chronic diarrhoea is more commonly parasitic than bacterial in origin, however a bacterial cause should always be excluded. In Kathmandu, *Campylobacter* is the second most commonly found pathogen in patients with diarrhoea lasting for two to four weeks (P. Pandey, personal communication). The most common parasitic causes of prolonged diarrhoea in travellers are *Giardia lamblia, Entamoeba histolytica*, *Cryptosporidium* and *Cyclospora*.[10]

GIARDIASIS

Giardia lamblia is the most common protozoan infection in returning travellers.[10] At the CIWEC clinic it accounts for 5% of cases of traveller's diarrhoea. *G. lamblia* tends to cause a prolonged, low-grade illness characterised by two to five loose bowel motions daily with accompanying nausea, mild fatigue and abdominal discomfort. 'Sulphurous burps' are often mentioned in travel books as being specific to *G. lamblia*, however analysis of data collected at CIWEC has shown that they are no more common in patients with *G. lamblia* than those with any other pathogen.

G. lamblia is diagnosed by stool examination, but may be difficult to find. Antigen testing can also be carried out and this gives a more reliable result. Empiric treatment for giardiasis is often suggested if a bacterial cause has been excluded in a patient with chronic diarrhoea post-travel. Tinidazole, 2 g daily for two days, is the standard protocol. In some areas of the world e.g., Kathmandu, tinidazole resistance is now developing. Treatment with quinacrine, 100 mg three times daily (TDS) for five days, is effective treatment in these refractory cases.

AMOEBIASIS

Entamoeba histolytica is an unusual cause of diarrhoea in travellers. The most important point to raise regarding *E. histolytica* is the identification of two distinct but morphologically identical strains of amoebae.[11] *E. histolytica* is a pathogen that can cause disease ranging from asymptomatic to liver abcess and fatal colitis. *E. dispar* is non-pathogenic. The two strains are indistinguishable under the microscope and can only be differentiated using *E. histolytica* antigen testing. *E. dispar* does not require treatment whereas *E. histolytica* should be treated with tinidazole 2 g daily for three days followed by diloxanide furoate 500 mg TDS for 10 days.

OTHER PARASITES

Cryptosporidiosis is also uncommon in travellers but should be considered in all cases of prolonged diarrhoea post-travel. The laboratory should be specifically requested to look for *Cryptosporidium*; at 4 microns (mm) diameter it is best diagnosed using an acid fast stain and fluorescent microscope. In immunocompromised individuals, *Cryptosporidium* can be a debilitating illness and there is currently no highly effective treatment.

Cyclospora accounts for 5% of the diarrhoea seen in Kathmandu, a city known to be highly endemic for the parasite. *Cyclospora* appears during the hot, rainy monsoon months in Nepal (June to October) and is characterised by the abrupt onset of watery diarrhoea accompanied by upper abdominal symptoms. Profound fatigue is commonly reported. The parasite is 8 mm in diameter and can be identified by the naked eye by an experienced microscopist, but is more easily identified with acid fast staining. Once again, the laboratory should be specifically asked to look for *Cyclospora*. Treatment is with trimethoprim-sulphamethoxazole double strength, twice daily for one week. Unfortunately there is no alternative treatment for those with sulphur allergy and without treatment the illness lasts on average six weeks.

If travellers have been on antibiotics, the diagnosis of *Clostridium difficile* should also be entertained and a request for *C. difficile* toxin made on stool examination.

TROPICAL SPRUE

Tropical sprue is a malabsorption syndrome acquired in the tropics and associated with weight loss, fatigue and decreased appetite. The cause of the disease remains unclear; however, it often occurs after an episode of acute bacterial diarrhoea when travelling. Diagnosis is made after empiric treatment for parasitic causes has failed, if the clinical criteria are fulfilled and the patient has an abnormal D-xylose test. Treatment is with 250–500 mg tetracycline four times daily for four to six weeks, and folate 5 mg daily. If there is no response after four weeks of treatment an alternative diagnosis should be considered and the patient should be referred to a gastroenterologist.[10]

Patients with chronic diarrhoea who do not respond to empiric treatment for bacteria and parasites, have a clear stool, no evidence of colitis, no weight loss and a normal D-xylose test are a problematic group. Dietary manipulation may be helpful, for instance avoidance of dairy products. It is important that they are reassured they do not have a hidden parasite and do not waste their time doctor shopping in order to find a solution. Post-infectious irritable bowel syndrome (IBS) is the most likely diagnosis and should be managed along standard lines for the treatment of IBS.

One should also be aware of the possibility of inflammatory bowel disease presenting for the first time post-travel. Thus, if there is weight loss, evidence of colitis or any concerning clinical features the patient should be referred to a gastroenterologist.

Skin conditions

CUTANEOUS LARVA MIGRANS

Cutaneous larva migrans is the most commonly reported skin condition in travellers returning from tropical countries.[12] It is caused by the larvae of animal hookworms *Ancylostoma braziliense* or *A. caninum*. Humans are infected as a result of skin contact with contaminated soil. Humans are only an incidental host, however, so whilst the larva burrows through intact skin it remains in the upper dermis.[13] Time from exposure to the onset of symptoms is one to six days and classically the lesion will start as an erythematous papule that then becomes serpiginous as the larva burrows along the upper dermis. It is usually intensely pruritic and it is this symptom that causes people to seek treatment. Complications such as impetigo and allergic reactions may occur. Whilst it is a self-limiting condition (spontaneous healing usually occurs within weeks or months), treatment with ivermectin or albendazole will usually result in rapid resolution of troublesome symptoms.[14]

LEISHMANIASIS

Leishmaniasis results from infection with one of the protozoan parasites of the *Leishmania* species. The organism is transmitted to humans by the bite of an infected sandfly and occurs in tropical and subtropical areas throughout the world except Australia. Worldwide, over two million cases occur each year and leishmaniasis is increasingly recognised as a risk to travellers.[15] The majority of cases in travellers are contracted in central and South America.[16] There are three quite distinct clinical syndromes – visceral leishmaniasis, cutaneous leishmaniasis and mucocutaneous leishmaniasis. The majority of cases in travellers are of cutaneous leishmaniasis. An ulcerous skin lesion develops at the site of the bite. These lesions are typically painless and slowly progressive and will heal spontaneously after between three and six months.[17] Diagnosis is made by biopsy and the patient should be referred to an infectious diseases specialist.

MYIASIS

Myiasis is caused by the invasion of skin by larval maggots of various *Diptera* fly species – most commonly the botfly in South America and the tumbu fly in Africa.[17] The botfly is the common name for *Dermatobia hominis*. The botfly lays its eggs on another insect, usually a mosquito, which then transfers the eggs onto human skin whilst feeding. These eggs penetrate the skin and then slowly develop into larvae, thus creating a subcutaneous nodule. At this stage, the larva remains in contact with the air and thus there is a punctum in the nodule through which the larva breathes.[18] Afflicted patients often feel a sensation of movement within the nodule as the larva grows. After about four to six weeks the larva matures and emerges from the lesion; however, most people seek medical attention before this occurs. Treatment consists of removal of the larva by occluding the punctum with vaseline or an occlusive dressing for 12 hours and then gentle removal. Antibiotics are not required unless there is evidence of secondary infection. Prevention is by use of insect repellent.

In Africa, the tumbu fly will present in a similar fashion. However, the eggs of the fly are usually laid on people's clothes as they are hung out to dry. When the infected clothes are worn the eggs hatch and penetrate the skin, and multiple lesions are the norm. Prevention is by ironing all clothes before wearing them.

Other common skin conditions include pyoderma, insect bite dermatitis, tungiasis and urticaria.

Schistosomiasis

Special mention should be made of schistosomiasis as it is common for travellers to present to their primary-care doctor requesting that they be checked for infection after travel to an endemic area. Schistosomiasis is caused by various species of blood flukes belonging to the genus *Schistosoma*.[19] The majority of infected travellers will be exposed to schistosomiasis in Africa, particularly by swimming in freshwater lakes such as Lake Malawi. There are four species of schistosomes that infect man but they all have the same lifecycle. Eggs are voided from humans in their stool and urine. On reaching fresh water, these eggs hatch and their larvae then infect specific species of aquatic snail (the intermediate host). After a period of time, the microscopic larvae are released into the water. Humans then become infected by exposure to the fresh water.

If patients are symptomatic, they will most commonly present with haematuria, dysuria or urinary frequency if infected with *S. haematobium*, or with abdominal pain, diarrhoea and rectal bleeding if infected with *S. mansoni*.[20] The majority of infected individuals are, however, asymptomatic and present for screening as they are aware that they may have been exposed. As infection can result in delayed serious complications, all travellers requesting investigation should undertake the following, ideally at least 12 weeks after their final exposure: FBC, schistosomiasis serology, one stool sample and urine dipstick. Eosinophilia is not a reliable finding. Serology is far more reliable with the ELISA test being >95% sensitive for *S. mansoni* and 90% sensitive for *S. haematobium*. Stool and urine microscopy provides additional support for a positive serological result. However, most travellers have a low parasite burden and hence rarely show eggs on microscopy. Positive serology requires treatment with praziquantel 20 mg per kg body weight.

Investigating the asymptomatic post-travel patient

Travellers will often present requesting a 'post-travel checkup'. A thorough history should be taken that looks for particular exposure risks, especially sexually transmitted diseases and schistosomiasis. A thorough examination should also be performed. A basic work up would include a FBC, one stool sample for ova/cysts/parasites (O/C/P) and serology as relevant e.g., for schistosomiasis or an STD checkup. This is a good opportunity to offer any vaccine boosters that may be required, or to undertake a post-travel Mantoux test if required. One should also keep in mind psychological problems that may occur after travel. In particular, readjustment disorder (reverse culture shock) for long-term travellers and expatriates is a well-recognised phenomenon and may present with somatisation.

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Rebreathers

Steve Goble

Key words
Scuba, technical diving, rebreathers/semi-closed, rebreathers/closed, mixed gas

Abstract
(Goble S. Rebreathers. *SPUMS J* 2003; 33: 98-102)
Rebreathers are rapidly becoming the equipment of choice for many technical divers and others who feel that they offer some diving advantages. Far from being something new, rebreathers are the oldest type of self-contained underwater breathing apparatus. In the past, most of their development and use has been based around the needs of the military, and a number of the more complicated recreational rebreathers are based on military equipment. A rebreather generally consists of a counterlung, carbon dioxide scrubber, oxygen cylinder, and a cylinder of diluent gas. It can be fully a closed circuit or semi-closed circuit and utilise either pendulum breathing or a loop breathing circuit. Rebreathers subject their users to the risks of hypoxia, and oxygen and carbon dioxide toxicity, and require strict adherence to routines and safe diving practices.

Introduction

Rebreathers have been available to recreational divers for a number of years. While their use in Australian waters has so far been limited by the value of the Australian dollar, there has been a rapid growth in their use in Europe and the USA. This has inevitably led to accidents, including a number of fatalities, in those areas. While accidents involving rebreathers are not yet showing up in the Diving Incident Monitoring Study (DIMS), Project Stickybeak, or Diving Emergency Service (DES) data, at least one near fatality and a neurological decompression illness case have occurred in Australasia during the last twelve months. Given the growth in the use of rebreathers, it is inevitable that at some stage doctors who deal with divers are going to be presented with a sick diver who has been using a rebreather. It is important that these doctors at least understand the principles of rebreather operation and the most common adverse events associated with the use of rebreathers.

The rebreather is the oldest form of self-contained underwater breathing apparatus (scuba). Probably the first recorded instance of its successful use was Lambert's entry of a flooded tunnel under the River Severn wearing an oxygen rebreather designed by Fleuss for mine rescue.[1] Despite this success, development of the rebreather was slow until World War Two. During that war, Italian Navy divers successfully used 100% oxygen (O_2) fully closed circuit rebreathers to attack Allied shipping at Gibraltar and Alexandria. After the Italian surrender, the British Royal Navy (RN) worked with the Italians and began its own development of rebreathers for use with O_2 and nitrox. After the war, some early recreational divers used war-surplus O_2 rebreathers. However, by the mid 1950s the open circuit demand valve had become much more popular, due to its ease of use, and the continued use and development of rebreathers were left mostly to the military.

Rebreathers come in a few basic types. They can utilise either pendulum breathing, in which the diver's breathing gas passes through a carbon dioxide (CO_2) absorbent ('scrubber') on inhalation and exhalation, or a loop circuit, in which the gas passes through the absorbent in one direction only. They can utilise either 100% O_2 or mixed gas, or both. They can be semi-closed circuit (produces bubbles and uses a constant gas flow) or fully closed circuit (no bubbles, uses a demand valve).

Clearance Divers Breathing Apparatus (CDBA)

The RN's Clearance Divers Breathing Apparatus (CDBA) is probably the most highly developed rebreather using the pendulum system of operation (Figure 1). This system incorporates a single breathing hose, with the scrubber located between the hose and the counterlung. The advantages of this system are several, among them: no one-way mushroom valves; increased scrubber efficiency due to the granules of scrubber media being presented to the gas on both sides of the grain; and simplicity of design. Disadvantages include the need for the diver to be aware that shallow breathing patterns will result in rebreathing gas that has not fully passed through the scrubber.

The CDBA is a complex system that was designed for heavy-duty use by military divers. It relies on a constant mass flow of gas, which can be either a nitrox mixture or 100% O_2. It contains an integrated weighting system, a bypass valve system, and an emergency gas supply in addition to the main cylinders. The counterlung is constructed of moulded rubber and has a capacity of 8 litres, it carries the scrubber and a relief valve, and is fabricated as an integral part of the front harness. The harness also carries two mounting pockets for the oxygen cylinders.

The scrubber is located centrally in the counterlung, directly under the diver's chin. It is modest in size, holding slightly

FIGURE 1. CIRCUIT DIAGRAM OF THE BREATHING SYSTEM OF THE CDBA IN SEMI-CLOSED CIRCUIT MODE.

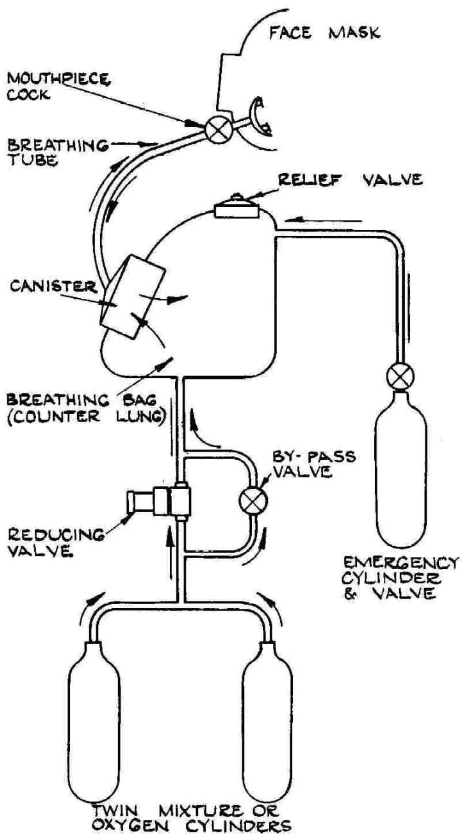


FIGURE 2. CDBA DIVER DRESSED FOR OXYGEN SWIMMING

less than one kilogram of CO_2 absorbent. This is partially compensated for by the superior efficiency of the pendulum system as described earlier. To the scrubber is attached a single breathing hose, a full-face mask and a dive/surface valve, which has two positions. One allows breathing from the counterlung through the scrubber, the other breathing from the atmosphere. Breathing in from the counterlung then switching the valve and breathing out to the atmosphere allows a dressed diver to expel gas from the counterlung to the atmosphere during pre-dive procedures.

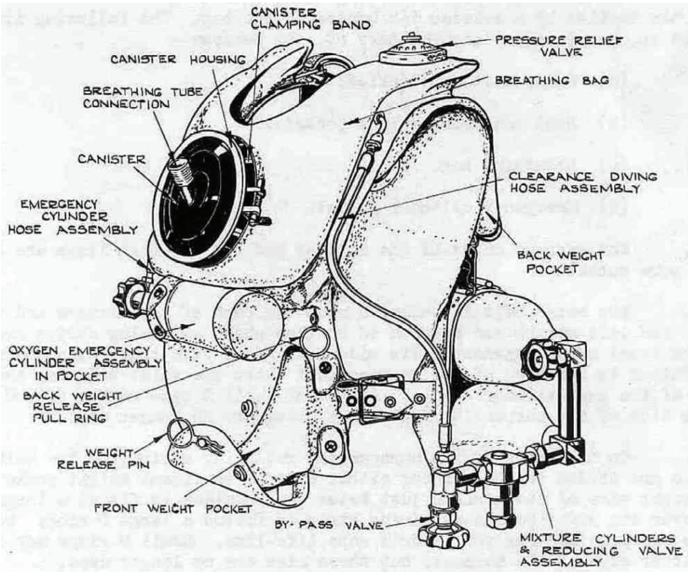
The reducing valve is a constant mass acoustic jet regulator, with a bypass valve, which supplies a constant flow of gas to the counterlung. Prior to diving, the required gas mixture is determined and the flow is adjusted accordingly. Once the flow is set, and the equipment is ready for use, the adjusting mechanism is no longer accessible making it impossible to adjust in the water. The regulator is industrial in nature, with all components being oversized and constructed of heavy brass billets machined to shape.

When the CDBA is rigged for oxygen swimming in semi-closed circuit mode, the twin oxygen cylinders on the front carry 147.6 litres of oxygen at 3000 psi (20×10^3 kPa). With the regulator flow set to 1.5 $l.min^{-1}$ for oxygen swimming, the cylinders have an endurance of 98 minutes. However, the endurance of the set is limited to 90 minutes by the life of the CO_2 absorbent. The weight pouch on the back harness contains lead balls, each weighing approximately 0.3 kg, which allows for reasonably precise weighting. Figure 2 shows a CDBA diver dressed for oxygen swimming.

Operationally, the twin O_2 cylinders are used as bail out for nitrox swimming; they are turned around in their pouch and connected to the right-hand side of the counterlung. The nitrox cylinders are filled with one of three different nitrox mixes and the regulator flow is set according to the mix being used. Figure 3 shows the CDBA set up for mixed gas diving. Maximum depth is 54 msw and the maximum partial pressure of oxygen (ppO_2) is 204 kPa (2 bar). In reality, the maximum ppO_2 was rarely reached, even at the respective mixes' maximum depths, due to dilution of the breathing gas in the counterlung by exhaled gases.

Possibly the most dangerous way to use the CDBA is in fully closed circuit, 100% O_2 demand mode. When in demand mode the regulator is not used, the cylinder is connected directly to the counterlung, and the diver manually adds O_2 when the counterlung is empty, being careful not to put in so much that the relief valve opens.

FIGURE 3. CDBA MIX SCHEMATIC



The CDBA is very popular amongst the clearance diving fraternity. It is comfortable to wear, there is no cylinder down the middle of your back, no bulky buoyancy compensator, and it requires very little weight. It is quiet, there are no bubbles blasting past your ear, just a gentle hiss from the regulator and a few quiet bubbles from your left shoulder. It is non-magnetic, the cylinders are aluminium and all other fittings are brass. This, and the lack of noise make it an ideal piece of equipment for mine countermeasures. In demand mode there are no bubbles at all, making the CDBA ideal for clandestine operations.

On the downside, it requires a great deal of training to learn to dive using this equipment. In the RN, we did four weeks of open circuit air diving, two to three dives per day, five days per week on scuba and surface supply before we were allowed anywhere near a rebreather. Basic rebreather training lasted four weeks, two weeks of O_2 swimming, and two weeks of nitrox diving. It took a few years to gain enough experience to use the CDBA in 100% O_2, closed circuit demand mode.

Gas toxicities

Rebreather equipment requires that divers maintain a rigid adherence to routines. There is a set procedure to follow before and during the dive. On reaching bottom, and before any depth change, the counterlung must be filled with fresh gas via the bypass valve. If the counterlung is not filled with fresh gas before any movement to shallower water, the ppO_2 in the counterlung will drop during the ascent. This leads to dilution hypoxia and the end result is usually an unconscious diver.

Apart from dilution hypoxia, divers using rebreathers are prone to two particular gas toxicities. Working with a maximum ppO_2 of 202 kPa (2 bar) means that central nervous system O_2 toxicity is a constant threat. Maximum depth limits have to be strictly adhered to. Modern recreational rebreather practice is to work with a maximum ppO_2 of 140 kPa (1.4 bar).

Carbon dioxide (CO_2) toxicity is the other gas toxicity associated with rebreather diving. When working hard, it is possible to breathe so hard and fast that the absorbent cannot keep up with demand and a CO_2 build-up occurs. Badly packed scrubber canisters or shallow breathing can also cause this problem.

Dräger LARV

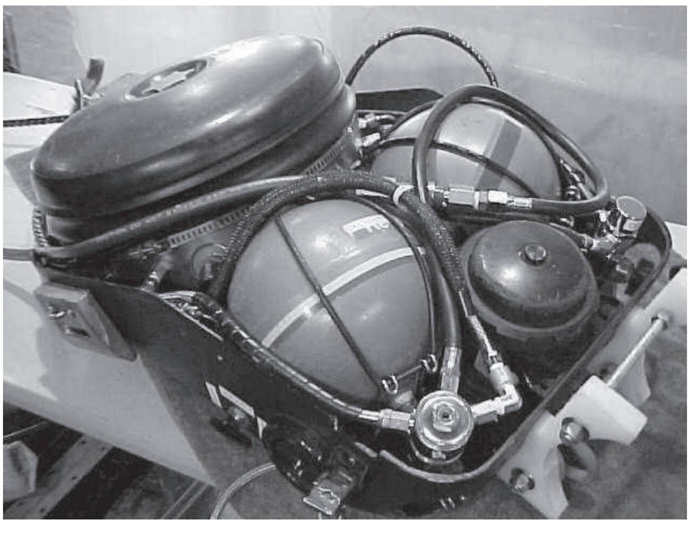
Eventually, rebreather designers took advantage of the second stage demand valve allowing for loop circuit, fully closed circuit rebreathers, such as the Dräger LARV oxygen rebreather. This is essentially purpose-built for combat swimmers, and is used by navies around the world. It is a very popular and well-built unit.

In the LARV's breathing loop, the diver's exhalation hose feeds directly into the counterlung. From the counterlung, the gas passes through the CO_2 scrubber and into the diver's inhalation hose. In the centre of the counterlung is an automatic/manual addition valve that provides the loop with oxygen. This valve is essentially a second stage demand valve; breathing in against a collapsed counterlung forces the tilt valve to operate and fresh oxygen is fed into the counterlung. Pressing the manual addition button is like pressing a purge valve. This is the most simple configuration possible for a rebreather loop.

Electrolung

While the use of second stage demand valve technology enabled fully closed circuit oxygen systems, mixed gas

FIGURE 4. BIOMARINE MK 15 IN RECREATIONAL DIVING SET UP



rebreathers still relied on constant mass flow and semi-closed circuit equipment. As solid state electronics got better and oxygen sensor technology improved, designers started looking at electronically controlled, fully closed circuit, mixed gas rebreathers.

One early version was the Electrolung, which made an appearance in the late 1960s and early 1970s, and was used for a while in the offshore diving industry as the dive equipment on diver lock out submersibles. Further development was stalled when the Health & Safety Executive in the United Kingdom decreed that a diver's main gas supply must be supplied from the surface. This effectively ruled out further rebreather development for the offshore oil industry.

Biomarine Mark 15 and 16

In the late 1970s, Biomarine in the USA, in conjunction with the US Navy, started development of an electronically controlled, fully closed circuit, mixed gas rebreather capable of using heliox mixtures to extreme depths. In Figure 4, we see the Biomarine Mk15 electronically controlled, fully closed circuit, mixed gas rebreather with the casing removed. This is the rebreather against which all others are measured. Currently, the US, British and Australian navies use a later version, the Mk16. Modifications for civilian use have included the addition of a utility bottle and a manual three-way valve.

The Mk15 and Mk16 are controlled by three oxygen sensors of the micro fuel cell type which, in conjunction with a small computer, maintain a preset ppO_2. If two sensors fail, the rebreather converts to a diluent loop with fresh diluent gas supplied to the counterlung. Removing the back cover exposes the CO_2 scrubber and the two gas spheres (Figure 4). One sphere is filled with pure O_2, the other with a diluent mix of either heliox or air. Spheres are used as they can be filled to higher pressures than cylinders, allowing for greater endurance.

Inside the cover of the CO_2 scrubber is an absorbent foam inset that absorbs water vapour, drool etc., from the exhaled gas. In the centre of the scrubber, the three oxygen sensors (micro fuel cells) are held in brackets at a 120-degree angle to each other. The different orientations of the faces of the sensors assist in preventing their blockage by water vapour. As the sensors are located out of the main gas-path, they are exposed to less than the total volume of water vapour present, yet they are in a position where each breath passes a sample of gas over their faces. This makes the design of the Mk15 resistant to condensation-induced oxygen sensor impairment.

The counterlung of the Mk15 is essentially a giant demand valve. Breathing in hard against the diaphragm pulls it down against the diluent addition valve and diluent gas is added to the counterlung.

A 'primary' display shows the breathing loop's ppO_2, as compared to the setpoint of the rig, in a very simple fashion. For a rig set at 1.4 bar (143 kPa) ppO_2, a green 'O' in the centre is illuminated when the rig is at 'setpoint'. Yellow '1' indications to either side of the 'O' are for slightly high and slightly low ppO_2 levels. Red alarms 'L' and 'H' at either end of the display indicate a serious low or high deviation from the setpoint. An 'A' shows the status of the sensors, being illuminated when a sensor is voted out by the digital electronics. Although called the 'primary' display, this is really just a crosscheck on the computer.

There is also an analogue 'secondary' display, which is really the primary method of monitoring the ppO_2 of the system. This is merely a millivoltmeter that reads the raw output from all three sensors. The scale on the face of the meter is calibrated in ppO_2, and the display is calibrated to new cells as they are installed. There is a rotary switch on one side that is used to select cell 1, 2, or 3 for viewing and can also be used to read the battery condition.

Straight up is the position of the needle that you want to see. The display is viewed periodically and the three sensors compared. If the primary display shows one sensor has been voted out, the secondary display can be used to confirm the failure. In the event of two sensors failing, a loop-flush with diluent gas is performed, and if the diver knows what the diluent ppO_2 should be at the present depth they can identify the remaining good sensor.

When the Mark 15 is set up for civilian use, a manual diluent addition valve is added, as well as a selector valve for diluent feed. This allows selection of a second diluent source for gas changes mid-dive. This configuration allows for a descent on air, a switch to heliox diluent at a precalculated depth (this makes a 'trimix' in the loop), and the reselection of air on ascent. With the loop then purged and refilled, a nitrox decompression can begin. At seven metres' depth, the valve can be positioned at the mid position, shutting off the diluent and allowing a pure oxygen operation to be conducted for final decompression. This works very well and is a tried and tested system.

As with all rebreathers, there is no facility to measure CO_2 levels. The diver has to accept that he has filled the scrubber correctly and there is no channelling, also that it was filled with fresh absorbent and has not been sitting around unsealed. Filling the scrubber properly requires meticulous care and attention.

Although modern solid-state electronics are very reliable and sensor technology has improved over the two decades it has taken to reach this stage of development, there are still drawbacks to using these rebreathers. A fully charged military version Mk15 weighs 29 kg and, as it is positively buoyant, a weighted diver carries around 40 kg. If rigged with an extra gas cylinder, as described earlier for civilian use, the weight increases even more. This is not the kind of equipment you want to run around with. Furthermore, diving with rebreathers does not come without a cost. The civilian version of the Mk15 costs around A$20,000 dollars, more if you want two diluent gas spheres and other extras.

Conclusions

In summary, the rebreather can be a useful tool for a few specific tasks:

- Combat swimming or espionage in the closed circuit 100% oxygen mode. The next person exiting a submarine to swim to shore wearing a closed circuit oxygen rebreather will not be the last.
- Mine countermeasures. These units are very quiet and made of non-magnetic materials – two qualities that are ideal for dealing with mines.
- Photography. The lack of bubbles or noise makes the units ideal for approaching fish.

In recreational diving circles, technical ('tech') divers are using fully closed circuit rebreathers to undertake extreme wreck and cave diving, where the long endurance and extreme depth capability allows them to penetrate to areas previously unreachable. However, the limitations discussed previously remain – gas toxicities, oxygen or carbon dioxide. Hypoxia is still an insidious effect of ascent. The use of all rebreathers, whether closed or semi-closed, requires a high degree of training and experience, and high skill levels. You need to know your equipment inside out and be completely familiar with its integral parts.

While the high cost of the more sophisticated rebreathers such as the Mk15 puts them into a very dedicated level, there are available lower cost nitrox units utilising more of a semi-closed circuit. These are increasingly popular with 'tech' divers. In the next decade, we can expect an upsurge in recreational rebreather diving and its associated medical problems.

Acknowledgement

Dave Sutton for permission to use photos from his website <www.nobubblediving.com>

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Deep air and mixed gas recreational diving accidents from the UK

News item, Diver Magazine, October 2002

Two divers lost their lives in separate incidents in August.

On 18 August, an incident off Brighton left a diver dead and his brother injured. The pair made a rapid ascent while diving the 48m-deep *Pagenturn,* 12 miles off Brighton. Solent Coastguard said that they appeared to have encountered difficulties while deploying a delayed SMB.

Graham Law, 40, from West Sussex, surfaced unconscious. Resuscitation attempts were made on the dive boat *Girl Gray,* but Law was pronounced dead after being airlifted to Brighton Hospital. Law's equipment is being examined at the Health & Safety Laboratory for the coroner.

His brother Richard, from Surrey, was taken aboard the dive boat with decompression illness. He had to be airlifted to Whipps Cross Hospital in London as, according to skipper Mike Snelling, 'all the chambers on the South Coast were full' that weekend.

The second fatality occurred a day later, when a diver appeared at the surface feet-first after a rapid ascent from a mixed-gas dive, 24 miles out from Littlehampton.

Peter Downes, 47, described as an experienced Advanced Instructor, was diving with Mendip Dive Club, from near Bristol. He is reported to have surfaced from a 28-minute dive to 66 m without making any stops. Downes was still attached to an underwater scooter on reaching the surface. Both this and his dive gear were lost during his recovery on to the dive boat *Voyager,* but his drysuit and computer were sent for examination by the Health & Safety Laboratory.

Attempts were made to revive Downes before he was airlifted by Solent Coastguard to Portsmouth's Queen Alexandra Hospital, where he was pronounced dead.

One of the many South Coast recompression treatments carried out on 18 August was to a diver lucky to escape death or injury after surfacing unconscious from a mixed-gas dive to 70 m off Brighton.

The diver is reported to have suffered a convulsion after selecting an incorrect (oxygen-rich) decompression gas at about 30 m. He was sent to the surface by his buddy. Recovered unconscious onto the dive boat *Spartacus*, he was airlifted and reportedly recovered fully after recompression treatment.

Reprints from other journals

Comparative efficacy of insect repellents against mosquito bites

Mark S Fradin and John F Day

Abstract

Background: The worldwide threat of arthropod-transmitted diseases, with their associated morbidity and mortality, underscores the need for effective insect repellents. Multiple chemical, botanical, and 'alternative' repellent products are marketed to consumers. We sought to determine which products available in the United States provide reliable and prolonged complete protection from mosquito bites.

Methods: We conducted studies involving 15 volunteers to test the relative efficacy of seven botanical insect repellents; four products containing N,N-diethyl-m-toluamide, now called N,N-diethyl-3-methylbenzamide (DEET); a repellent containing IR3535 (ethyl butylacetylaminopropionate); three repellent-impregnated wristbands; and a moisturizer that is commonly claimed to have repellent effects. These products were tested in a controlled laboratory environment in which the species of the mosquitoes, their age, their degree of hunger, the humidity, the temperature, and the light–dark cycle were all kept constant.

Results: DEET-based products provided complete protection for the longest duration. Higher concentrations of DEET provided longer-lasting protection. A formulation containing 23.8 per cent DEET had a mean complete-protection time of 301.5 minutes. A soybean-oil-based repellent protected against mosquito bites for an average of 94.6 minutes. The IR3535-based repellent protected for an average of 22.9 minutes. All other botanical repellents we tested provided protection for a mean duration of less than 20 minutes. Repellent-impregnated wristbands offered no protection.

Conclusions: Currently available non-DEET repellents do not provide protection for durations similar to those of DEET-based repellents and cannot be relied on to provide prolonged protection in environments where mosquito-borne diseases are a substantial threat.

Reprinted with kind permission from New England Journal of Medicine 2002; 347: 13-18.

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John Day is at the Florida Medical Entomology Laboratory, University of Florida, Vero Beach, FA, USA

Key words
Reprinted from, travel medicine, malaria, insect repellent

Editor's comment:

At the 2002 SPUMS ASM, Dr Batchelor stated strongly her opinion that only DEET-containing repellents should be used, and this is clearly substantiated by Fradin and Day. In this study, volunteers inserted their repellent-treated arms into a cage with a fixed number of unfed mosquitoes and recorded the elapsed time to the first bite.

After the original study was completed, a new botanical repellent containing oil of eucalyptus was also tested and this had a mean protection time of 120 minutes. Alternatives to topically applied repellents have proven to be ineffective, such as ingested compounds including garlic or thiamine (vitamin B1).

Multiple factors determine how effective any repellent will be, so a given repellent will not protect all users equally. Only products containing DEET offer long-lasting protection after a single application. However, DEET is not perfect; it may be washed off by perspiration, rain or swimming, and its efficacy apparently decreases with higher environmental temperatures.

DEET has a remarkable safety profile after 40 years of use. Fewer than 50 cases of serious toxic effects have been documented, and three quarters of them were easily resolved. The Environmental Protection Agency has concluded that 'normal use of DEET does not present a health concern to the general US population.'

Until a better repellent becomes available, DEET-based repellents remain the gold standard of protection.

A POEM a week for the BMJ

Richard Smith, editor BMJ

A POEM is Patient-Oriented Evidence that Matters.
From now the *BMJ* will publish every week a POEM, a summary of a valid piece of research that carries information that is important to patients and so to their doctors. Unfortunately most research does not provide information that matters to patients. The POEMs will be published beside Editor's Choice. POEM stands for Patient-Oriented Evidence that Matters, and the concept was developed by David Slawson and Allen Shaughnessy, academics in family practice from University of Virginia in the United States.[1,2]

The concept has its origins in a formula developed by Slawson and Shaugnessy:

$$U = R \times V / W$$

where U = usefulness of the information to doctors, R = relevance of the information to doctors, V = validity of the information, and W = work to access the information. In words, the most useful information for doctors is information that is relevant to their practice, valid, and does not take too much work to access. After listening to a presentation by Maria Musoke, a researcher from Uganda, on the usefulness of information to rural health workers in Uganda I added 'interactivity' to the top line of the equation.[3] The information is still more useful if you can interact with the source and interrogate it.

The formula provides a test of the ways in which doctors look for information they need. Traditional journal articles, although usually valid, are rarely directly relevant to a practitioner and are hard work to read and they cannot be interrogated, although rapid responses (electronic letters to the editor) provide a possible means of getting answers from authors. The usefulness of original articles might thus be categorised as low. Textbooks should be relevant, although it's disturbing how often they fail to provide an answer to a direct question, and are comparatively easy to access. Their validity is questionable because they are rarely based on a systematic review of the literature and are often out of date, and they cannot be interrogated. They are thus of medium usefulness. In contrast, expert colleagues will give a direct and relevant answer to a question, should be little work to access, and can be interrogated. They are thus a highly useful source of information, although sometimes the validity of their answers may be low, 'the blind leading the blind.' The formula thus explains why doctors use colleagues most commonly to answer questions and journals least often.[4]

Doctors suffer from what Muir Gray, director of the National Electronic Library of Health, calls 'the information paradox': they are overwhelmed with information, many receiving their own weight in journals and newspapers every month, and yet cannot find the information they need when they need it. At least two questions arise during the average consultation between a doctor and patient.[4] Most of those questions can be answered but few are. When I asked a sample of doctors to give me the one adjective they associate with their information supply, 90% gave a negative answer: overwhelmed, crushed, despairing. More than half of doctors feel guilty that they don't read more. Information has negative connotations for doctors.

Doctors are in a 'knowledge business' and yet have severe information problems. The electronic age allows the possibility of a solution,[4] but it hasn't been found yet. POEMs are a step forward. The summary shows the three criteria that POEMs have to meet. Very importantly they have to provide information that will matter to patients. Will they live or die? Will they feel sick? Will they have pain? Will they be able to do what they want to do? A great many studies in medical journals give information on mechanisms of disease, aetiology, prevalence, pathophysiology, and pharmacology studies that may be important but don't matter to patients. Faced with far more material than they can ever hope to master doctors might find it useful to concentrate on the studies that provide evidence that will matter to patients. They will discover that it is a minority of studies.

POEMs are selected by searching the current issues of 100 journals looking for relevant studies, potential POEMs, which are then evaluated for validity. The valid POEMs are summarised, and the summary is then reviewed and revised. The service is provided by InfoRetriever, who have kindly allowed us to publish a POEM each week. Those who would like to subscribe to their full service should access their site at <www.infopoems.com/index.cfm>.

Summary

POEMs have to meet three criteria:

- They address a question that doctors encounter
- They measure outcomes that doctors and their patients care about: symptoms, morbidity, quality of life, and mortality
- They have the potential to change the way doctors practise.

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Edited to suit journal style only

Critical appraisal

The use of hyperbaric oxygen therapy did not decrease disability following ischaemic stroke

Clinical bottom line:

1 Hyperbaric oxygen therapy did not decrease disability after acute ischaemic stroke.
2 There is a trend for worse outcome following hyperbaric oxygen therapy.

Citation/s

1 Rusyniak DE, Kirk MA, May JD, Kao LW, Brizendine EJ, et al. Hyperbaric oxygen therapy in acute ischaemic stroke. Results of the hyperbaric oxygen in acute ischaemic stroke trial pilot study. *Stroke* 2003; 34: 571-574

Three-part clinical question

In patients with acute ischaemic stroke, does the application of hyperbaric oxygen compared with standard measures result in any reduction in disability or death?

Search terms

Cerebrovascular accident, brain infarction

The study

Double-blinded concealed randomised controlled trial with intention-to-treat.

The study patients: Adults greater than 18 years with clinical characteristics of acute ischaemic stroke less than 24 hours in duration. No haemorrhage on C/T brain scan.
Control group: (N = 16; 13 analysed) Single 'sham' treatment with 100% oxygen for 60 minutes at 1.14 bar (143 kPa) in a monoplace hyperbaric chamber.

Experimental group: (N = 17; 17 analysed) Single treatment with 100% oxygen for 60 minutes at 2.5 bar (255 kPa) in a monoplace hyperbaric chamber.

The evidence: See Table 1

Comments

1 NIHSS is a widely used disability scale specifically designed for stroke assessment. Favourable outcome was improvement >4 points or score of 0 at 24 hours, and score equal to or less than 1 at 90 days.
2 Missing and dead patients allocated to unfavourable outcome in the 90-day analysis above. Analysis excluding these subjects was difficult to interpret.
3 Single 60-minute hyperbaric oxygen treatment is an unusual intervention.
4 Co-morbidities not described as potential confounders.
5 The control group was younger and predominantly white. Effect on result is unknown.
6 Authors used results to abandon further investigation.
7 Three additional stroke scales used for 90-day analysis showed no major differences.

Appraised by

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This appraisal has been adapted from the database of randomised controlled trials in hyperbaric medicine at <www.hboevidence.com>

TABLE 1.
MAJOR OUTCOMES IN RANDOMISED STUDY OF HYPERBARIC OXYGEN FOR ISCHAEMIC STROKE

Outcome	Time to outcome	Sham group rate	HBOT group rate	Relative risk reduction	Absolute risk reduction	Number needed to harm
Favourable NIHSS score	24 hours	31%	18%	44%	0.14	7
95% CI				100% to -49%	0.43 to -0.15	2 to infinity
Favourable NIHSS score	90 days	50%	29%	41%	0.21	5
95% CI				100% to -24%	0.53 to -0.12	2 to infinity
Death	90 days	19%	12%	37%	0.7	14
95% CI				100% to -93%	0.32 to -0.18	3 to infinity

Hyperbaric Medicine in South Africa

Frans Cronje

HBOT is not new to South Africa. Five of the leading national Government Hospitals acquired Vickers monoplace chambers over the period of 1960 to 1983. HBOT was primarily used as a radio-enhancer for external beam radiotherapy during this time, and most of the hyperbaric chambers were therefore installed in the respective radiotherapy departments. HBOT was also occasionally used in the treatment of gas gangrene and necrotizing infections, but when the indication for radiotherapy became obsolete, most of these units closed down. Only the unit in Bloemfontein is still providing regular HBOT to this day. There are also five Naval recompression facilities, situated in the major coastal cities around the country and these have all occasionally treated patients with HBO over the past ten years. However, none of them provide a regular HBO service and are primarily available for naval dive operations and for treating occasional civilian cases of decompression illness.

The recent revival in clinical hyperbaric oxygen therapy started in 1993 at the Institute for Aviation Medicine, a specialized unit in the South African Military Health Service (SAMHS). The small five-foot (1.5 meter) Draeger recompression chamber (formerly used to treat divers and aviators with decompression sickness) was employed by the author to treat a small number of patients with mandibular osteoradionecrosis, referred from Pretoria Academic Hospital. These few incidental treatments soon made way to what has become a full-time dedicated clinical HBO service, and the rapid growth required the installation of a larger chamber in 1996. This chamber (nicknamed “Miss Piggy” due to its apricot-peach color) increased the level of awareness of HBO, while the results obtained re-established recognition for the therapy. The author eventually resigned from the SAMHS in 1998 and opened the first private HBO facility at the Eugene Marais Hospital in Pretoria. Recently, three additional hospital-based, private, multiplace hyperbaric chambers have started up in South Africa, and one monoplace facility in Namibia. This development is once again making HBOT more readily available, and promoting its appropriate use in South Africa.

From 1983 to 1998, the UHMS indications were almost exclusively applied in South Africa, with the exception of isolated cases of multiple sclerosis in the early 1980s and some sports injuries and problems with non-union and septic non-union of bone. However, in 1998 a parent-group in Pietermaritzburg initiated the use of low-pressure HBOT for the treatment of cerebral palsy. A total of nine informal CP-treatment chambers opened between 1998 and 2000. This urged the Southern African Undersea and Hyperbaric Medical Association (SAUHMA), the official scientific and peer-review organization for diving and hyperbaric medicine in this country – affiliated to the UHMS – to formalize safety, training and reimbursement standards for South Africa as a matter of urgency. Three of the former CP treatment facilities have since evolved towards becoming mainstream HBO facilities, while several others have closed down.

In 1997 the author developed the Diving and Hyperbaric Medicine Staff Training course (DHMSTC) which has since been designated by the UHMS as a sponsored introductory course in hyperbaric medicine. A Clinical Hyperbaric Chamber Operator’s Course (CHCOC) was subsequently developed and these two courses have been endorsed by SAUHMA as forming the minimum recommended training for the practice and application of HBOT. Through the efforts of SAUHMA, the DHMSTC, CHCOC, NFPA 99 Chapter 19 Safety Guidelines for Hyperbaric Facilities, as well as the UHMS documents on multiplace and monoplace chamber safety have been accepted and adopted in South Africa. Recently, Francois Burman, a South African mechanical engineer and technical advisor of SAUHMA published a Risk Assessment Guide for Recompression Facilities through the International Divers Alert Network. This reference is likely to become an international hyperbaric safety benchmark and forms the basis of the evolving South African Bureau of Standards’ statutory safety and standards document on hyperbaric chambers.

Medicine in South Africa is divided into Government Health and fee-for-service or private medicine with its associated medical insurance structures, managed health care groups, and HMOs. Due to the demise of the original Vickers units, HBO is no longer readily available to Government Health patients. Interdepartmental financial transfers are required for the use of military facilities by Government Hospitals, and this has become prohibitive. In the private sector, HBOT is still largely restricted by a relatively small number of facilities. It is hoped that once more private facilities have been established, a mechanism can be created whereby Government Health patients can once again gain access to therapy without incurring high costs, directly or indirectly.

Until recently, there was no dedicated treatment code and tariff structure for hyperbaric therapy. Vaguely comparable codes had to be used to bill for HBOT and these have met with varying success. While the American Medical Association’s CPT-9 code structure will probably eventually be introduced to this country, a unique code structure was urgently required in the interim. After three years, the South African Medical Association eventually accepted a dedicated set of physician treatment codes related to HBO and this year, after seven years, a technical tariff was approved. This is a very significant step forward and it is hoped that this structure will assist in ensuring effort-dependent and ethical application of HBOT in South Africa.

Hospital-based conventional hyperbaric medicine is relatively expensive in South Africa and obtaining reimbursement will remain an ongoing challenge. Treatment costs range from $88 (in the military setting) to $130 (in the private sector) – including physician supervision. For this reason, Third Party payers approve the acute indications more easily, as these involve a smaller number of treatments. The chronic UHMS HBO indications often require significant motivation and are less readily approved. These include (in decreasing order of resistance) chronic refractory osteomyelitis, selected problem wounds (almost exclusively diabetic wound problems) and radionecrosis. Some medical aids have unfortunately made policy decisions against reimbursing for HBO and it has become an important objective for SAUHMA to reverse this by distributing scientific evidence for HBOT, cost-effectiveness, as well as creating mechanisms and safeguards to prevent abuse of the therapy. The goals of SAUHMA are very similar to the UHMS and at present, only the UHMS indications are endorsed.

While the road ahead is by no means easy, it is likely that private HBOT will become firmly established in South Africa over the next 5 years, and that its primary application will preferentially evolve towards the more acute UHMS indications.

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Key words
Reprints from, general interest, underwater medicine, hyperbaric oxygen, medical society

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Letters to the Editor

Thoughts regarding air-integrated versus separate-second-stage octopus supplies

Dear Editor,

Acott has previously discussed problems with buoyancy compensators (BCDs).[1] In the recent review of regulator incidents by Goble and Acott they state ‘The combination of a second stage regulator and a low-pressure BCD inflator as the ‘spare’ regulator is extremely difficult to use…’[2]

In an out-of-air (OOA) emergency, the air-integrated (Air2) alternative air source is definitely an inferior solution. If you are also wearing a dry suit, it becomes virtually unmanageable. An Air2 should never be fitted without a pull dump cable in the BCD deflator hose, to enable dumping the BCD without removing the Air2 from the mouth. However, this is a heavy task loading in a difficult circumstance, increasing the probability of an uncontrolled rapid ascent.

Another drawback of the Air2 configuration is the high probability that the unit is not serviced annually. Divers also tend to forget to cap the hose fitting, so water can enter the air barrel. If it is disconnected in sea water it must be thoroughly rinsed in fresh water to avoid corrosion.

On the other hand, proper gear maintenance and dive planning will make it extremely unlikely that you will need to share air, as first stages rarely fail catastrophically. An advantage of the Air2 is that it teaches donating the primary, which I believe is the proper method, since odds are the stricken diver will go for the primary in any case. Therefore, despite Acott’s concerns, for no-decompression diving at recreational depths an Air2 is an acceptable compromise, provided students are taught properly how to use it and are warned of its limitations.

The most suitable open-water rig is a short-hose second stage hung from the neck with a bungee cord as a secondary or ‘octopus’ and a 2 m primary wound once around the neck. It is the primary that is donated in an OOA emergency and the donor takes the secondary. With this arrangement, there is plenty of hose for the recipient, reducing stress and allowing a controlled ascent, even from depth. This is the method favored by the GUE agency, and is an offshoot of the Hogarthian rig evolved for use in cave diving.

References

1 Acott C. An evaluation of buoyancy jacket safety in 1,000 diving incidents. *SPUMS J* 1996; 26: 89-95
2 Goble S, Acott C. Regulator incidents: 52 incidents from the Diving Incident Monitoring Study. *SPUMS J* 2003; 33: 30-34

Kirk J Bloede
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Reply from Dr Christopher J Acott

Thank you for the opportunity to reply to Mr Bloede's letter. Whilst I cannot add much, some points need to be emphasised.

The original Air2 leaked and was responsible for some OOA or low-air situations even with the divers regularly checking their contents gauges (I personally am included in these data). There have been no more reports received about this problem in the past five years.

The original Air2 could not be used with a dump cable in the deflator hose. Even if it now can be used, any emergency situation that requires one diver to remove their second stage from their mouth for buoyancy control is dangerous, because it is associated on many occasions with a rapid ascent. The donor in the management of an OOA situation must maintain any buoyancy compensator auto inflation/deflation device in a readily available position. This has been highlighted in the Diving Incident Monitoring Survey (DIMS) data.

A lack of servicing was highlighted in the DIMS data but this is also a problem of 'octopus' regulators in general. Because they are rarely used there is no need to service them! Unfortunately, a lack of proper gear maintenance and dive planning are common contributing factors in the DIMS reports. DIMS also showed that in the OOA and low-air situations a failure to check the contents gauge was the main cause.[1]

From the DIMS data I do not believe that an Air2 or similar device employing a combination of a second stage and inflation/deflation device is safe even in 'no stop' recreational diving. The management of any emergency situation must use the 'KISS' principle and having a dual role for any piece of equipment is dangerous.

Reference

1 Acott CJ. Incident reporting: out of air and diving safety. In: Cimsit M, Aktas S, Aydin S, eds. *Proceedings of the XXth Annual Meeting of the European Underwater and Baromedical Society on Diving and Hyperbaric Medicine*. Istanbul: Hyperbaric Medicine and Research Centre [HITAM], 1994: 32-41

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Key words
Letters, scuba, equipment, emergency ascent

The Abacus Project, Canada

Dear Editor,

Thank you again for providing the means through the *SPUMS Journal* to bring the Abacus Project to the attention of researchers and practitioners interested in dive safety. I appreciate being given permission to reproduce our *SPUMS Journal* article.[1] The paper is available as a PDF file, which includes a revised membership application form for SPUMS that fits on a single page when printed. The SPUMS web site URL on the application page is hot-linked.

Recently, the UCBC sponsored a cold-water diving safety symposium as part of Underwater BC 2003. The Vancouver Aquarium and Marine Science Centre donated a booth to the Abacus Project, and we had tremendous interest in the results from the public. We distributed 800 copies of the article and a summary sheet of the results. The amount of interest took us by surprise.

I have stayed pretty neutral in public on my views about whether the results indicated diving is a high- or low-risk activity. Only one person thought the rate of decompression illness was high. Several family members of divers commented they found the results reassuring. Just about everyone seems to find the incidence lower than they would have guessed.

Have you heard anything or had any comments or reactions from the Journal subscribers?

Reference

1 Ladd G, Stepan V, Stevens L. The Abacus Project: establishing the risk of recreational scuba death and decompression illness. *SPUMS J* 2002; 32: 124-128

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E-mail: *<Gary@PsychoDiver.com>*

Editor's note:
The authors have copies of all the documents they developed, examples of correspondence, protocols, etc., in other words a manual of sorts, available for anybody interested. They had hoped that their investigation would spark debate over the methodology and/or create interest in doing similar studies elsewhere. The interest generated in British Columbia by this research project is in somewhat stark contrast to the response generated amongst our nearly 1000 subscribers to the majority of articles in this journal. Is there anyone out there?

Key words
Letters, epidemiology, recreational diving, accidents

SPUMS Notices

Minutes of the SPUMS Executive Committee Meeting held in Sydney on 26 October 2002

Opened: 0950hr

Present: Drs R Walker (President), G Williams (Immediate Past-President), C Meehan (Secretary), M Davis (Editor), D Doolette (Education Officer), M Bennett, S Mitchell, D Walker (Committee Members). Dr S Mitchell was present during the afternoon only.

Apologies: Dr B Trytko (Treasurer), Dr D Smart (ANZHMG Representative)

1. **Minutes of the previous meeting (May 2002)**
   Moved that the minutes be accepted as a true record. Proposed R Walker, seconded G Williams, carried.

2. **Matters arising from the minutes**

2.1 Update on the SPUMS administration, report presented by Dr C Meehan on behalf of Steve Goble.
There was discussion about the SPUMS Journal on CD. The CD will be advertised on the SPUMS web site. The cost of the CD will be $25 for members and $160 for non-members inclusive of GST. The CD will be updated every two years. There was some discussion about an online version of the Journal in the future. A membership drive was again discussed and Dr Bennett agreed to formulate a membership package. This will be circulated to the Committee for discussion. Committee members will endeavour to promote membership in their own areas.

2.2 Update on NZ Chapter closure given by Dr Mike Davis. The financial information has been handed over to Dr Trytko. There is approximately $5,000 remaining in the account. These funds will be transferred to SPUMS. This will finalise closure of the NZ Chapter. The Society owns books resident in the NZ Naval Hospital in Auckland. A formal letter will be sent to Commander Alison Drury, Senior Medical Officer, New Zealand Navy donating them to the Hospital.

2.3 Update from ANZHMG, supplied by Dr D Smart. Dr M Bennett spoke about this on behalf of Dr D Smart. The next HTNA meeting will be in Hobart during the last week of August 2003.

2.4 Update from new Editor, Dr M Davis. A report was supplied to the meeting by Dr M Davis, including several points for discussion. There are ongoing problems with papers not finalised in time by those presenting at meetings. Maybe abstract for the meeting. Mike to draft new letter for members re presenting at meetings and then writing up a paper for the Journal. Problem when some of the presentations are on research not finalised, and wouldn't be ready to finalise paper. Idea that all SPUMS diplomas get letter to formally present it at the next ASM. Abstracts possibly of presentations that are not really for papers. Editor will decide. Conveners need to work with Editor to make sure that the most is got from the ASM for publishing in the Journal. Six points were presented for discussion:

2.4.1 Need to establish a New Zealand account for day-to-day expenses controlled by the Editor. This account would have eftpos and require two signatures on cheques. The old account in NZ to be closed and the money still within it transferred to new account for use for the Journal. As originally proposed a proper budget will be presented for the 2004 budget onwards.

2.4.2 Request the President write to all presenters at the 2002 ASM who have not yet submitted manuscripts asking them to do so promptly. This has been discussed previously.

2.4.3 Share with NZMA the running costs of the office where the Journal is produced. Agreed in principle.

2.4.4 Cost of changing to colour publication. Enhance photos, and maybe promote advertising. Discussion re appropriateness of advertising in the Journal. Trial. Re-discuss in 12/12 at the next face to face in Australia.

2.4.5 Advertising space for DAN-SEAP to be free of charge. Editor to determine reasonable market rates for advertising in the Journal.

2.4.6 As discussed.

2.5 Update on UHMS in Sydney given by Dr M Bennett. The dates of the conference are 25–28 May 2004. It is planned to start the SPUMS ASM two days later. The planned dates would be 31 May to 5 June approximately.

2.6 Letter to TSANZ re respiratory fitness to dive, asthma and diving. No response at this stage and the letter will be resent.

2.7 Letter Dr M Le May was discussed.

2.8 Update given by the Education Officer, Dr D Doolette.

3. Annual Scientific Meetings

3.1 2002 ASM, Iririki Island, Vanuatu. Final figures presented. There was an overall loss of $7,000 at this meeting. This was due to the number of registrants being considerably reduced and because of SPUMS having sole use of the resort.

3.2 2003 ASM, Palau. In view of the recent unrest in Asia, travel to Palau is now recommended via Cairns instead of Manilla.

3.3 2004 ASM, Dr G Williams gave a presentation on a suitable venue in Noumea.

4. Treasurer's report

This was supplied by Dr B Trytko and circulated at the meeting.

5. Correspondence

5.1 Email from Dr Hamish Turnbull was circulated. Dr R Walker will reply.

6. Other business

6.1 Pre-requisite for the SPUMS award for the HTNA to be that the winning paper be submitted for publication in the Journal.

6.2 Minutes of the SPUMS AGM in May 2002 were circulated.

6.3 Committee contact details were updated.

6.4 IMCA, The International Marine Contractors Association represents offshore, marine and underwater engineering companies. An International course for Medical Examiners of Divers will be held in the Dutch Antilles 9–14 February 2003.

Closed: 1720hr

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 medically qualified financial member of the Society.

2 The candidate must supply evidence of satisfactory completion of examined course(s) 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 clinical 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, 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 NHMRC/AVCC statement and guidelines on research practice (available at http://www.health.gov.au/nhmrc/research/general/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 the 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, University of Adelaide,
Adelaide, South Australia 5005, Australia.
Phone: +61-(0)8-8303-6382.
Fax: +61-(0)8-8303-3909.
E-mail: <David.Doolette@adelaide.edu.au>

Key words
Qualifications, underwater medicine, hyperbaric oxygen, research

ACCEPTED INDICATIONS FOR HYPERBARIC THERAPY

The SPUMS Australian and New Zealand Hyperbaric Medicine Group and the ANZ College of Anaesthetists Special Interest Group in Diving and Hyperbaric Medicine

September 2000 (reviewed October 2002)

BROAD INDICATION	SPECIFIC INDICATION	RECOMMENDED REVIEW THRESHOLD (NUMBER OF TREATMENTS)
Bubble injury	Decompression illness	15
	Arterial gas embolus (diving/iatrogenic/misadventure)	10
Acute ischaemic conditions	Compromised flaps and grafts/ microvascular ischaemias	40
	Crush injury	20
	Compartment syndromes	20
	Post-operative	20
	Reperfusion injuries	20
	Acute acoustic trauma	20
Infective conditions	Clostridial myonecrosis	20
	Non-clostridial myonecrosis/ necrotizing fasciitis/cellulitis	20
	Malignant otitis externa	50
	Refractory mycoses	30
	Pneumatosis cystoides intestinalis	30
	Refractory osteomyelitis	60
	Intracranial abscess	40
Radiation tissue damage	Osteoradionecrosis:	
	established	60
	prophylactic	30
	Soft tissue radionecrosis:	
	established	60
	prophylactic	30
Problem wounds	Microvascular chronic ischaemic ulcers: diabetic ulcers/gangrene/decubitus ulcers	50
	Venous ulcers	30
	Frostbite	30
	Surgical incisions	30
	Spider bite	50
	Pyoderma gangrenosum	50
Toxic gas poisoning	Carbon monoxide (mod/severe)	10
	Smoke inhalation	10
	Cyanide	10
	Hydrogen sulphide	10
Ocular ischaemic pathology	Cystoid macular oedema	50
	Retinal artery/vein occlusion	30
Miscellaneous	Thermal burns	20
	Exceptional blood loss anaemia	10
	Tumour control in association with radiotherapy	30

NOTES:

1 The purpose of this list is to document the conditions for which the organisations above believe hyperbaric oxygen therapy is indicated. These recommendations are based on review of the literature and clinical experience. These conditions are limited to those where the evidence for the efficacy of HBO is at least as strong as currently accepted therapeutic alternatives.

2 This list is made available by the organisations above for the use of individual hyperbaric medicine facilities in formulating admission and discharge policy. The list constitutes recommendations only and does not mandate clinical practice.

3 It is proposed that this list be reviewed by a joint committee of members of the ANZHMG and ANZCA SIG on an annual basis. Submissions will be possible through these organisations and all available evidence at the disposal of this joint committee will be considered.

4 The maximum recommended number of treatments for each condition is a guide to therapy and should not be regarded as a required minimum for adequate treatment. In occasional cases, these figures may be exceeded for valid clinical reasons.

5 The ANZHMG and ANZCA SIG support clinical research into the efficacy of HBO in these and other conditions. Patients with conditions other than those above should be regarded as experimental and treatment undertaken in that context. These organisations hold that such treatment should be administered with the approval of a local ethics committee and involve no charge for professional or facility services.

SPUMS Diplomas

The following Diploma theses have been accepted since November 2002:

Measurement of fatigue following 18 msw dry chamber dives breathing air or enriched air nitrox
Richard Harris, Adelaide
Undersea Hyperb Medicine 2003 (in press)

Predictors of middle ear barotrauma associated with hyperbaric therapy
Jan Lehm, Sydney
SPUMS J, 2003 (accepted for publication)

Blood sugar level reductions with hyperbaric oxygen therapy
Barbara Trytko, Sydney
SPUMS J 2003; 33: 62-69

Hyperbaric oxygen treatment and survival from necrotizing soft tissue infections
David Wilkinson, Adelaide
Publication in preparation.

Congratulations to these four diplomats.

The database of randomised controlled trials in hyperbaric medicine developed by Dr Michael Bennett and colleagues at the Prince of Wales Diving and Hyperbaric Medicine Unit is at:

<www.hboevidence.com>

SPUMS Journal CD

The SPUMS Journal, volumes 1-30, is available on CD.

To read and print these documents Adobe Acrobat Reader (version 3 or later) is required. This may be downloaded free of charge from the Adobe web site <www.adobe.com>

The CD is available to members for Aust $25 (incl. GST or overseas mailing). The cost to non-members and institutions is Aust $90 inclusive. Supplies are limited
Cheques or money orders should be made payable to:
'South Pacific Underwater Medicine Society'.
Credit card facilities are not available for this.

Contact:
Steve Goble, SPUMS Administrative Officer,
C/o ANZ College of Anaesthetists,
630 St Kilda Road, Melbourne,
Victoria 3004, Australia.

The Australian and New Zealand College of Anaesthetists

Foundation Certificate Holder in Diving & Hyperbaric Medicine

Call for applications

The Australian and New Zealand College of Anaesthetists plans to offer a Certificate in Diving & Hyperbaric Medicine on the basis of eighteen months' experience in an ANZCA accredited hospital based Hyperbaric Medicine Unit. The Training Program will be introduced to provide senior trainees and Fellows of ANZCA and other equivalent specialist Colleges with broadly based experience in the management of diving & hyperbaric patients who fulfil the indications and criteria for hyperbaric oxygen therapy. The Certificate will be overseen by the ANZCA Certificates Committee. It is anticipated that the initial examination will be held on an as needed basis.

Foundation appointments as Certificate Holders will be available to experienced individuals from the specialist Colleges in Australia and New Zealand and other areas in which ANZCA examines, who practise in Diving & Hyperbaric Medicine. *(ANZCA Professional Document. TEI - Guidelines for hospitals seeking College approval of posts for vocational training in diving & hyperbaric medicine).* ANZCA Council has approved the establishment of a Certificate of Diving & Hyperbaric Medicine. Foundation Certificate Holders will be admitted by 30th June 2003.

Those eligible must meet the following criteria:

1 The candidate must hold Fellowship of the Australian and New Zealand College of Anaesthetists or an appropriate specialist qualification or a PhD/MD in an area relevant to hyperbaric medicine.
2 The candidate must have had substantial involvement in a Department of Diving & Hyperbaric Medicine and be in current practice with a minimum of 2 clinical sessions/week. Confirmation is required by the relevant hospital that the candidate has been involved in specialist Diving & Hyperbaric Medicine Practice.
3 The candidate must have a DipDHM awarded by the South Pacific Underwater Medicine Society.
4 The candidate must have adequate airway skills with a minimum of 6 months' experience in anaesthesia or has proven and demonstrated airway skills.
5 The candidate participates in a Continuing Medical Education and Quality Assurance Programme (ANZCA MOPS or equivalent).
6 The candidate contributes to the field of Diving & Hyperbaric Medicine by:
a development of professional activity in this field;
b regular contributions to undergraduate/postgraduate education in this field and/or by:
c publications in scientific journals and/or contributions to scientific meetings.

Obligations of Foundation Certificate Holders will include: participation in ongoing professional activity in this field, including Maintenance of Professional Standards in Diving and Hyperbaric Medicine; potential involvement as Diving & Hyperbaric Medicine Examiners; payment to ANZCA of appropriate annual dues which will supplement those of their primary specialty.

Applications will be reviewed by the Certificates Committee and appointments made by College Council. Applicants should submit curriculum vitae, together with accompanying documentation to support the requirements above.

Enquiries regarding applications may be directed to:
Dr Robert M Wong, Chairman DHM SIG
Phone: +61-(0)8-9431-2233
Mrs Joan Sheales, CEO
Phone: +61-(0)3-9510-6299
Fax: +61-(0)3-9510-6931

Applications should be marked 'Confidential', and submitted no later than 30 June 2003, and addressed to:
Criteria for Foundation Certification for the Certificate in Diving & Hyperbaric Medicine of the SIG of ANZCA,
The Australian and New Zealand College of Anaesthetists,
'Ulimaroa', 630 St Kilda Road,
Melbourne,
Victoria 3004, Australia.

The candidate must fulfil the following criteria:

1 Is in current practice of Diving & Hyperbaric Medicine with a minimum of two clinical sessions per week in diving and hyperbaric medicine department.
2 Has accumulated at least 18 months' (FTE) clinical experience in diving and hyperbaric medicine in a hospital-based facility and has covered the clinical work in the ANZCA Training Program of the DHM SIG.
3 Has a fellowship of a specialist College or is in possession of an MD/PhD in a relevant and appropriate area of study.
4 Is in possession of a DipDHM awarded by the South Pacific Underwater Medicine Society.
5 Has adequate airways skills – minimum of 6 months' anaesthetics experience or has proven and demonstrated airway skills.
6 Is involved in medical education of medical students/ RMOs/registrars/nurses.
7 Is enrolled in ANZCA MOPS program or equivalent.
8 The candidate contributes to the field of Diving & Hyperbaric Medicine by:
a development of professional activity in this field;
b regular contributions to undergraduate/postgraduate education in this field and/or by;
c publications in scientific journals and/or contributions to scientific meetings.

Note: The criteria expire after 30 June 2003. From that date, all candidates will have to present for the Certificate Examination conducted by ANZCA.

Book reviews

Hyperbaric surgery: perioperative care

Dirk Jan Bakker and Frederick S Cramer

488 pages, hardback
ISBN 1-9605360-8-9
Flagstaff, Arizona: Best Publishing Company, 2002
Available from Best Publishing Company, P O Box 30100, Flagstaff, Arizona 86003-0100, USA.
Ph: (+1) 928 527 1055; Fax: (+1) 928 526 0370
E-mail: <divebooks@bestpub.com>
Copies can be ordered online at <www.bestpub.com>
Price US$154.00, postage and packing extra

This hyperbaric surgery tome is dedicated to Professor Dr. med. Ite Boerema, the recognised pioneer in the field. He conducted extensive research on 'surgery in an operating room with high atmospheric pressure' and in the 1950s performed open-heart surgery under hyperbaric conditions. He was the organiser of the first International Congress on Hyperbaric Medicine in Amsterdam in 1963.

The authors are both surgeons and inform us that this book is the first of its kind to write about hyperbaric surgery and that they would 'like to show the way surgeons are thinking when using HBOT [hyperbaric oxygen therapy] in their daily practice.' They remind us that 'not much surgery is done nowadays under hyperbaric conditions,' but that surgeons have always been very much involved in HBOT and that there are still many surgical indications for HBOT.

The book is a compilation of classic hyperbaric medicine topics, with each chapter written by one of twenty 'distinguished international experts' from six different countries. They hope to show that 'HBOT has a definite and respected place in medicine and is not a therapy in search of a disease.' The book is intended for 'the practising surgeon who has the availability of a hyperbaric chamber'.

The chapters are thorough and often draw on greater than one hundred references. The book starts with an interesting history of hyperbaric medicine and surgery and then, amazingly, dives straight into a chapter on air embolism. This is followed by the role of HBOT in the surgical management of chronic refractory osteomyelitis, before returning to the next logical chapter, on the physiological and pharmacological basis of HBOT.

What follows then is a bubbly trail of conventional HBOT chapters covering the core topics, including osteoradionecrosis, crush injuries and problem wounds, each with a surgical slant. Amazingly, for a hyperbaric surgery text, there is a whole chapter on 'clinical aspects of decompression disorders'. There seems to be some repetition, with one chapter on HBOT in the management of non-healing wounds and another on HBOT as an adjunct to surgical management of the problem wound.

I found the chapter entitled 'When HBO meets the ICU: intensive care patients in the hyperbaric environment' very useful with good checklists for intubated patients and information on everything from infusions to ventilators. The brief chapter on frostbite addressed mechanisms and the role of HBOT and was also useful. The book is illustrated throughout with excellent colour photographs, which clearly illustrate the benefit of HBOT.

Hyperbaric surgery? Definitely not a treatment in search of a disease, but perhaps surgeons in search of a cause. Hyperbaric medicine has become a specialty in its own right run by hyperbaric specialists, and is progressively evidence based. Just as operating within hyperbaric chambers has slipped into the history books so too has the direct involvement of surgeons in HBOT other than as a referral base. This book does not really 'show us the way surgeons are thinking when using HBOT,' but rather it is another general hyperbaric text with a few good chapters.

Sandy Inglis

Key words
Book reviews, hyperbaric oxygen, textbook

On-site management of scuba diving and boating emergencies

Wesley Yapor

262 pages, hardback
ISBN 0-930536-02-X
Flagstaff, Arizona: Best Publishing Company, 2002
Available from Best Publishing Company, P O Box 30100, Flagstaff, Arizona 86003-0100, USA.
Ph: (+1) 928 527 1055; Fax: (+1) 928 526 0370
E-mail: <divebooks@bestpub.com>
Copies can be ordered online at <www.bestpub.com>
Price US$14.95, postage and packing extra

This A5-sized book is presented as a manual covering commonly encountered problems a diver may face both on the water and under it. It is attractively covered in orange and red, encouraging me to review it while on vacation diving and boating. Unfortunately, it does not fulfil its stated aims and was disappointing in many areas. The line drawings are dull, and the text uninteresting with no bullet points or key-point summaries, which limits its usefulness on a boat or in a crisis. The inclusion of some anecdotes of incidents or case studies would have brightened the dullness.

Chapters are titled: equipment, medical examination, medical management, underwater emergencies, surface emergencies, boating emergencies, and travel-related conditions.

The equipment chapter starts with a description of a first-aid kit that reveals the major fault of the book: it is long on generality and short on specifics. The kit includes an 'oxygen tank' and covers its use in one paragraph. I looked at the section on underwater emergencies to correct this deficiency and found the statement '…deliver oxygen by mask until emergency personnel arrive.' This is the extent of discussion of the use of oxygen, so the reader does not learn the importance of oxygen in the treatment of decompression illness or gain a rudimentary knowledge of oxygen equipment and delivery. Even though the book is for a non-medical readership, I would regard this as essential to the stated aim. The rest of the chapter is similarly vague or brief about equipment and its use.

The chapters on medical examination and management provide adequate descriptions, although a standard first-aid manual would be of more practical use. The chapter on underwater emergencies is remarkably brief on the prevention and management of decompression illness.

Diver rescue on the surface and underwater is covered reasonably well, but then the book wanders into dangerous irrelevance by including methods of estimating longitude and latitude. The latitude estimation is stated to cover 60 degrees North to 60 degrees South, but actually covers only the northern hemisphere. Even putting the correct dates in the nomogram, I was unable the find my latitude closer than 5 degrees while knowing the right answer and while not lost at sea. Covering travel medicine in 40 pages is an impossible task, even without the inclusion of irrelevant material such as how to secure a spinal victim on the floor of an aircraft during turbulence.

In summary, I would recommend that readers take on their boats and dive trips the local equivalents of the New Zealand St John's First Aid Manual, Boatmasters Course manual and Padi dive manual and not purchase this book.

Graham McGeoch

Key words
Book reviews, diving, accidents, first aid

Mending the bends: assessment, management, and recompression therapy

David Merritt

76 pages, soft cover
ISBN 0-930536-05-4
Flagstaff, Arizona: Best Publishing Company, 2002
Available from Best Publishing Company, P O Box 30100, Flagstaff, Arizona 86003-0100, USA.
Ph: (+1) 928 527 1055; Fax: (+1) 928 526 0370
E-mail: <divebooks@bestpub.com>
Copies can be ordered online at <www.bestpub.com>
Price: US $19.95, postage and packing extra

It is not clear even after reading this book whom the targeted audience is. The title would suggest it was written for medical practitioners yet the anecdotal style, lack of depth and scant references would appear to be more suitable to the avid non-medically-qualified diver.

The initial chapters give a very brief overview of diving physics, the mechanical effects of pressure, air diving, toxic inhaled gases and alterations in cardiopulmonary performance at depth yet leave the reader dissatisfied in that no topic has been dealt with in any degree of complexity.

Whilst appreciating the author is trying to inform the uneducated, to suggest that all patients who present with a squeeze (barotrauma), no matter where it is or how small it may seem, are at increased risk of decompression sickness (DCS) and arterial gas embolism is untrue. Recreational divers are well informed and will soon lose faith in a medical practitioner who considers a provisional diagnosis of DCS when they present after an aborted dive (and less than one minute bottom time) secondary to a middle ear barotrauma.

For an introductory manual the discussion of oxygen toxicity is confusing. Whilst stating that oxygen treatments at 60 fsw are at 2.8 ATA the author also states that in a dry chamber, oxygen can usually be tolerated up to 2 ATA. There is no further discussion as to the differences seen in dry and wet exposures and no advice as to the safety and efficacy of the US Navy Table 6 recompression table. Most practitioners would not routinely calculate the unit pulmonary toxicity dose (UPTD) unless the patient had received considerable oxygen prior to recompression or if faced with an extended table. The patient's clinical condition, response to treatment, residual signs and awareness of possible pulmonary oxygen toxicity guide recompression, not a single UPTD score.

The chapter on the hazards of the undersea environment is simplistic and glib and does not contribute any information relevant to the management of DCS. The advice to routinely use antibiotics in the treatment of a near-drowned victim is not consistent with that of experts in this field.

The chapters on DCS are again simplistic and leave the reader dissatisfied. The advice that any pain distal to the axilla or the groin can be safely treated as type I DCS and any pain proximal to those points as type II DCS would lead the reader to believe a comprehensive neurological examination was a waste of time! The author does provide detail on the conduct of a neurological examination but this is brief and provides no information as to the neurological signs the examiner should be looking for.

The discussion on treatment tables, 'What table do I use,' provides a rationale for each US Navy treatment table beginning with air tables and finishing with an oxygen soak.

There is no detailed discussion as to what is the most commonly used table nor why the oxygen tables are used preferentially. To the uninitiated, air tables or even in-water recompression may appear to be the most appropriate treatment regime.

In consideration of drug therapy for DCS the author makes the comment that no drug or combinations of drugs have been proved by controlled double-blind studies in humans to be effective. He then states 'that anecdoctal reports don't count (they do, but I had to put in that disclaimer),' which may imply a lack of scientific rigour in his management approach. I know of no specific study that has proved that steroids reduce brain and spinal cord swelling as well as reduce the inflammatory response seen in vascular and tissue injuries as a result of DCS as suggested by the author when recommending their routine use. Certainly, within Australia neither is aspirin the mainstay in management.

The book does include the diving accident treatment flow charts and a number of US Navy treatment tables.

Overall, this book does not live up to its title and would not provide the level of detail required by a medical practitioner to manage a patient with decompression sickness. There are many excellent diving medicine textbooks available, that are mandatory reading for those interested in the specialty. Unfortunately, this book is not one of those.

Robyn Walker

Key words
Book reviews, scuba diving, accidents, decompression illness, treatment

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Description of a diving machine

Karl Heinrich Klingert

51 pages, hardback, case bound with dust jacket
ISBN 0-954383-40-0
UK: Historical Diving Society, 2003
Available from Historical Diving Society <www.thehds.com>
Ph: +44-(0)1737-249961
E-mail: <info@thehds.com>
Price GBP18.00, postage and packing extra (UK GBP3, Europe GBP4. elsewhere GBP6)

This excellent publication is the third monograph to be published by the Historical Diving Society. Introduced by Michael Jung, the leading authority on Klingert's work, this monograph comprises the first English translations of Klingert's two very rare publications: *Description of a Diving Machine for Use in Rivers* and *A Brief Supplement to the History and Description of a Diving Machine, Together With the Explanation of a Lantern or Lamp Which Burns in any Vitiated Air, and in Water*.

Michael Jung gives a well-written and informative history of Klingert's life. He tells us that Karl Heinrich Klingert was born on 16 January 1760 in Breslau. Now the city of Wroclaw in modern Poland, Breslau was the capital of Silesia, which in 1772 became a province of Prussia. Situated some 560 kilometres from the sea, the only water in Breslau available for an inventor of diving equipment is the river Oder and its tributaries; this makes Klingert's inventions all the more remarkable. For the uninitiated I'd better explain that in 1797 Karl Klingert published a description of a surface-supplied, semi-atmospheric diving apparatus complete with a means of communicating with the surface. Even if you have not heard of him, it is likely that you will have seen a picture of his apparatus.

In *Description of a Diving Machine for Use in Rivers*, Klingert describes in detail the manufacture and instructions for use of his diving machine. The diving machine consists of a large helmet and an under-cylinder both constructed of tin plate. The helmet is joined to the cylinder by a leather jacket, the sleeves of which extend to just above the elbow. Leather breeches extend from the under-cylinder to just above the knees. Connected to the bottom of the under-cylinder is an iron frame that prevents the leather breeches from being pushed against the body by water pressure.

Two hoses are attached to the helmet, one provides air from the surface and the other is a speaking tube enabling the diver to communicate directly with the surface. The diver is weighted by a series of weights hung from hooks on the under-cylinder.

When one reads the descriptions of late-18th-century equipment and methods of manufacture and combines it with a look at the classical picture of the diver in confident pose holding an axe, it is easy to dismiss the whole thing as the unworkable ramblings of a dreamer. If this is the case, readers may be surprised to learn that on 24 June 1797 a dive was conducted using Klingert's diving apparatus in approximately 4 metres of water for 13 minutes, during which time the diver 'sawed through a tree standing upright at the bottom of the river.'

In the second of Klingert's publications he describes two means of making the diver more independent. One is utilising the equipment already described attached to a large cylinder of air that has a platform for the diver to stand on. A large handle winds a piston in and out at the bottom of the cylinder to control buoyancy.

His second method of making the diver more independent is virtually an early design for scuba. He proposes a large, open helmet fitted snugly over the shoulders and held down by a harness and weights. Air is supplied to the helmet from a cylinder of compressed air slung at the hip, the supply valve being manually operated by the diver.

However, the invention that caught my imagination is a means of underwater illumination. Klingert designed a lantern that consists of a cylinder of compressed air with a control valve at the top and a miner's lamp attached to the valve. A brass ring at the top of the glass supports an inverted glass cone that keeps the water out of contact with the hot glass. A tube then leads exhaust gases from the top of the lamp down the side of the lamp to prevent water ingress. This lamp could be used underwater or in mines and would burn for over three hours. Of course, to construct these items Klingert also had to design and build cylinders capable of being pressurised and a pump with which to compress the air. Both of these he describes in the supplement.

In hardcover and comprising just 51 pages, this is an excellent little book. Jung's introduction gives a fascinating insight into the genius of a man who was always thinking and inventing not just diving equipment but many more items, including a battery-powered clock.

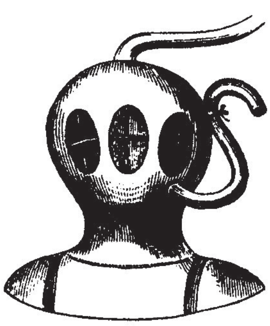
Klingert's two publications with the original copperplates have been translated into English without losing the language of the period. Both of these pieces show that Klingert was not just a thinker but he was also a doer; as Mechanic to the Royal Prussian Government he could follow through on his ideas and actually manufacture the equipment he designed.

The Historical Diving Society (HDS) is to be applauded for its efforts in translating, editing and publishing this excellent text. Klingert's diving apparatus was one of the milestones of diving equipment development, and thanks to the dedication of societies such as the HDS these milestones are being recorded before it is too late. For anyone with the remotest interest in diving history, mechanical history or general history this book is a must. It is a limited edition, so you will need to be quick.

Steve Goble

Key words
Book reviews, history, scuba

THE HISTORICAL DIVING SOCIETY
Annual Conference, Saturday 18 October 2004



To be held at the Lecture Theatre of Portsmouth University (Langstone Centre), Langstone, Portsmouth.
Tickets cost £20. Purchase in advance from: The Secretary, Historical Diving Society, 25 Gatton Road, Reigate, Surrey, RH2 0HB. E-mail: <mjf@lglodge.freeserve.co.uk>

CEO/President

Divers Alert Network (DAN) America

Divers Alert Network (DAN) America seeks a world-class expert in dive safety to assume the position of President of this non-profit 200,000-member association of recreational divers.

The mission of DAN is to give expert medical information and advice for the diving public, to provide emergency medical advice and assistance for medical diving injuries, and to work to prevent injuries and promote diving safety. (See <www.diversalertnetwork.org> for extensive organisational information.)

The CEO/President in this position is responsible for:

- the organisation's effective management including all headquarters operations located in Durham, North Carolina and a staff of 80;
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- effectively maintaining DAN's close association with Duke University Health Systems and other diving organisations worldwide.

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- a strong background in managing, motivating and developing programs and funding sources for research and educational purposes;
- excellent communication skills in writing and in addressing public and professional audiences.

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Mimi Letchinger, 5000 S. East End Ave.,
24C, Chicago, IL 60615, USA or
E-mail: <MIMILETCH@aol.com>

SPUMS 2004 Annual Scientific Meeting

Noumea – New Caledonia
Venue - Le Meridien Noumea
May 30th – June 6th 2004
(meeting to run June 1st – 5th inclusive)

SPUMS meeting to follow UHMS Sydney 2004

Convener
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Fax: *+61-(0)3-9885-1164*
Toll Free: *1800338239*
E-mail: *<Allwaysdive@bigpond.com.au>*

HTNA ANNUAL MEETING 2003
Dates: 27 to 30 August, 2003
Venue: Hotel Grand Chancellor, Hobart, Tasmania
Guest Speakers: David Elliott, Valerie Flook and Ian Millar
Contact: Corry van den Broek
E-mail: <corry.vandenbroek@dhhs.tas.gov.au>

UNDERSEA and HYPERBARIC MEDICINE SOCIETY

37th Annual Scientific Meeting
Preliminary Notice
Dates: 24 to 27 May, 2004
Venue: Four Seasons Hotel, Circular Quay, Sydney
Contact: International Conferences & Events (ICE)
E-mail: <uhms@iceaustralia.com>
ASM web site: <http://www.iceaustralia.com/uhms2004>

EUROPEAN UNDERSEA BAROMEDICAL SOCIETY
2003 Scientific Meeting
Dates: 27 to 31 August, 2003
Venue: University of Copenhagen
The Panum Institute
Blegdamsvej 3 C
2200 Copenhagen N, Denmark
Contact: EUBS 2003, c/o Department of Anaesthesiology
Centre of Hyperbaric Medicine, Righospitalet
Blegdamsvej 9, DK-2100, Copenhagen, Denmark
Phone: +45-(0)3-5454-3467
E-mail: <hbo@rh.dk>
EUBS congress web site: <http://www.hbo.dk>
EUBS web site: <http://www.eubs.org>

PACIFIC RIM MEDICO-LEGAL CONFERENCE 2003
Dates: 27 September to 4 October, 2003
Venue: Heron Island, Great Barrier Reef, Australia
Contact: Lorenzo Boccabella
E-mail: <boccabella@qldbar.asn.au>

ROYAL AUSTRALIAN NAVY MEDICAL OFFICERS UNDERWATER MEDICINE COURSE 2003

Dates: 24 November to 5 December, 2003
Venue: HMAS Penguin
The Medical Officer's Underwater Medicine Course seeks to provide the medical practitioner with an understanding of the range of potential medical problems faced by divers. Considerable emphasis is placed on the contra-indications to diving and the diving medical, together with the pathophysiology, diagnosis and management of the more common diving related illnesses.
Cost: $1578.00 (tbc)
For information and application forms contact: The Officer in Charge, Submarine & Underwater Medicine Unit, HMAS PENGUIN, Middle Head Rd, Mosman, 2088 NSW
Phone: +61-(0)2-9960-0572
Fax: +61-(0)2-9960-4435
E-mail: <Sarah.Sharkey@defence.gov.au>

ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE COURSES 2003

Medical Officers Course

July/August 2003

Basic	21/7/03	to	25/7/03
Advanced	28/7/03	to	1/8/03

October/November 2003

Basic	27/10/03	to	31/10/03
Advanced	3/11/03	to	7/11/03

Cost:
Basic Diving Medicine Course: $825.00
Advanced: $825.00

DMT Full Course

October 2003 3 weeks, 13/10/03 to 31/10/03

DMT Refresher Course

July/August 2003 2 weeks, 21/7/03 to 1/8/03
October 2003 1 week, 20/10/03 to 24/10/03

For further information or to enrol contact:
The Director, Hyperbaric Medicine Unit
Royal Adelaide Hospital, North Terrace
South Australia 5000.
Phone: +61-(0)8-8222-5116
Fax: +61-(0)8-8232-4207

ANZCA ANNUAL SCIENTIFIC MEETING 2004
Diving & Hyperbaric SIG

Dates: 1 to 5 May, 2004
Venue: Perth Concert Hall and Duxton Hotel, Perth, WA
Contact: Katie Clarke, Congress West, 3/12 Thelma Street, West Perth, WA 6872
Phone: +61-8-9322-6906
Fax: +61-8-9322-1734
Email: <conwes@congresswest.com.au>

FREMANTLE HOSPITAL DEPT OF DIVING & HYPERBARIC MEDICINE DIVING MEDICAL EXAMINATION FOR RECREATIONAL DIVERS

A three-day course will be conducted for medical practitioners who wish to perform medical examinations for recreational divers in accordance with Australian Standard AS 4005.1. RACGP CME credit hours applied for.
Dates: 28 to 30 November 2003
Venue: Fremantle Hospital, Alma Street, Fremantle, WA
Contact: Mrs Beth Karlsson, Administrative Assistant
Phone: +61-(0)8-9431-2233
Fax: +61-(0)8-9431-2235

DIVING MEDICAL CENTRE (AUSTRALIA)

A 3-day Diving Medical Examiner's Course will be conducted by the Diving Medical Centre (Australia) in Queensland over Easter 2004.
Dates: 10 to 12 April, 2004
Venue: To be advised
This course is approved by SPUMS to teach doctors to examine recreational divers, dive masters and instructors to the Australian AS4005.1 standard.

The course has been approved by the RACGP for 120 CPD points (Group 1).
Contact: Dr Bob Thomas, Brisbane
Phone: +61-(0)7-3376-1056 for details

CLINICAL MANAGEMENT of DIVING ACCIDENTS

An advance course for medical practitioners

TRIAGE AND MANAGEMENT OF DIVING ACCIDENTS

an International Workshop

Dates: 10 to 14 November, 2003
Venue: Patong, Thailand
Contact: Professor David Elliott, 40 Poetworth Road, Haslemere, Surrey GU27 2HX
Fax: +44-(0)1428-658678
E-mail: <davidelliott@aol.com>

10TH INTERNATIONAL CONFERENCE ON EMERGENCY MEDICINE (ICEM 2004)

Speakers are invited for this meeting in Cairns in 2004
Dates: 6 to 10 June, 2004
Venue: Cairns Convention Centre, Queensland
Web site: <www.icem2004.im.com.au>
Contact: Conference Secretariat, Intermedia Convention and Event Management, P O Box 1280, Milton, Queensland 4064, Australia
Phone: +61-(0)7-3858-5535
Fax: +61-(0)7-3858-5510
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Contributions should be sent to:
The Editor, SPUMS Journal,
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Private Bag 4710, Christchurch, New Zealand.
E-mail: <spumsj@cdhb.govt.nz>

Requirements for manuscripts
Documents are acceptable on disk or by e-mail. The preferred format is Word 6 for Windows. Two printed copies of all text, tables and illustrations should also be mailed. All articles should include a title page, giving the title of the paper and the full names and qualifications of the authors, and the positions they held when doing the work being reported. Identify one author as correspondent, with their full postal address, telephone and fax numbers, and e-mail address supplied. The text should be subdivided into the following sections: an Abstract of no more than 250 words, Introduction, Methods, Results, Discussion, Acknowledgements and References. Acknowledgments should be brief. References should be in the format shown below. Legends for tables and figures should appear at the end of the text file after the references.

The printed copies and electronic files should be double-spaced, using both upper and lower case, on one side only of A4 paper. Headings should conform to the format in the *Journal*. All pages should be numbered. Underlining should not be used. Measurements are to be in SI units (mm Hg are acceptable for blood pressure measurements) and normal ranges should be included.

The preferred length for original articles is 3,000 words or less. Inclusion of more than five authors requires justification as does more than 30 references per major article. Case reports should not exceed 1,500 words, with a maximum of 10 references. Abstracts are also required for all case reports and reviews. Letters to the Editor should not exceed 400 words (including references, which should be limited to five per letter). Legends for figures and tables should be less than 40 words in length.

Illustrations, figures and tables should NOT be embedded in the wordprocessor document, only their position indicated. All tables are to be in Word for Windows, tab-separated text rather than using the columns/tables option or other software, and each saved as a separate file. They should be double spaced on separate sheets of paper. No vertical or horizontal rules are to be used. Illustrations and figures should be separate documents in JPG or TIFF format.
Photographs should be glossy, black-and-white or colour. Slides should be converted to photographs before being sent. Colour reproduction is available only when it is essential for clinical purposes and may be at the authors' expense. Indicate magnification for photomicrographs.

Abbreviations should only be used in brackets after the complete expression, e.g., decompression illness (DCI) can thereafter be referred to as DCI.

References
The Journal reference style is the 'Vancouver' style *(Uniform requirements for manuscripts submitted to biomedical journals*, updated October 2001. <http://www.icmje.org/index.html>).
In this system references appear in the text as superscript numbers.[1,2] The references are numbered in order of quoting. Index Medicus abbreviations for journal names are to be used (<http://www.nlm.nih.gov/tsd/serials/lji.html>). Examples of the format for quoting journals and books are given below.

1 Anderson T. RAN medical officers' training in underwater medicine. *SPUMS J* 1985; 15: 19-22
2 Lippmann J, Bugg S. *The diving emergency handbook*. Melbourne: JL Publications, 1985

There should be a space after the semi-colon and after the colon, and no full stop after the page numbers. Titles of quoted books and journals should be in italics. For those using referencing software, the format is the same as the *British Journal of Anaesthesia*. Accuracy of the references is the responsibility of authors.

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

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+61-8-8212-9242 (International)
The toll-free number 1-800-088-200 can only be used in Australia

NEW ZEALAND
0800-4-DES111 or 09-445-8454 (in New Zealand)
+64-9-445-8454 (International)
The toll-free number 0800-4-DES111 can only be used in New Zealand

The DES numbers in both countries are generously supported by DAN-SEAP

PROJECT STICKYBEAK

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

Information may be sent (in confidence) to:
Dr D. Walker
P.O. Box 120, Narrabeen, N.S.W. 2101.

DIVING INCIDENT MONITORING STUDY (DIMS)

DIMS is an ongoing study of diving incidents. An incident is any error or occurrence which could, or did, reduce the safety margin for a diver on a particular dive. Please report any incident occurring in your dive party, but do not identify anyone. Most incidents cause no harm but reporting them will give valuable information about which incidents are common and which tend to lead to diver injury.

Using this information to alter diver behaviour will make diving safer.

To obtain or to return Diving Incident Report forms write to:
DIMS,
30 Park Avenue, Rosslyn Park, South Australia 5072, Australia.

PROJECT PROTEUS

The aim of this investigation is to establish a data base of divers who dive or have dived with any medical contraindications to diving. At present it is known that some asthmatics dive and that some insulin dependant diabetics dive. What is not known is how many. How many with these conditions die is known. But how many dive safely with these conditions is not. Nor is the incidence of diving accidents in these groups known.

This project is under the direction of Dr Douglas Walker and Dr Mike Bennett. The investigation has been approved by the Ethics Committee of the Prince of Wales Hospital, Randwick, approval number 01/047.

If you are in such a group please make contact. All information will be treated as CONFIDENTIAL. No identifying details will appear in any report derived from the data base.

Write to: Project Proteus
PO Box 120, Narrabeen, New South Wales 2101, Australia.
E-mail <diverhealth@hotmail.com>

CONTENTS

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