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CONTENTS

GLEANINGS FROM MEDICAL JOURNALS, COURSES AND MEETINGS ARE DETAILED ON THE BACK COVER

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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 medical practitioners and those engaged in research in underwater medicine and related subjects. Associate membership is open to all those, who are not medical practitioners, who are interested in the aims of the society.

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All contributions should be typed, double-spaced, using both upper and lower case, on one side of the paper only, on A4 paper with 45 mm left hand margins. All pages should be numbered. No part of the text should be underlined. These requirements also apply to the abstract, references, and legends to figures. Measurements are to be in SI units (mm Hg are acceptable for blood pressure measurements) and normal ranges should be included. All tables should be typed, double spaced, and on separate sheets of paper. No vertical or horizontal rules are to be used. All figures must be professionally drawn. Freehand lettering is unacceptable. Photographs should be glossy black-and-white or colour slides suitable for converting into black and white illustrations. Colour reproduction is available only when it is essential for clinical purposes and may be at the authors' expense. Legends should be less than 40 words, and indicate magnification. Two (2) copies of all text, tables and illustrations are required.

Abbreviations do not mean the same to all readers. To avoid confusion they should only be used after they have appeared in brackets after the complete expression, e.g. decompression sickness (DCS) can thereafter be referred to as DCS.

The preferred length of original articles is 2,500 words or less. Inclusion of more than 5 authors requires justification. Original articles should include a title page, giving the title of the paper and the first names and surnames of the authors, an abstract of no more than 200 words and be subdivided into Introduction, Methods, Results, Discussion and References. After the references the authors should provide their initials and surnames, their qualifications, and the positions held when doing the work being reported. One author should be identified as correspondent for the Editor and for readers of the Journal. The full current postal address of each author, with the telephone and facsimile numbers of the corresponding author, should be supplied with the contribution. No more than 20 references per major article will be accepted. Acknowledgements should be brief.

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 5 per letter). Accuracy of the references is the responsibility of authors.

References

The Journal reference style is the "Vancouver" style, printed in the Medical Journal of Australia, February 15, 1988; 148: 189-194. In this 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. 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 (2): 19-22
2 Lippmann J and Bugg S. *The diving emergency handbook*. Melbourne: J.L.Publications, 1985: 17-23

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REPORTS OF INTEREST

GLEANINGS FROM MEDICAL JOURNALS

Abstracts from the Undersea and Hyperbaric Medical Society Annual Scientific Meeting 1990

MEETINGS AND COURSES

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.

EDITORIAL

The last issue was a milestone for the SPUMS Journal. For the first time it was sent to over 1,000 paid up members and associates. Since then another 20 people have been added to the mailing list which now stands at 1,065 including the free list. The print run for this issue of the SPUMS Journal is 1,150. The Society has grown steadily in the years since 1976 when the membership totalled less than 200. This year has seen 80 new North American members.

Although the Journal is not catalogued by Index Medicus it is subscribed to by the National Library of Medicine in the United States, the British Library in the United Kingdom and the National Research Council, Canadian Institute for Scientific and Technical Research. Application for Index Medicus status will be made again and again until it comes through.

A new hazard of diving, cerebral air embolism following a giant stride entry, is one of the cases reported from Townsville. The likely explanation is that the trainee was overweighted, which happens to many students in these days of efficient and universal buoyancy compensators. To do exercises on the bottom is easier if the trainees are overweighted and have to put air in their compensators to become neutrally buoyant and able to swim in comfort for the sightseeing part of the dive which is their reward for doing the exercises properly.

Dr John Parker contributes a further paper on the diving medial questionnaire from AS 2299 as a predictor of failing in a diving medical and for the detection of asthma. 50% of those with a history of “childhood asthma” still had sufficient airway obstruction to fail the medical. The case for a histamine provocation test for all who have had asthma in childhood and apparently grown out of if gets a bit more support. With the two papers that appeared in the last Journal we have learnt a lot about the causes of failure in diving medicals and of the efficacy, or rather lack of it, of the PADI Resort Questionnaire for detecting people who should not dive without having a medical.

The Alfred Hospital team describes their first 100 cases and the outcome of treatment. Their paper ends with recommendations for safer diving. Dr McIver’s paper explains clearly the various clinical manifestations of decompression illnesses. Michael Gatehouse and Tom Wodak offer a view from the legal profession of the inquests discussed by John Lippmann in the last issue. They draw attention to the lack of information in a verdict of “death by drowning” without explaining what actually led to the death. Their paper is full of unanswered questions which need answers. Some can be, we hope, answered by doctors but some answers depend on changes in legal attitudes. Our columns are open for all those who can answer the questions posed in this paper .

The changes to the Rules of the Society have been approved and the revised Statement of Purposes and Rules is enclosed with this issue. Now that the rules reflect actuality we hope that they will not need changing for many years.

The directors of the various Australasian Hyperbaric Units have formed the Australian and New Zealand Hyperbaric Medicine Group and the Executive Committee of SPUMS has made sure that it has got off to a good start by making it a Standing Committee of SPUMS. We will hear more from this group in the future as their research projects get published.

Nitrox, which should more properly be known as oxygen enriched air, appears in our pages for the first time in the review on page 162. The use of such a mixture is becoming common enough in the U.S.A. for the July/August issue of Pressure, the newsletter of the Undersea and Hyperbaric Medical Society, to be devoted to the topic of its safety. There is recreational diving using nitrox in the States and it is only a matter of time before it arrives in the South Pacific. The diving medical and instructor communities must be prepared to cope with its arrival.

The papers from the 1990 Annual Scientific Meeting (ASM) include the final paper from Ray Rogers on the testing of the Recreational Dive Planner (RDP). There is enough information in this and his previous paper to allow the thinking reader to decide on the risks associated with using the RDP. SPECT (see page 163 to find out what that means) appears to be an advance in finding out what happens to brain blood flow during and after decompression illness. As most SPUMS Annual Scientific Meetings are in tropical waters Steve Dent’s paper on the Palauan Reefs should be widely appreciated and makes a good introduction to next year’s ASM in Port Douglas, with its theme of the ecology of the Great Barrier Reef.

A paper reprinted from the British Medical Journal shows that UK fish farm workers dive as unintelligently and are as prone to decompression illness as those in Tasmania. From America we reprint papers dealing with diving alone which effectively happens to everyone who buddies with a photographer, rescuing a buddy when one is untrained in such rescues which we fear applies to some members and associates of SPUMS, one that sorts out some myths about what to do, and not do, after diving and a review of a book about dive computers which assesses and compares all computers available when it was written.

ORIGINAL ARTICLES

STUDENT DIVERS, AN AT RISK POPULATION TWO CASE REPORTS

Robyn Walker

Introduction

Cerebral arterial gas embolism (CAGE) resulting from pulmonary barotrauma is well documented.[1-3] Predisposing factors cited include inadequate exhalation, uncontrolled buoyant and underlying lung pathology (cysts, bullae).4 A number of accidents however, result from apparently normal ascents with adequate exhalation or normal breathing patterns.[4] The most common presentation of CAGE is an acute cerebral insult occurring within minutes of the diver reaching the surface.[5] Typical symptoms and signs include an altered level of consciousness, sensory and motor changes and chest pain.[4] Spontaneous improvement of these focal neurological deficits frequency occur, however these improvements are not always sustained. Early recompression is the definitive treatment.[4]

A common misconception is that divers only experience difficulties performing deep dives. Air embolism however tends to occur most often in people who dive less frequently and especially in inexperienced divers.[4]

The following two case reports reinforce the dangers of shallow water and demonstrate that student divers are at risk.

Case 1

A 19 year old female, undertook an open water diving course. On days one to three she underwent pool training sessions to a maximum depth of 3 m. Days 4 and 5 involved an overnight trip to the Great Barrier Reef. The first two ocean dives to a maximum of 12 m were completed without incident. On the first dive of the next day she performed a giant stride entry into the water, with her regulator in her mouth. Immediately on surfacing from this she complained of left sided chest pain which was increased in severity by deep inspiration and coughing. She swam to the stern of the boat, unwilling to continue the dive because of the pain. After leaving the water, she was given an analgesic tablet and lay down on her bunk.

Several hours later she sat up and immediately noticed a heaviness in her body. She felt weak down the left side and had no sensation in her left arm and leg. She was unable to speak and felt dizzy. These symptoms persisted unchanged for fifteen minutes and then gradually improved over a number of hours.

On examination at Townsville General Hospital ten hours after the initial incident she was found to be alert and orientated. Her left arm was weaker than the right arm, grade 4/5, and power in both lower limbs was also decreased to grade 4/5. She had anaesthesia to pin-prick and light touch on the left in a C3-T7 distribution.

A diagnosis of CAGE was made and she was recompressed in a Dräger Duocom Portable Recompression Chamber and transferred to Prince Henry Hospital, Sydney.

TABLE 1

RECOMPRESSION TREATMENT REGIME FOR CASE 1

(information supplied by Prince Henry Hospital)

6-10-89	Extended Table 62
7-10-89	Extended Table 62
	Table 61
8-10-89	9 m soak 120 minutes, 30 minute ascent
	9 m soak 105 minutes, 20 minute ascent
9-10-10	9 m soak 120 minutes, 5 minute ascent
10-10-89	9 m soak 120 minutes, 5 minute ascent
11-10-89	9 m soak 125 minutes, 5 minute ascent
12-10-89	9 m soak 125 minutes, 5 minute ascent
16-10-89	9 m soak 125 minutes, 5 minute ascent

The treatment profile is shown in Table 1. Significant improvement occurred during these treatments with complete resolution of her motor weakness, however, there was minimal recovery of her sensory deficit.

Investigations performed during her hospital stay included CT head scan, MRI head scan and chest X-ray, none of which showed any abnormality.

On review one month following the incident, she was found to have residual anaesthesia of the left arm with total proprioceptive loss and she had an abnormal gait. There was evidence of sympathetic disturbance in the left hand. She was referred for continuing physiotherapy.

Case 2

A 25 year old female, also undertook an open water certification course. The class had practised basic skills in their first pool session and all appeared comfortable in the water. The instructor swam the class into deeper water (maximum 3 m) and then indicated to them that they should surface. Close to the surface the instructor noted her to be struggling and assisted her to the side of the pool. She was unable to pull herself out of the pool and had to be assisted out by the training staff. Witnesses noted that her face exhibited marked left sided drooping. She was unable to move her left arm, nor could she stand unsupported because of weakness in her left leg. Oxygen therapy was commenced. She was placed in a head down position.

When I examined her forty-five minutes later at Townsville General Hospital, a left hemiparesis with left facial paresis was evident, but no sensory abnormalities were detected. Recompression was undertaken, as shown in Table 2.

After this course of treatment the facial paresis had resolved completely. There was however residual spastic changes in the left leg but she was able to walk with the aid of a stick. Minimal recovery of power was seen in the left arm.

TABLE 2

RECOMPRESSION TREATMENT REGIME FOR CASE 2

9-04-90	Extended table 62
10-04-90	18 m soak 60 minutes, 30 minute ascent
	18 m soak 60 minutes, 30 minute ascent
11-04-90	18 m soak 60 minutes, 30 minute ascent
	18 m soak 60 minutes, 30 minute ascent
12-04-90	18 m soak 60 minutes, 30 minute ascent
	18 m soak 60 minutes, 30 minute ascent
13-04-90	18 m soak 60 minutes, 30 minute ascent
14-04-90	18 m soak 60 minutes, 30 minute ascent
15-04-90	18 m soak 60 minutes, 30 minute ascent
16-04-90	18 m soak 60 minutes, 30 minute ascent

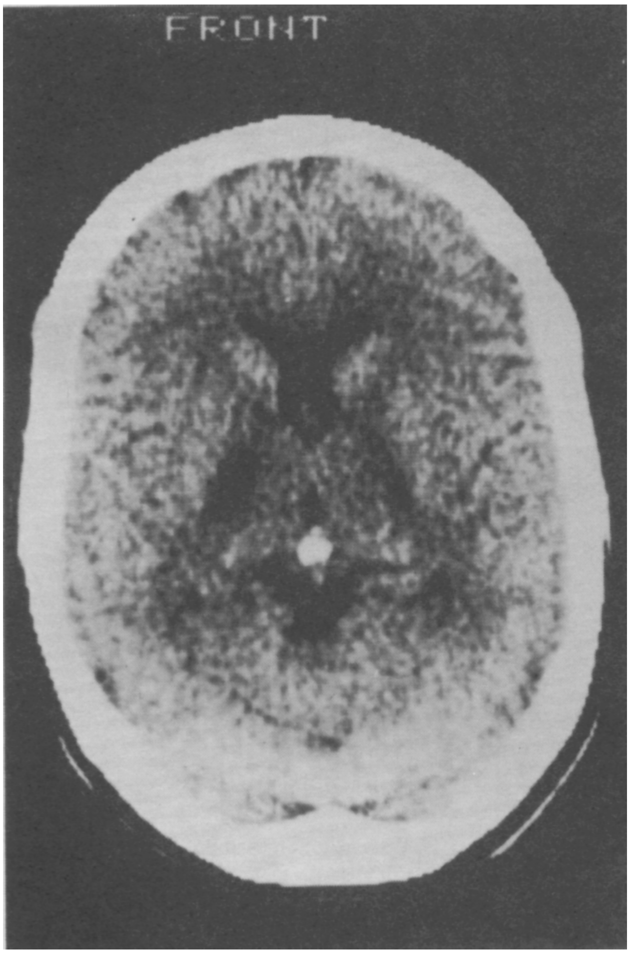

Figure 1. CT head scan of Case 2 showing an area of low attenuation adjacent to the right internal capsule.

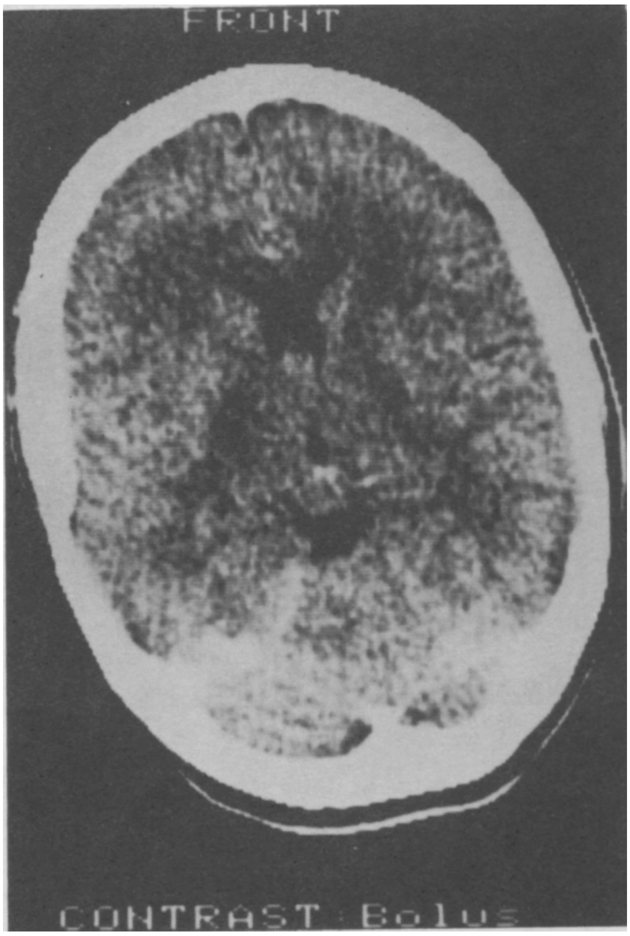

Figure 2. CT head scan, with contrast medium, of Case 2. The area of low attenuation in figure 1 is not enhanced, suggesting a small right limbic infarct consistent with the clinical findings.

Intensive physiotherapy and occupational therapy continues. A CT scan of her head performed eleven days after the incident revealed a moderate sized area of low attenuation adjacent to the right internal capsule (Figure 1). This was not enhanced with any contrast media and no mass effect was demonstrated (Figure 2). These appearances are consistent with a small limbic infarct which can explain her clinical presentation.

Discussion

Underwater panic and exhaustion of air supply followed by an uncontrolled ascent are typical scenarios used by recreational diving instructors to illustrate the origins of CAGE in divers. It is not well appreciated that an apparently uncomplicated swimming pool dive or a boat entry into deep water, while using compressed air breathing apparatus may result in embolism.

During ascent lung volumes will expand according to Boyle's Law and can lead to pulmonary barotrauma. A rise in alveolar pressure of 80-100 mm Hg is sufficient to force air into pulmonary capillaries.[4] This corresponds to an ascent from a depth of one metre to the surface with the lungs fully inflated and gas trapping present.

The sequence of events in Case 1 suggest that the diver was carried a metre or more below the surface (probably because she was overweighted) following her giant stride entry, took an involuntary breath in response to the stimulus of sudden immersion and was then swept rapidly to the surface by her partially inflated buoyancy compensator before she could exhale. Such a sequence easily explains her CAGE. I have not been able to find any previous report of this complication of giant stride entry.

Case 2 was observed by her instructor to exhale during the ascent. The ascent rate was controlled and a follow up chest X-ray revealed no gross lung pathology. In the absence of such predisposing factors for CAGE, the role of localized air trapping as opposed to a generalized overpressure injury must be considered. She was noted to be in difficulty in mid water, and, knowing the ascent was otherwise uncomplicated, this suggests embolization occurred before she surfaced. Walker[7] reported two fatal cases of mid-water embolization occurring in open water.

The use of a head down position in the first-aid management of CAGE is debatable. Many authors support the use of this posture.[2,8-10] Anecdotal reports have documented sudden deterioration in the condition of victims with a change in posture from head down to head up.[10] This clinical observation is supported by animal studies in which gas bubbles were observed to travel "backwards" up the aorta in head up animals against the direction of blood flow.[10] This would indicate bubbles distribute according to their buoyancy at least in the great vessels. However, increasing opposition to the head down posture is emerging. Results from animal studies by Dutka et al.[11,12] have led them to conclude a prolonged head down position following CAGE results in increased intracranial pressure and blood brain barrier damage despite hyperbaric therapy.

The two cases presented here do not illustrate any advantage of a head down posture over a horizontal posture. Case 1 certainly shows that CAGE victims should not be sat up, while Case 2 did not demonstrate any resolution nor deterioration of symptoms or signs with a head down position. The poor response of this diver to recompression highlights the inadequacy of conventional treatment to ameliorate the known secondary effects of gas bubbles on vascular endothelium and blood constituents.[13]

Both divers have been left with significant neurological abnormalities which limit their employment and interfere with their day to day activities. Their medical histories had no identifiable risk factors which would have identified them as being at increased risk for CAGE.

Conclusion

These two cases demonstrate that CAGE can occur in shallow water. Prevention requires that instructors emphasise to their students the importance of exhaling immediately inhalation has been completed. Correct weighting of students so that they are neutrally buoyant on the surface, will prevent deep descent with giant stride entry.

Acknowledgements

I wish to thank Dr G. Gordon, Dr V. Callanan and Dr D. Gorman for their editorial assistance and M. Shapter for the medical photography.

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This paper was written when Dr R M Walker MB.BS., Dip DHM., was holding the position of Locum Director of Hyperbaric Medicine at the Townsville General Hospital, Townsville, Queensland, Australia.

CLINICAL MANIFESTATIONS OF THE DECOMPRESSION ILLNESSES

N.K.I. McIver

Introduction

"Many cases are on record to show the danger of lost time".

This sombre warning first issued in 1982[1] still holds good today. Despite training of both amateur and commercial divers in the recognition of decompression illness, delays at all stages are all too frequent. The implications in the light of the work of Palmer, Calder and Hughes are obvious in attempting to avoid permanent residual spinal or cerebral damage.[2]

Dysbarism embraces all the illnesses caused by changes of pressure and volume: barotrauma and decompression sickness.

Barotrauma

Changes in volume in air or gas containing spaces cause the largest proportion of morbidity and mortality, by tearing lung tissue and leading to cerebral arterial gas embolism (CAGE). This is seen in its purest form in submarine escape training where there has been no prior inert gas load taken up by the tissues. In the diving context, the distinction between arterial embolism and decompression sickness may be less clear cut when there is an inert gas tissue load as well. Collapse and unconsciousness, with or without convulsions may occur (the commonest presentation in the Royal Naval submarine escape tank training series), due to gas in the cerebral or coronary arteries. This usually occurs on ascent or immediately on surfacing and the patient may die before being recompressed.[3]

A second form may have variable symptoms, cortical in origin and may respond to recompression initially but relapse later and a third form may make a full recovery on recompression.

Where there is a fast or uncontrolled ascent followed by a rapid onset of serious symptoms, arterial gas embolism should be suspected. This, in most cases, will have occurred within 5 or at the outside 10 minutes after reaching the surface.

The following diagnostic criteria are suggested.[4]

1 Collapse or unconsciousness occurring without warning immediately or within the first few minutes after decompression.
2 Inco-ordination.
3 Confusion.
4 Weakness or paralysis of limbs.
5 Visual disturbance.
6 Unilateral paraesthesiae.

An unresponsive stupor, possibly with eyes open, has been described.

Decompression Sickness

AETIOLOGY

Gas as bubbles in the circulation or separated "autochthonous" gas in tissue can occur when local supersaturation is reached during decompression.[5-7] Extra- vascular bubbles can cause damage by occlusion of the circulation with tissue hypoxia, disruption of cells, compression of adjacent tissues as in the spinal cord, tearing of tissue or tissue planes. Intravascular bubbles can trigger a cascade of secondary events. These include activation of complement, haemorrhage or clotting, and respiratory changes causing reduction of venous drainage of the spinal cord.[8] The differing aetiology can explain both the quite bewildering variety and severity of presenting symptoms and signs described in decompression sickness (DCS).

CLASSIFICATION

DCS is classified as Type I (mild or pain only) or Type II (serious or neurological).[5] There are differing approaches to treatment of dysbaric illness based on successful regimes around the world. Most have different therapy for DCS and arterial gas embolism (AGE), and also for Types I and II DCS.[9] Inappropriate therapy is just as significant as delay in the failure of therapy or the occurrence of relapse in the treatment of DCS.

PRESENTATION

Type I DCS is obvious to the patient and to observers but it must be emphasised that this refers to pain in, or very close to, a major limb joint. All other pain must be considered a Type II event and treated as such. Examples include the unpleasant raw burning discomfort in a limb, deep back pain or abdominal pain which may be spinal in origin.

Type II DCS may also present insidiously with alteration of sensation of the lower limb (common in commercial DCS cases). This may be incorrectly ascribed to local or positional discomfort and is not infrequently unrecognised initially with potentially serious consequence later.

Type II decompression sickness was regarded as predominantly a spinal cord disease with infrequent cerebral involvement[10] but confirmation of concomitant cerebral perfusion deficits in divers with apparent spinal cord DCS raises once again the point made by Professor Lambertsen that decompression sickness is a diffuse, multifocal disease.

The clinical presentation may vary from apparently localised spinal cord trans-section (Brown-Sequard syndrome) to bizarre diffuse neurological or psychiatric syndromes and it may be extremely difficult to localise the site of the lesion.

It was traditionally taught that Type II DCS would have a latent interval from several minutes to 1 or 2 hours (or more) before onset of symptoms. This has been seriously challenged in a thought provoking paper[11] where the latent interval to presentation in 1,070 human cases of DCS was reviewed. By attempting to include only cases of DCS rather than arterial gas embolism cases, three broad categories were defined. Cerebral, spinal and cerebral and spinal.

The cerebral cases included only those with grand mal seizure, reduced level of consciousness or with a cortical picture of motor or sensory deficit. The rather vague cases of headache, fatigue, malaise or vague psychiatric symptoms were excluded, nevertheless these may be manifestations of Type II DCS and should be treated as such.

The spinal cases included only those with bilateral signs and symptoms or the cord hemisection syndrome and those cases affecting bowel, bladder or sexual function. The authors showed that Type II DCS presents within a shorter time interval (latency) when classified in this manner and removing the Type I cases which have longer latency. 56% of all cases arose within 10 minutes of surfacing, with 50% of cerebral cases arising within 3 minutes and 50% of spinal cases arising within 9 minutes.

However, the CNS cases may involve inner ear, brainstem, cranial or peripheral nerves also. The location of the site of the lesion may be in doubt leading to less precise diagnosis and inaccuracy of this classification.

Neurological DCS may present in a most rapid and malicious form with swift progression to motor loss and paraplegia. This is more common in our experience in scuba divers and may be due to a greater decompression insult or a different aetiology.

Cases have been described after dives of short duration, where there was no need for decompression stops, and yet serious spinal DCS has arisen. DCS would not have been expected. Causes of bubbles getting through the lung filter include a patent foramen ovale or other pulmonary vascular shunts.[12]

A recent paper describes cases of transient serious symptoms following a no-stop dive, suggestive of cerebral arterial gas embolism (CAGE) which resolve spontaneously. There then follows the development of spinal cord symptoms.[13] This has been called Type III DCS and may be a recognisable entity casting more light on aetiology.

Classification of Symptoms

CEREBRAL AND CRANIAL NERVE

It was believed, for unexplained reasons, that aviators were more prone to cerebral symptoms than divers. However, if one asks patients carefully there are frequent transient symptoms suggestive of cerebral gas formation. Common symptoms are alteration of balance, vision, hearing or speech. More diffuse alteration of affect, thought or memory may be obvious to trained observers (diving supervisors) whereas the patient may be the last to recognise this. Specific cranial nerves such as the facial or trigeminal may be affected.[14]

SPINAL

Any motor or sensory tract of the spinal cord may be affected by DCS. Post-mortem lesions may be haemorrhagic or thrombotic and are visible later as areas of demyelination and gliosis with sub-pial sparing.[2,15] The symptoms reflect the area of pathology but may be extremely patchy and difficult, even for a neurologist, to assess and explain.

Conclusion

Any doctor or casualty officer may be consulted by a diver who has presenting symptoms. All symptoms should be considered decompression-related until proved otherwise in order to prevent the consequences of delay.[16] The main concern is that what is apparent clinically may be the tip of the "neurological iceberg" pathologically. No symptoms should be ignored. Of 470 cases, treated by the North Sea Medical Centre over the last 24 years, 115 patients turned out not to have had dysbaric illness. Decompression sickness can masquerade in many different guises.

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DECOMPRESSION ILLNESSES

18 months experience at the Alfred Hospital Hyperbaric Service

Max Weinmann, David Tuxen, Carlos Scheinkestel and Ian Millar

Abstract

One hundred divers presented to the Alfred Hospital Hyperbaric Unit with decompression sickness (DCS, 95 divers) or cerebral arterial gas embolism (CAGE, 5 divers) were reviewed with particular attention to potential predisposing causes, response to treatment and determinants of outcome.

Twenty-six divers presented with DSC following dive profiles outside current table recommendations. The remaining 78 divers developed DCS despite diving within tables. Other commonly identified potential risk factors were multiple dives and/or multiple ascents (55 divers), rapid ascent (17 divers), previous DCS (12 divers), alcohol (6 divers) and altitude (5 divers). No risk factor could be identified in 17 divers. Presenting symptoms were often mild, however significant neurological deficits were identified in 80 divers. All diver were commenced on 18 metre tables and had an average of 3.5 ± 2.2 treatments. Thirty divers had incomplete clinical resolution despite 3.9 ± 2.5 treatments and one with severe CAGE died. Late presentation (> 120 hours) and past DCS were common in patients with incomplete resolution ($P < 0.05$).

It was concluded that seemingly mild DCS is associated with significant incidence of neurological deficit and incomplete resolution. More conservative dive times, avoidance of the identified risk factors and early recourse to treatment are recommended.

Introduction

Since the establishment of the Hyperbaric facility at the Alfred Hospital, Melbourne, the service has witnessed a steadily increasing number of divers presenting with DCS: 1987-88 45 divers, 1988-89 79 divers, 1989-90 80 divers. The number of divers presenting with DCS in Victoria is at least twice that of any other state.[1] This may partly be attributed to the growing number of participants in the sport (approximately 4,000-10,000 per year), growing diver awareness of this condition, as a result of the educational efforts of sport diving organizations, and publicity about the development of the new hyperbaric facility. This paper reviews in detail the clinical patterns of, and possible predisposing factors to DCS, its response to hyperbaric oxygen (HBO) treatment and clinical outcomes in the first 100 divers treated.

Methods

The first 100 divers presenting with DCS or CAGE were studied with particular attention to possible predisposing factors, clinical symptoms, findings on examination and duration of treatment.

On presentation a detailed history of symptoms, dive profiles and predetermined risk factors was taken. The risk factors considered were multiple ascent/multiple dives, rapid ascent, diving outside current sport dive table recommendations, alcohol, altitude exposure following diving, and a history of DCS.

Clinical examination included general examination for potential aetiological factors. Careful neurological examination and simple tests of neurocognitive function were also done. Neurological examination included detailed assessment of sensation, power, reflexes, and balance using a sharpened Romberg test (the diver was asked to stand in a heel toe position with arms crossed and eyes closed; the number of falls in one minute were recorded). Neurocognitive function was assessed by a careful history of memory, concentration and task performance. Serial seven's (repeated subtraction of 7 from 100 until the lowest positive number is reached; the number and nature of errors and the speed of performance was noted) and short term memory of 5 subjects (number remembered correctly was noted) were performed routinely. Chest X-ray, lung function tests, full blood examination and blood biochemistry were performed before all first treatments.

All patients commenced treatment with a Royal Navy Recompression Table 62 (RN Table 62). If DCS or CAGE was severe and/or unresponsive after 40 minutes at 18 m then Table 62 was extended at 18 m or 9 m or both. Ensuing treatment profiles were based on 18 m Royal Navy Table 61 (RN Table 61) or a modified Table 61 (termed Table 60.5A). Table 60.5A consisted of descent to 18 m on air over 5 minutes, then two 25 minute periods on 100% O_2 at 18 m were each followed by a 5 minute air break. Ascent to 9 m was on 100% O_2 and took 15 minutes, and was followed by a 5 minute air break at 9 m. Finally the ascent to surface was also on 100% O_2 and lasted 15 minutes (total time 1 hour 40 minutes, attendant on air for the first 1 hour 20 minutes then on 100% O_2 during 5 minutes air break at 9 m and during the final ascent).

Chi-squared analysis or Fisher's exact test was performed on all data; p values of < 0.05 were considered statistically significant.

Patient data

TABLE 1

DEMOGRAPHIC DATA
Mean Values Shown + SD

	DCS	CAGE
Number of patients	95	5
Age (years)	30.9	25.2
SD	± 7.3	±7.8
Male : Female	73 : 22	3 : 2
Recreational divers	81	4
Professional divers	14	1
dive instructors	4	1
oil rig divers	0	1
other	10	0
Maximum depth (metres)	21.5	24.6
SD	±8.3	±6.2

There were no statisticially significant differences between those with DCS and CAGE

Demographic data is outlined in Table 1. Five divers were diagnosed as suffering from CAGE. With the exception of one diver, who sustained a massive fatal CAGE, the divers with CAGE, did not differ significantly from divers with DCS with respect to aetiology, clinical manifestations or outcome. These four divers with mild CAGE have therefore been grouped with divers suffering from DCS for subsequent analysis. The most common presenting complaint in divers with DCS was peri-articular pain which persisted despite the administration of analgesics in some divers (Table 2). It was often this lack of response to analgesics or the passage of time which prompted presentation rather than the onset of pain. Other common complaints were of profound lethargy (68 divers) which was accompanied by disturbed cognition in 34 divers and was manifest as poor concentration and difficulty with performing relatively simple mental tasks (such as comprehension of written material). Mild headache was also common (60 divers), whereas paraesthesiae or muscle weakness were less common (42 and 20 divers respectively).

Clinical findings

A wide range of neurological deficits was found (Table 2). While 28 divers presented with neurological disturbances as their sole symptom, 80 divers had clinical evidence of nervous system injury, making this more common than the most common presenting symptom. Musculoskeletal involvement was less common, with persistent joint tenderness evident in 7 of the 72 divers in the absence of effusion or obvious joint deformity. In spite of symptoms consistent with DCS, 15 divers had no detectable abnormality on examination.

Table 3 lists the potential predisposing factors which were considered. The most frequent factors identified in the development of DCS in this group were multiple ascents (arbitrarily defined in this review as 2 or more dives per day or 2 or more ascents in a single dive), and diving outside current sport dive table recommendations (PADI Tables).[2] Rapid ascent (17% of divers) were attributed to lack of diver experience, out of air emergency ascents or equipment malfunction. Alcohol was drunk between 6 to 12 hours prior to diving in 6 divers.

Five divers developed symptoms of DCS at altitude following diving. Interestingly, only one of these involved hypobaric conditions of flight 24 hours after diving. One diver developed recurring symptoms upon returning home to the foot-hills around Melbourne (400-600 m) each night after treatment, 2 divers developed recurrence of DCS while crossing the mountain ranges returning to Melbourne by train after primary treatment in Adelaide (630 m) and 1 diver developed joint pain during ascent in an elevator to the 30th floor of a building. Twelve divers had a previous history of DCS.

TABLE 2

SYMPTOMS AND CLINICAL FINDINGS ON PRESENTATION

Symptoms	
Pain	72
Lethargy	68
Headache	60
Altered sensation	42
Impaired mentation	34
Weakness	20
Clinical findings	
Neurocognitive	80
sensory deficit	36
disturbed sensorium	27
weakness	21
reflex abnormality	18
impaired co-ordination	11
Periarticular tenderness	7
Other	
skin rash	1
None	15

Following diagnosis patients received an average of 3.5 ± 2.2 treatments. Sixty-three divers experienced complete symptomatic and clinical resolution (following 3.2 ± 1.7 treatments) while 37 divers had residual clinical or

TABLE 3

POSSIBLE RISK FACTORS FOR DCS IN 100 DIVERS

Outside dive tables		26
Other indentifiable risk factors		93
multiple ascents/dives	55	
rapid ascent	17	
previous DCS	12	
alcohol	6	
to altitude after diving	5	
No obvious cause		17

The figures are equivalent to percentages symptomatic abnormalities of these 3 did not respond to treatment (3.9 ± 2.5 treatments). Incomplete response was characterized by residual neurological symptoms ranging from minimal paraesthesiae (14/37, 38%) through to minor cognitive impairment (17/37, 46%).

Of the 3 non-responders, one diver presented with massive CAGE, unconscious and with generalized seizures. Despite a 3 day saturation dive at 18 m his neurological and overall state continued to deteriorate. CT brain scan demonstrated widespread cerebral infarction. The diver died within 48 hours of completion of treatment. The remaining two divers had a previous history of DCS and one presented very late (38 days after the causative dive).

Time to presentation was considered as a possible marker of response to treatment (Table 4). Divers who presented more than 5 days after the responsible dive, were arbitrarily labelled as late presenters. This group of 21 divers had a slightly higher incidence of incomplete resolution but this was not statistically significant.

The incidence of most risk factors for the development of DCS were not significantly different in divers with and without residual problems (Table 5). There was a trend for diving outside the tables to be more common in the incomplete responder group ($p = 0.08$) but the only risk factor which significantly predisposed to incomplete clinical resolution was previous DCS (22% vs 6%, $p < 0.03$).

The majority of divers presenting with DCS were recreational (Table 6). Professional divers exceeded table recommendations more frequently than sports divers (33% vs 22%, not statistically significant). The former group demonstrated a greater incidence of previous DCS.

Neurological involvement, which was present in most patients, was not a predictor of response to treatment; 80% of responders presented with clinical evidence of neurological injury (50 divers), compared with 81% (30 divers) in the residual clinical deficit group.

Discussion

This report has shown that a large and increasing number of divers presented with DCS and CAGE in the state of Victoria, that DCS arose in 74% of divers despite diving within diving table recommendations, that symptomatically mild DCS was associated with an 80% incidence of neurocognitive abnormalities and that incomplete resolution occurred despite prolonged treatment in 37%.

Although the rapid escalation in the popularity of diving has produced a much large population at risk of DCS, most divers are presenting with symptomatically milder forms of the illness when compared with traditional descriptions. This undoubtedly reflects increasing diver education and more conservative diving practices, especially amongst recreational divers. These factors have resulted in less severe forms of the illness and an increased understanding of neurological deficit and incomplete resolution remains concerning. This highlights the importance of identifying and avoiding risk factors both for the development of DCS and for its incomplete resolution.

The lack of a single indentifiable factor responsible for the development of DCS is compounded by variability between divers. It is now recognised that repetition of “safe diver profiles” may still produce DCS.[3,4] In light of such variability, some authors question the reliability of diving tables where strict adherence to protocol cannot be considered to provide complete immunity against DCS.[4,5] There was no obvious predisposition to the development of DCS in 17% of divers, while 74% of dive profiles were within current sport dive table recommendations.[5] This is of particular relevance with the proliferation of dive computers and the practice of multi-level diving which is providing the sports diver with a new flexibility in “safe dive planning”. However, the infallibility of dive computers remains a commercial goal rather than a scientific reality as attested to by reports of malfunction and cases of DCS.[6-9] Similarly the application of unproven physiological models and the inability to assess diver tissue nitrogen leads some authors to challenge the application of such instruments in sport diving.[10-12]

Dive profiles, while important, are not the only determinants of nitrogen kinetics during hyperbaric exposure which remains a complex interaction between diver and environmental related factors. It is the nature of this interaction and the identification of DCS determinants that remains controversial.[13,14]

That 55% of our patients reported performing multiple dives and ascents demonstrated the importance of the increased tissue saturation after multiple hyperbaric exposures. Decompression requirements are altered in the presence of residual tissue nitrogen saturation from previous descents.[15]

The use of alcohol prior to diving was recorded in 6% of representing divers. While its potential to impair diver judgment is well known, its effects at a cellular level and influence upon biochemical events at the gas/tissue interface are yet to be determined. Alcohol may impact on nitrogen kinetics via vasodilatation and potential stabilization of venous gas emboli which may alter the excretion of the gas load and predispose to the development of DCS.[14,16,17]

Upon completion of the dive, the stored tissue nitrogen is gradually eliminated, however early exposure to altitude creates a pressure gradient for the rapid dissolution of tissue nitrogen and the evolution of gas bubbles from nitrogen nuclei[18] as attested to by 5 divers in this series. Once a critical volume of gas is exceeded symptoms occur in

TABLE 4

OUTCOME OF DIVERS WITH EARLY AND LATE PRESENTATION

	All Divers	Early Presenters (< 120 hours)	Late Presenters (> 120 hours)
Number of divers	100	79	21
Presentation interval in hours and SD	100 ± 195	37 ± 29.5	340 ± 329
Resolution	63	52 (66%)	11 (52%)
Incomplete resolution	34	25 (32%)	9 (43%)
No response	3	2 (3%)	1 (5%)

There were no statistically significant differences between the early and late presenting groups

TABLE 5

RESPONSE TO TREATMENT IN RELATION TO POSSIBLE RISK FACTORS

Aetiology	Incomplete or no response n (%)	Resolution n (%)	P*
Total number of divers	37	63	
Outside dive tables	13 (35)	13 (21)	0.08
Other identifiable risk factors			
multiple ascent/dives	22 (59)	33 (52)	
rapid ascent	5 (14)	12 (19)	
previous DCS	8 (22)	4 (6)	0.03
alcohol	2 (5)	4 (6)	
altitude	0 (0)	5 (8)	
No obvious cause	5 (14)	12 (19)	

* Only p < 0.1 shown

TABLE 6

COMPARISON OF DCS RISK FACTORS PROFESSIONAL VS RECREATIONAL DIVERS

	Professional n (%)	Recreational n (%)	P*
Total	15	85	
Outside tables	5 (33)	19 (22)	
Outside identifiable risk factors			
multiple ascents or dives	8 8 (53)	47 (55)	
rapid ascents	2 (13)	15 (18)	
previous DCS	6 (40)	6 (7)	0.002
alcohol	0 (0)	6 (7)	
altitude	1 (7)	4 (5)	
No obvious cause	3 (20)	14 (16)	

* Only p < 0.1 shown

relation to the tissue involved.[15]

A complicating factor, which may contribute to the increased number of divers presenting in Victoria, is the potential role of hypothermia. Although hypothermia was not originally addressed, Victorian waters are colder than the northern states and therefore promote a different nitrogen elimination profile. Early experiments conducted on temperature acclimatized eels (at 11°C) led Belaud and Barthelemy [16] to conclude that the DCS threshold was actually raised by hypothermia. This was in part supported by Dunford and Hayward[19] where divers who commenced the dive cold, demonstrated fewer venous gas emboli than those who remained warm throughout the dive, or who had later became hypothermic. These findings allude to the temperature dependence of nitrogen uptake and elimination which is modified by the circulatory responses of hypo- and hyperthermia. During the dive, at normothermia, the tissues gradually become saturated with nitrogen. This process may be accelerated by exercise which increases muscle and subcutaneous blood flow and the rate of tissue saturation.[15] As the dive progresses peripheral cooling and vasoconstriction occur, the reduced circulation leads to reduced gas flux and "trapping" of nitrogen which potentiate the risk of DCS.[15,16] Although worse with hypothermia, this process occurs with subcutaneous cooling in the absence of central hypothermia. Further, should the diver engage in vigorous exercise at this point (such as occurs on dive courses, salvage and recovery, and rescue) the alteration in physical forces upon intra and extra cellular fluid tension with movement, generates negative hydrostatic pressures sufficient to produce cavitation and bubbles.[20,21]

Nitrogen kinetics may similarly be affected by obesity, in view of the high lipid solubility of the gas, and compounded by the frequent association with lack of cardiorespiratory fitness.[16,22] This is supported by Dembert et al.[14] who demonstrated a 5 to 6 times greater risk for the development of DCS in Naval divers in the highest quartile of full body weight. The gas forming capacity of lipid is due both to tissue mass and nitrogen solubility[20], and bubble formation is a function of tissue saturation and cavitation tendency.[21]

There was a very high incidence of neuropathology (80%) in our series of divers. The reported incidence of clinically identifiable neurological involvement with DCS has ranged from 24-89% even in the absence of symptoms.[23-27] The lack of symptoms in the presence of neurological involvement was probably due to the accompanying neuropsychological impairment due to DCS[25, 27] which impairs insight. This insight often returned during treatment.

While the mechanism of neurological DCS remains unproven, one of the many controversial theories has been provided by Hallenbeck et al.[28] who performed venographic studies of the epidural venous system following hyperbaric exposure in dogs. Doppler studies showed venous bubbles in the lungs which were accompanied by a rise in central venous pressure which was transmitted to the epidural veins producing stasis and ultimately obstruction. Neuronal damage ensued as venous sludging lead to hypoxia and infarction and was compounded by the activation of inflammatory chemical mediators at the blood/bubble interface.

In later study,[29] extravascular interruption of spinal perfusion was demonstrated as a potentially significant contributor to hypoxic neuronal injury. Decompression allows gas expansion so that tissue pressure can exceed perfusion pressure. This "mass effect" is of particular relevance to the spinal and cortical vascular watershed areas.[30,31]

Significant neurological injury is consistent with a large nitrogen load as suggested by Melamed and Ohry[23] where 75% of DCS with neurological involvement followed diving to depths greater than 30 m. The mean depth in our population was 22 m and was associated with clinical neurological involvement in 80%. Kunkle and Beckman,[31] suggest that bubbles, with their associated potential neurological sequelae, may develop de novo in the arterial circulation, following supersaturation of blood during rapid ascent. Such "atraumatic emboli" may develop at an ascent rate as low as one foot/second (60 feet a minute is the recommended rate of ascent for the USN decompression tables). The lower temperatures of Victorian water, with a reduced body temperature, may reduce the threshold for bubble formation.

The neurological injury of DCS may also be contributed to be subclinical pulmonary barotrauma where the bubble load may be increased by the passage of air emboli from broncho-alveolar venous fistulae to the central nervous system.[23,24]

Previous neurological assessment of patients with DCS has demonstrated a high incidence of cognitive dysfunction, and that isolated spinal involvement is in fact uncommon.[23,25,26,32,33] This is consistent with Rozsahegyis' earlier contention that DCS is a diffuse neuronal insult secondary to unique neuronal vulnerability of the nervous system related to:

1 Spinal cord movement which potentially leads to inter-and intra-cellular cavitation with resultant bubble formation.

2 The high metabolic rate of neurones which are therefore sensitive to the metabolic disruption and inflammatory responses initiated by bubble formation.

3 The lipid rich myelin sheath surrounding neurones which provides a potential nitrogen reservoir allowing diffusion of gas into the axon.[20]

The subsequent neuronal damage may therefore culminate in a multifocal encephalomyelopathy.[34]

Once symptoms evolve, the interval between their development and the institution of recompression, has been identified by some investigators as the major factor in determining clinical outcome.[23,25] This study showed a trend toward less favourable outcome in those divers who presented late but this did not reach statistical significance. 75% of divers with a previous history of DCS demonstrated clinical residuals despite treatment, presumably due to preexisting residual tissue injury.[22]

The diverse, non-specific, and often mild nature of the symptoms of DCS,[13,36] were often underestimated and attributed to other causes. For example, it was not infrequent for divers to attribute fleeting myalgias to lack of fitness, or headache to minor sinus barotrauma. This was often compounded by the unfortunate myth that only "incompetent divers" get bent and the possibility of DCS was then dismissed. This culminated in late presentation following failure of the symptoms to remit or to respond to analgesia. We believe that any symptoms following diving must be considered as potential manifestations of DCS and should be reviewed as soon as possible by a doctor experienced in diving and hyperbaric medicine. The neurological cost of delay is potentially high, with residual neurocognitive deficits evident in 20-80% of reported series,[24,26,27,32] and in 48% of "late presenters" in this study.

Although the efficacy of delayed hyperbaric treatment has not been well established this should not prevent the initiation of treatment even if patients present more than 10 days beyond the onset of symptoms.[36,37]

Conclusions

The results of a retrospective review of 100 divers with DCS and CAGE have demonstrated that:

1 Diving outside the tables, a well recognized risk factor, was not the most common precipitant. Diving within current sport diving table recommendations was not protective for the development of DCS. Common risk factors identified were multiple dives, multiple ascents, rapid ascent, previous DCS, alcohol and altitude. Cool climate diving with or without clinical hypothermia may also contribute to the high incidence of DCS in Victoria.

2 Although presentation was most commonly a result of muscle and joint pains and lethargy, neurological manifestation the most common manifestations of DCS were, often in the absence of symptoms.

3 Late presentation and past history of DCS was associated with a higher incidence of residual deficit.

Although individual risks for DCS may be low, the large and growing sport diver community is resulting in an increasing number of divers presenting with DCS with risk of permanent deficit and impaired higher mental function and future work capacity.

Recommendations

We believe the following recommendations should be adopted by the recreational diving community we serve.

CONSERVATIVE DIVING PRACTICES

1 Diving well within the dive tables rather than to their limits.

2 A maximum of 2 dives per day with a long surface interval between them.

3 Only one ascent per dive.

4 Shorter dive times in cold water.

5 Meticulous avoidance of other identified potential risk factors, especially hypothermia, early exposure to altitude, rapid ascent and diving following the use of alcohol

EARLY PRESENTATION

For **any** symptoms (even if seemingly mild) following diving,.early presentation to a recompression facility or a hyperbaric physician.

We believe that adopting the above practices could potentially reduce the risk of DCS to on third of its current levels.

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Key Words:

decompression sickness, arterial gas embolism, diving.

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SOME MEDICO - LEGAL THOUGHTS ON CORONERS' INQUESTS

Michael Gatehouse and Tom Wodak

Introduction

The discussion by John Lippmann[1] in the last issue has stimulated us to ask some questions worthy of consideration by those interested in underwater medicine, as well as by those with a commercial involvement in sport diving.

Deep diving deaths

Two of the deaths investigated by the Coroner occurred diving onto a wreck at approximately 33 m depth located near to the entrance of Port Phillip. Both were experienced divers and adequately qualified to undertake their respective dives. There are some apparent common aspects to the two cases.

In each case the diver who died appeared to be having problems obtaining sufficient air from his demand valve. In each case attempts to share air with the buddy, buddy breathing in one case and the use of an octopus regulator in the other, were unsuccessful. In both instances stress was induced in the divers who died and in their buddies (each of whom survived the ordeal). Both the divers who died started to have difficulties because of insufficiency of air supply. In each case recovery of the tank revealed that there was ample remaining air for safe ascent. The problem for both divers was the failure of their regulators to deliver sufficient air.

In one case subsequent testing determined that the "J" valve was malfunctioning and provided resistance to airflow when in the "on" position. In the other the tank valves of both the deceased diver and his buddy were only partially open reducing the flow of available air.

We acknowledge that issues relating to training, in and utilization of, buddy breathing and octopus breathing arise in these deaths. As do other issues including equipment care and maintenance. We accept that there is a need for close examination of these aspects by instructors. We wonder whether there is anything which can be learned from these two incidents about stress and its effect on divers especially whilst participating in deeper dives.

It seems that when trouble began each diver was at a depth equivalent to at least 4 atmospheres. It is likely that nitrogen narcosis played no small part in the way in which each diver coped (or failed to cope) with the problems with which he was confronted.

Is enough known about the effects of stress on divers who may be suffering from nitrogen narcosis and their ability to carry out what should be fundamental and vital skills when so affected?

Is this a matter which can, or should, be the subject of medical evaluation and assessment when a diver presents for an initial "diving medical" or again for periodic review?

Whilst a trainee or novice diver may be expected to react adversely to an unexpected change in circumstances, in each of these two cases the deceased diver had the capacity to adapt to his altered situation. Yet in both cases sadly that did not happen, and each of the buddies was also placed at risk.

Stress caused death?

An other diving death investigated by the Coroner was that of a 51 year old male who died in a maximum depth of 12 m in Port Phillip. He had undergone an entry level training course in warm northern waters. This was his first dive in temperate southern waters as well as being his first experience of diving in a full 7 mm wet suit. He was using this newly acquired diving equipment for the first time.

This diver had a history which, in retrospect, may have been significant. In the past he had served in the RANR where he had applied, unsuccessfully, to undergo diving training. In 1979 he had developed a malignant tumour which had been treated by surgical excision and extensive radiotherapy after which he developed tremors. A neurologist had prescribed, and the diver took, propranolol (Inderal) for his tremors.

About four months before his fatal dive and whilst undertaking his entry level training, the deceased had six open water dives in tropical conditions. He was observed to be physically tired, even exhausted, and very cold with shaking hands after each of these dives. Before participating in the entry level course a medical examination had been conducted and he had been found fit to dive.

There was no evidence before the Coroner concerning the qualifications of the examining doctor nor of the nature and extent of the examination. There is nothing to indicate whether the doctor had undergone any training in or had any knowledge of hyperbaric or diving medicine.

This case raises what should be the requirement for medical examination of prospective divers. That such assessments should be undertaken by members of the medical profession skilled in diving and hyperbaric medicine ought not to be in dispute and ought to be accepted without question by all instructor agencies and charter operators.

The more difficult task is to determine the parameters of such a medical assessment acknowledging the realities of time and cost and the reliance by doctors in obtaining an accurate and thorough history from each prospective diver.

With the benefit of hindsight one may consider that it might have been useful to know why the deceased diver was refused permission to undergo diving training whilst a member of the RANR; whether the fact that he was taking propranolol was known to and considered by the examining doctor; whether the effects of propranolol on divers is understood; whether, in the light of the age of the diver and the post mortem findings of the presence of moderate atheroma and occlusion of between 30% and 60% of the coronary arteries, appropriate investigation of the cardio-vascular system of the diver was undertaken.

In this case, once again the Coroner considered the stress to have been an implicating factor together with anxiety induced by combined effects of this being the first dive in such waters, wearing a full wet suit for the first time and the use of all new equipment.

Again, the relationship between stress and diving accidents has been emphasised as a causative factor.

With stress likely to have been such a prominent precipitating element in each of these three incidents does that mean, that more should be done to asses the capacity of a diver to cope with stress? Or does it mean that more training of divers is required to improve their ability to manage emergencies likely to provoke or involve stress and anxiety.

Hyperventilation death

The fourth death involved an experienced diver who was snorkelling at the time of the fatal incident. The Coroner emphasised three aspects of this incident. The first was the likelihood that the diver had engaged in hyperventilation prior to the snorkel dive from which he failed to surface. The second was the likelihood that he was overweighted whilst the third was that the buddy system was not in use at the time.

The dangers of hyperventilation would seem to be well known. The deceased was an assistant diving instructor and diver of considerable experience and ability. He was also known to be an asthmatic although there is nothing to indicate that his death was in any way related to that condition.

There were no witnesses to the events which immediately preceded the commencement of the fatal dive, so whether or not hyperventilation was a factor must remain a matter of speculation albeit that there is little reason to doubt that this was a causative factor.

Is the incidence of hyperventilation amongst experienced snorkelers sufficiently frequent to warrant further study of the subject of post-hyperventilation blackout or is it simply a matter of all snorkelers better understanding what is meant by hyperventilation?

Is drowning the correct finding?

The Coroner found that three of the deaths were due to drowning and one to an air embolism. This raises the question as to whether the post mortem investigation of diving fatalities determine the appropriate cause (or multiple causes) of death.

In one of the diving deaths the post mortem findings included moderate atheroma and some coronary artery occlusion. In this case the Coroner found that combination of anxiety, increased carbon dioxide retention and probable precipitation of ventricular fibrillation led to unconsciousness and ultimate drowning. The Coroner found too that the use of propranolol may have also been a contributing factor.

The point here is that on its face, the cause of death was said to be “drowning”. There were other ingredients involved but the causative role of each of these other factors may not have been appropriately investigated in order to determine whether there is anything which needs to be understood and applied to the pursuit of safer diving.

Although the cause of death in diving incidents is often attributed to drowning, there are often other contributing elements involved. The role played by these other factors may be such that without their occurrence the ultimate fate of the diver might have been averted.

Conclusion

Is enough understood about the medical relevance of the sequence of events which may lead to death by drowning? In addition we wonder whether the need to establish a cause of death leads to the Coroner to concentrate on the final cause of death rather than what led to the drowning. We hope that this paper will stimulate discussion.

Michael Gatehouse is solicitor and partner in a large Melbourne firm of solicitors.

Tom Wodak is a barrister in Melbourne. Both are FAUI instructors.

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THE RELATIVE IMPORTANCE OF DIFFERENT PARTS OF THE DIVING MEDICAL IN IDENTIFYING FITNESS TO DIVE AND THE DETECTION OF ASTHMA.

John Parker

Introduction

This is a report of one medical practitioner's review of two hundred consecutive sports diving medical failures inorder to attempt to assess the relative importance of the diving medical in identifying fitness to dive and in detecting asthma.

Methods

The diving medical has been fully described in another paper.[1]

Each failure was reviewedin order to identify at what stage of the diving medical the reason for failure was first anticipated. The diving medical was divided into four stages:-

Stage 1
Reading the completed questionnaire before seeing the diver.
Stage 2
Interviewing the diver about the questionnaire.
Stage 3
Physical examination.
Stage 4
Investigations.

The frequency which each question in the questionnaire anticipated, or failed to anticipate a reason for failure was recorded.

All divers who failed their diving medical because of asthma were reviewed to identify at what stage of the medical the asthma was identified.

Results

The 200 diving medical failures were compiled from 2,051 consecutive initial sports diving medical examinations. Two hundred and twenty one reasons for failing the diving medical were recorded. The actual causes for failure and the frequency of each cause of failure has been documented in a previouspaper.[1]

The stages at which failure was first anticipated are shown in Table 1.

TABLE 1

STAGES AT WHICH THE 221 FAILURES WERE FIRST ANTICIPATED

107	(48%)	failed at stage	1
33	1(5%)	failed at stage	2
61	(28%)	failed at stage	3
20	(9%)	failed at stage	4

The questionnaire (Stages 1 and 2)

The questions which accurately predicted a reason for failure were obvious and predictable (Table 2).

TABLE 2

QUESTIONS WHICH ACCURATELY PREDICTED A REASON FOR FAILURE

Asthma	68
Discharging ear or infection of ear	9
Pneumothorax	8
Deafness or tinnitus	8
Present disability	3
Heart disease	2
Chest injury or infection	2
High blood pressure	2
Fits or Epilepsy	1
Operation on ear	1
Diabetes	1
Hernia	1
Pregnancy	1
Total	**107**

The questions which needed discussion before a reason for failure became evident included the more general enquiries (Table 3).

Other questions which led on to useful discussion and enquiry but rarely led on to a failure included:- hayfever (severity?), sinusitis (severity?), wearing of glasses/contact lenses (what they intended to do underwater?), claustrophobia (how serious?), motion sickness (proposed prophylaxis?) and previous diving experience (previous problems? ability to equalize?).

Some conditions relevant to scuba diving were not well screened. These included abnormalities of the sinuses and haematological disorders.

TABLE 3

QUESTIONS NEEDING DISCUSSION BEFORE A REASON FOR FAILURE BECAME EVIDENT

Asthma	11
Present disability	5
Other chest complaints	3
Previous operations	3
Bronchitis or pneumonia	2
Chronic cough	1
Sinusitis	1
Medication	1
Migraine	1
Hepatitis	1
Back injury	1
Paralysis or muscles weakness	1
Previous hospital admission	1
Other illnesses	1
Total	**33**

Other questions seemed of little relevance or asked specifically for problems which although possibly relevant to professional diving or conditions of employment were not of relevance to the sports diver, or could easily be covered by the system enquiry. These were swollen joints, sleepwalking, indigestion, vomiting blood or rectal bleeding, malaria or other tropical diseases, venereal diseases, haemorrhoids, insurance rejection, previous pension, family history of suicide or mental illness.

It was surprising that many obvious questions were **not** answered correctly by the diver (Table 4.). When later the condition was detected and admitted, varying reasons for omission were given. These included "I didn't think it mattered", "I forgot" or "I didn't see it".

Specific questions of interest

MEDICATION

Two hundred and ninety six divers were on medication. Only 2 divers failed solely because of it. A wide range of medication was encountered (Table 5).

SMOKING HABITS

Six hundred and twenty four (30%) of the divers were cigarette smokers. Ninety (4.4%) smoked 20 or more cigarettes per day. No-one failed directly because of their smoking habits. Predictably 10 of the 12 divers who failed due to a lower respiratory tract infection were smokers. Seven of the 10 divers who failed with unexplained poor lung function were also smokers.

TABLE 4

QUESTIONS NOT CORRECTLY ANSWERED

Medication	24
Asthma	11
Present disability	
cold	8
hayfever	1
Ear discharge	3
Chest surgery	1
Pneumothorax	1
Diabetes	1

TABLE 5

MEDICATIONS TAKEN BY DIVERS

Contraceptive pill	145
Sympathomimetic inhalers	55
Antibiotics	27
Antimalarials	26
Antihistamines	11
Non-steroidal anti-inflammatories	8
Beclomethasone nasal spray	8
Beclomethasone inhaler	8
Decongestant nasal drops	4
Pseudoephedrine	4
Cimetidine	2
Frusemine	2
Prednisolone	2
Salazopyrin	2
Thyroxin	2
Acyclovir	1
Aspirin	1
Bleomycin	*1
Danazole	1
Diethylpropion	1
Evening Primrose Oil	1
Iron	1
Loperamide	1
Nystatin	1
Oestrogen	1
Prazosin	1
Sodium valproate	1
Warfarin	*1

*Failed for medication alone

The examination (Stage 3)

Sixty one (28%) of the 221 reasons for failure were first identified at this stage (Table 6).

TABLE 6

REASONS FOR FAILURE FIRST IDENTIFIED BY THE EXAMINATION

Non-patent eustachian tubes	13
Lower respiratory tract infection	11
Upper respiratory tract infection	8
Impacted wax in external ear canal	6
carred tympanic membrane	3
Middle ear effusion	3
Cardiac arrythmias	3
Otitis media	3
Severe dental caries	2
Asthma	1
Active hayfever	1
Anaemia	1
Hypertension	1
Perforated tympanic membrane	1
Pneumothorax (from scar)	1
Previous chest surgery (from scar)	1
Obesity	1
Herpes simplex of face	1
Total	61

The investigations (Stage 4)

Twenty (9%) of the reasons for failure were identified at this stage. Respiratory function tests identified 18, histamine provocation tests and urinalysis identified one each.

RESPIRATORY FUNCTION TESTS

Of the 18 divers who had abnormal lung function tests, 7 were shown to have reversible airways disease (by an increase in FEV_1 of 15% or greater after 5 mg of nebulised salbutamol)[2], whilst 11 divers were failed provisionally pending full assessment by a respiratory physician.

URINALYSIS

Twenty divers showed proteinuria, all of whom had a normal urine upon subsequent testing. Eight divers showed glycosuria of which only one was shown to have a high blood sugar level. (It was eventually discovered that this diver was a known diabetic trying to obtain a diving medical certificate under false pretences).

CHEST X-RAY

In 2051 cases under review 231 (11%) had chest X-rays of which only 3 showed an abnormality, one with a bulla and two with pleural adhesions.

AUDIOGRAM

Forty four (2%) divers had an air conduction audiogram performed. Seven divers were failed due to severe hearing impairment.

PREGNANCY TEST

This was done on six female divers with no positive results.

ELECTROCARDIOGRAM

All divers over the age of 45 years, 20 (1%) divers in all, were given a resting electrocardiogram. Only one abnormality was found, an atrial fibrillation which had already been detected during the examination.

The stages at which asthmatics are detected

Eighty divers were failed because of asthma. Of these 68 were identified by the questionnaire alone (stage 1), 11 were identified during the interview (stage 2), 1 was identified during the examination (stage 3) and 8 were identified by investigations (stage 4). Seven divers failed the routine respiratory function tests and one failed a histamine provocation test.

Thirty divers gave a history of asthma in early childhood but no attacks since the age of 12 years. On further questioning 10 of these were found to have occasional asthmatic symptoms or to admit to occasional use of bronchodilator inhalers. (One diver claimed that he had not any asthma for 16 years but still carried an inhaler). One diver had mild wheezing on examination whilst three more had abnormal respiratory function tests.

Of the remaining 16 divers 5 were given a histamine provocation test (they were only recently made available) of which one failed. Thus of the 30 divers who gave a history of childhood asthma only 15 (50%) were considered fit to dive (Table 7).

TABLE 7

HISTORY OF "CHILDHOOD ASTHMA"

Considered normal	15
Still had symptoms	10
Abnormal spirometry	3
Positive provocation test	1
Bronchospasm on examination	1

Discussion

The sports diving medical should be aimed at assessing safety and fitness to undertake sports diving. The present generally accepted Australian sports diving medical examination has been evolved from the Australian Navy and commercial diving bodies. With new legislation concerning sports diving and diving medicine being introduced into Queensland and possibly all of Australia, now is a suitable time to review both the diving medical standards and the format of the diving medical.

No review of the relative importance of the different stages of the sports diving medical nor its efficacy has ever been undertaken. By reviewing the different stages of the diving medical it may be evaluated and suggestions made for improvement.

The questionnaire

The questionnaire is an important and effective part of the diving medical. To be fully effective it needs to be easily understood and reasonably brief, each question being a specific discriminator of potential problems in scuba diving. A question should be classed in one of the following categories: an enquiry for a specific contraindication or diving relevant problem (e.g. asthma), a general system enquiry (e.g. any stomach or bowel disease?), a general enquiry on past or present health (e.g. have you ever been in hospital? and an enquiry on past diving/hyperbaric experience.

Most of the questions asking for specific symptoms (e.g. indigestion) were poorly answered and rarely led to any useful information. System enquiry could be covered by fewer but more general questions.

Discussion around the medication being taken often led on to past health problems not admitted in the questionnaire because it was considered trivial by the diver. Some divers who denied having asthma freely admitted using bronchodilator inhalers. The use of inhalers would be a useful additional question to be included in the questionnaire.

It is also useful to know for how long they have been smoking and to calculate the "pack-years", where one pack-year is smoking 20 cigarettes per day for one year. Hence 40 cigarettes per day for five years equals 10 pack-years. In this manner the smoking habit can be quantitated.

Past occupations are sometimes of relevance to scuba diving and should be requested in the questionnaire.

The findings in this paper suggest that the present questionnaire can be improved by asking more direct questions for problems shown to be poorly perceived by many divers, omitting questions on specific conditions not very relevant to sports diving, making a system enquiry in more general terms and adding questions to cover conditions not presently adequately screened.

Even though asthma and medications are asked for directly on the questionnaire it is recommended that they be sought after verbally during the interview.

Using the findings from this review a modified questionnaire has been compiled to try and incorporate these suggestions (Table 8).

The examination

The examination was shown to be very important especially in finding problems with the respiratory tract and ears. The number of divers with aural and respiratory tract problems of which they are unaware or choose to ignore is large. More direct questions need to be incorporated into the questionnaire to identify these conditions at an earlier stage of the medical examination.

Screening for colour vision, although very interesting, has no relevance to sports diving and need not be part of the medical.

The investigations

The investigations have also been shown to be an essential part of the medical.

RESPIRATORY FUNCTION TESTING

Simple respiratory function testing has always been accepted as an essential part of the diving medical to try and to identify asymptomatic yet significant lung disease. Any respiratory function test must be simple to perform, easily reproducible and meaningful in its interpretation. It must be able to identify both obstructive and restrictive lung disease.

One of the problems with any spirometric assessment is the large range of normal variation. Colebatch (personal communication) compared the individual variation between the common spirometric indices in the 1950's and found the FEV_1/FVC ratio to have the smallest variation.

If a statistical limit of normality of two standard deviations from the mean is applied, the lower limit of normality for the FEV_1/FVC ratio would approximate 90% of the predicted values. As the divers being examined in the 1950's were mainly male naval divers between the ages of 18 and 35 the value of 75% became the accepted value of the lower limit of normal. These age groups are starred and in bold type in Table 9.

TABLE 8

PROPOSED QUESTIONNAIRE FOR SPORT DIVING MEDICALS

Name	Sex	DOB	Age
Address		Nationality	
Occupation	Previous Occupations		
Dive School			

How would you rate your fitness? Excellent Good Fair (ring one)

Please answer Yes or No	**Yes**	**No**
Do you have any disability or illness?		
Do you have a cold?		
Do you have a cough (smoker's or otherwise)?		
Are you suffering from hayfever?		
Is your hearing normal?		
So you suffer from motion sickness?		
Do you take any pills, tablets, medication, or any drug of any type?		
Do you use an inhaler?		
Do you smoke?		
How many cigarettes a day?		
For how long (years) have you smoked?		

Have you ever suffered or do you now suffer from any of the following?

	Yes	**No**
Asthma		
Pneumonia or bronchitis		
Pleurisy		
T.B. or consumption		
Burst lung or pleurisy		
Any operation on the chest or lung		
Any other chest complaint		
Hayfever or blocked nose		
Sinusitis, sinus pain or problems		
Perforated ear drum		
Discharge from ear		
Recurrent ear infection		
Operation on ears		
Dizziness or vertigo		
Deafness or difficulty in hearing		
Do you suffer ear pain in aircraft		
Do you wear glasses or contact lenses		
Any eye problems		
Heart attack or angina		
Rheumatic fever		

	Yes	No
High blood pressure		
Stroke or CVA		
Palpitations		
Any heart disease or abnormalities		
Depression		
Panic attacks		
Claustrophia		
Any nervous disorder		
Epilepsy or fits		
Migraines or severe headaches		
Head injury or concussion		
Paralysis or muscle weakness		
Bad back or back injury		
Broken bones		
Any joint or bone disease		
Any skin disease		
Are you pregnant?		
Are you late for your menstrual period?		
Any kidney or bladder disease		
Diabetes		
Any stomach or bowel disease		
Any liver disease		
Hernia		
Any bleeding or blood disorder		
Any disease or disorder not listed		
Have you ever had an operation?		
Have you ever been in hospital?		
Have you ever had a serious accident?		
Are you being treated by a doctor for any condition?		
Have you ever been in contact with anyone with TB?		
Have you ever snorkel dived?		
If so approximately how many times?		
Have you ever scuba dived?		
If so approximately how many times?		
Have you ever had a problem whilst diving?		

Please Note: Although not compulsory, it is strongly advised to have a routine chest x-ray before commencing scuba diving as a full check for abnormalities of the lung. Although rare, cysts can occur in the lung with no symptoms and could lead to a burst lung. (Extra cost $).

DO YOU WISH TO HAVE A CHEST X-RAY? YES NO

I certify that all my statements are true and complete to the best of my knowledge

Signed Date

TABLE 9

PREDICTED FEV1/FVC RATIOS OF DIFFERENT AGE GROUPS AND SEXES

Females								
Age	**12**	**15**	**18**	**25**	**30**	**40**	**50**	**60**
Predicted ratio	94	94	88	88	87	86	85	85
90% Prediction	84	84	79	79	78	77	76	75
Males								
Age	**12**	**15**	**18**	**25**	**30**	**40**	**50**	**60**
Predicted ratio	92	92	85	85	84	83	81	79
90% Prediction	82	82	*__76__	__*76__	__*75__	75	73	71

At present the FEV_1/FVC ratio of greater than 75% is still most used as the standard of satisfactory lung function.[3]

However, the FEV_1/FVC ratio has some disadvantages.

Lung function changes with age. Present diving instructor organisations accept any diver over the age of 11 years and have no upper age limits. The predicted respiratory function normals of a 12 year old girl are very different from those of a 60 year old man (Table 9).

It is easy to cheat. If the diver does not exhale completely, artificially reducing the FVC, the ratio will be easily raised.

The commonest source of error in spirometry is the failure to record a full FVC. The FEV_1 however, shows no decrement therefore artificially increasing the ratio.[4]

If the diver, especially if tall, has large lungs then there may be an abnormally low ratio due to dysynapsis of the airways. Because the main expiratory resistance in the normal lung is in the large upper airways, especially the trachea, a diver with large lungs but a slightly small trachea, is unable to exhale as fast as expected, no matter the state of the smaller airways or the respiratory force applied. However such a diver is in no danger of pulmonary barotrauma through small airway closure.[5,6]

Being a ratio it will only identify obstructive airway disease for in severe restrictive airway disease both FEV_1 and FVC are reduced.

The FEV_1/FVC ratio is not a good predictor of pulmonary barotrauma.[7] To counter these disadvantages the FEV_1 and FVC were also noted as percentages of predicted normals. (With the newer computerised spirometers all the predicted normals are printed out with the results). If a statistical limit of normal to two standard deviations from the mean is applied, then the lower limit of acceptable lung function would approximate 80% of predicted normal of FEV_1 and FVC.

Of the 11 divers who failed their respiratory function tests with no apparent pathology and were referred to a respiratory physician, some will have normal lungs and simply be in the lower range of normal values. Unfortunately because of the transient nature of the divers having diving medicals in this area no follow up is possible as the majority of these people cancel their dive course and continue their travels.

CHEST X-RAYS

A chest X-ray was taken if there was a personal history of lung disease, serious lung infection or recurrent lung infections, a family history of tuberculosis, a suspicious occupational history, a history of smoking for ten pack-years or more, a past history of mechanical ventilation of the lungs, any abnormality found on clinical examination of the respiratory system or poor lung function test results.

The need for a routine chest X-ray in sports diving medicals has been debated for years. The argument for taking a chest X-ray in any diver without one of the above indications is to exclude asymptomatic pulmonary cysts, bullae, asymptomatic silicosis and sarcoidosis. The incidence of asymptomatic pulmonary silicosis and sarcoidosis is about 5 per 100,00 of the population.[8,9] A literature search for the incidence of asymptomatic pulmonary cysts was unfruitful. A telephone survey of 20 radiologists concluded it was a very rare finding. Guesses (by radiologists) at the incidence of asymptomatic pulmonary cysts in this age group of population centred around 1 in 10,000. If asymptomatic pulmonary sarcoidosis and silicosis have an incidence of 1 in 20,000 then 3 out of every 20,000 chest X-rays can be expected to show a contraindication to scuba diving. At a cost of $55 per chest X-ray (AMA rate), which is not claimable under Medicare, the cost of each positive finding would be $366,666.

It is up to both the diving medical bodies and the diving industry to decide whether routine chest X-rays should be mandatory for all sports diving medicals.

Meanwhile it would seem reasonable practice to offer every potential diver a chest X-ray with an explanation of its advantages and allow the diver to make the choice. (See note in Table 8).

ELECTROCARDIOGRAM

Edmonds and Walker[10] showed that cardiac deaths "peaked" in the 45-50 year old age group. A routine resting cardiogram for divers 45 years or older would therefore seem to be a reasonable precaution. Although no unexpected results were found in this series only 25 divers were in the age group at risk.

AUDIOGRAM

Although aural barotrauma is by far the most common diving related injury, the incidence of significant hearing loss following such injury is uncertain. It is surprising how many divers with completely occluded external ear canals have no idea that their hearing is diminished until the canal has been cleared. (One hundred and thirty six divers (6.6%) needed their ears to be cleared). Asking the diver whether his hearing is normal is therefore an unreliable method. However, standards set down in AS2299 for professional divers state that anyone with a 35Hz or 50db or more on higher frequencies must be screened by an ENT specialist. It is presently unclear whether these standards should be applied to sports diving and whether routine air conduction audiograms should be performed routinely.

PREGNANCY TESTS

It is generally accepted that women be advised not to scuba dive whilst pregnant.[11] Pregnancy was therefore considered a reason to provisionally fail the initial sports diving medical. All female divers should be asked whether a pregnancy was possible. If affirmative than a pregnancy test should be shown to be negative before the diver is passed.

Detecting asthma in diving medicals

It would appear that the dive shops screened out many of the asthmatics before the diving medical. The incidence of asthma in the adult population is about 10%.[12] One would therefore expect about 200 asthmatics in this series yet only 83 marked it on their questionnaire. It has become routine to ask every potential diver at the interview if they are asthmatic and many admit that they have a "bit of a wheeze sometimes" or "just a touch of it". Others denied they had asthma but freely admitted using bronchodilator inhalers.

The importance of good routine respiratory function tests is reinforced by the fact that 7 divers were only shown to be asthmatic by the tests.

Fifty per cent of divers who gave a history of "childhood" asthma were found to still have symptoms, signs or abnormal lung function tests. It is recommended that all divers with such a history be given a histamine provocation test even if they are apparently symptom and sign free. Any doctor performing diving medicals without ready access to a respiratory laboratory is encouraged to set up the equipment and procedure to perform provocation tests.

Conclusions

All stages of the diving medical have been shown to be essential.

I recommend modifications to the AS 2299 diving medical questionnaire.

The FEV_1, FVC and FEV_1/FVC ratio as percentages of the predicted normal should be calculated and used in the interpretation of respiratory function.

A chest X-ray may not be indicated by all divers as part of their medical.

Twenty three per cent of asthmatics identified during the medical are not identified by the present AS 2299 questionnaire.

Fifty per cent of divers who give a history of "childhood" asthma were found unfit to dive.

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SPUMS NOTICES

MINUTES OF THE SPUMS EXECUTIVE MEETING (TELECONFERENCE), April 4th 1991 at 1000 EST

Apologies
Dr J. Robinson

Present
Drs D Gorman (President), G Barry (Treasurer), J Knight (Editor), .Slark (Past President), D Davies (Education Officer), C Acott, D Wallner and J Williamson.

1 Minutes of the previous meeting

The Minutes, having been circulated, were taken as a true and accurate copy of the previous meeting. Proposed by Dr Davies, seconded by Dr Slark.

2 Business arising from the Minutes

2.1 AGM 1991 MALDIVES

Terry Cummins' presentation at the AGM was raised. It is apparent that some people feel that SPUMS may be aligning itself with PADI rather than all diver instructor organisations. Dr Gorman pointed out that in this context Terry Cummins is representing the National Scuba Qualification Committee and not PADI.

2.2 AGM 1992 PORT DOUGLAS

Dr Williamson reported that the academic program was advancing for this meeting and that a new program was in the hands of the Secretary and Dr Barry. All speakers invited to participate from AIMS have agreed to participate. This undertaking has been given by Michel Pichon.

The dates for this meeting are to be finalised as speakers need to to make long term plans. The academic component of the meeting has a very full program and in addition the ANZHMG wishes to make a presentation at the meeting and hold a meeting of that sub-committee.

Dr Barry indicated that with the savings achieved by switching from the Science Centre Foundation to our new secretariat we should be well able to offer each invited speaker (approximately 25 speakers) two nights accommodation and meals.The Committee decided that we will provide two nights accommodation plus meals and that if we get a large attendance at the meeting then we could be in a position to provide a contribution towards speakers' travelling costs as well, bearing in mind most speakers live locally.

Dr Gorman indicated that conversation with Geoff Skinner had indicated that numbers expressing interest in the 1992 meeting far exceed any previous meeting held by SPUMS.

The meeting will be two blocks of meeting interspersed by a few days diving on “Quicksilver.” Presentations on “Quicksilver” do not seem to be practical.

It was felt the conference should run from May 30th into the first week of June. The Committee thought there was no reason why, if there is a great deal of material, the conference could not be extended to eight days in length. It was suggested that we check there will not be a clash with UHMS.

3 ANZHMG

Dr Williamson informed the Committee a teleconference of the Australia and New Zealand Hyperbaric Medicine Group (ANZHMG) has been held. There is a lot of enthusiasm in the group for this committee. Multicentre trials are starting. The Cystoid Macula Oedema protocol, which Dr Williamson has rewritten, looks as if it will involve the Prince Henry Unit in Sydney, as well as, the units in Fremantle, Adelaide and Townsville.

The Ophthalomologists, including professors, in Sydney and in Perth, are displaying considerable interest. The group as a whole is very keen to liaise with military authorities and Surgeon Commander Tim Doolan, in Canberra, and also Dr Gorman are very keen to promote this. It is possible that this group will dovetail and have meetings with the military when SPUMS is offshore. There is a military medical association forming in Australia.

The group will always dovetail their meetings with SPUMS when SPUMS meetings are in Australia. But as this is very unusual it is more likely they will dovetail with the military medicine people when SPUMS is offshore.

The group is studying the question of registrar training and the diploma. There is a day long meeting planned on Friday 15th November at the Alfred Hospital and the next teleconference is to be on August 21st.

There was some discussion about funding of the ANZHMG. SPUMS will fund the teleconferences in the future. However, Dr Williamson has indicated in the future there may be a subscription from members of ANZHMG which will be used in part to offset the cost of conferences. Dr Williamson foreshadowed that once the Standing Committee is fully established that the probability that there would only need to be two or three teleconferences per annum. In response to a question from Dr Davies, Dr Williamson pointed out that members of the Standing Committee had gone to a lot of trouble to group themselves around as few phones as possible in order to save money on the teleconferences. Dr Williamson indicated that Dr Davies would be very welcome to attend any of the future conferences.

In summary, Dr Gorman indicated that the executive of SPUMS has indicated its completed and unanimous support for this standing Committee and that the support is on-going. Dr Williamson expressed the thanks of the ANZHMG for this support.

4 Coffs Harbour Meeting

Dr Wallner indicated that the meeting had been successful. A questionnaire was distributed at the conclusion of the meeting and most participants indicated they like the concept of regional meetings, as many had difficulty in getting away from their respective practices for our annual general meeting. There were 25 participants, four of whom were full members of SPUMS. The participants rated the accommodation as excellent. The audience was composed of visiting GPs from the area, dive instructors and local divers. The talks were excellent, however, Dr Wallner noted it was hard to assemble a suitable program for all the difference people attending. Most people indicated they would like to see Regional Meetings continue. The diving was indifferent due to inclement weather.

Dr Gorman felt that the type of meeting that Dr Wallner has arranged at Coffs Harbour is one, if not the major, function of SPUMS and asked if he was going to arrange a further meeting. Dr Wallner said he was happy to do so and was looking at Bryon Bay. He noted that it is important that there is somebody in the area of the conference who he can liaise with. A paper by Alan Bridger and case studies by Cathy Shannon and Peter Lewis may be suitable for publication in SPUMS Journal and he will approach them accordingly. Dr Gorman offered the congratulations to Dr Wallner and Dr Knight requested that he write a small report of the publication in the Journal.

5 Dive safe subscription

Dr Knight said that as the diving instructor organisations have not supported DES to the extent that they indicated they would, he felt that diving doctors should set an example. He suggested that $5.00 out of each Australian subscription to be sent to DES as a subscription to Dive Safe. Dr Acott indicated that he would prefer to postpone discussion of this matter until the AGM in the Maldives. This is on account of the developments in DES, in particular the formation of what will probably be known as International DAN Australia. Dr Acott further stated that the funding of DES comes half through the AUF by the way of government grant, the other half in theory is meant to be made up by diving organisations. To date only PADI and FAUI have contributed. This inconsistency in funding is one of the reasons why DES is going to go along the same lines as DAN in the USA, which experienced similar problems.

Dr Acott indicated that he would be publishing in the Journal a true account of the problems of funding as experienced with the diving organisations in Australia. He further indicated that the was happy to see Dive Safe published in the SPUMS Journal in future. In view of this, it was suggested that SPUMS make a one off contribution to assist DES in its current financial problems. Dr Williamson indicated that with the restructuring of DES to the DAN model, it may be necessary before things are fully established to seek a second donation from SPUMS. He felt that the new subscription insurance basis of the organisation will take about 6 months to get running.

Dr Knight said that he suggested a contribution of $5.00 per member because this was the amount the Journal cost to post to overseas members and he thought it was an appropriate sum for SPUMS to donate to DES for Australian members. SPUMS should make a one off donation of $3,000 and that it should be widely known through the Journal that it had been necessitated by the lack of support of the diving instructor bodies , who are telling their diving members that they are supporting DES. Dr Barry said that at this time of the year a large donation of this order would preferably be postpone till July when new subscriptions were coming in. Finally, it was proposed that we set aside $5.00 from the subscription of Australian members, the sum to be made available in either single or multiple instalments, commencing as funds become available, as a donation to DES. It was proposed by Dr Knight and seconded by Dr Davies. It was carried unanimously. Dr Barry pointed out that the sum of money being made available is a donation and not a deduction from subscription. SPUMS is free to donate surplus funds to whoever it may choose. Dr Gorman indicated that this donation must be made very public and the reasons for its necessity should be as widely publicised as possible. After discussion it was agreed that as the sum of money is a donation, the Executive is empowered to make this decision without canvassing each and every member of the SPUMS organisation in Australia.

6 Hyperbaric and Technical Nursing Association

This subject has been raised by Peter Atkinson, who is a Hyperbaric technician at the Alfred Hospital Unit. Dr Williamson said that the nursing and technical staff are absolutely critical to the on-going functioning of hyperbaric units. He noted that they had impressive qualifications and skills. These people have impressive skills which they feel warrant recognition and they do not feel comfortable being associate members (because they do not have a medical degree) and not being permitted to vote. They feel that the outcome of voting by people who may not necessarily have their skills and knowledge may have an effect on their future.

The question of them joining the Standing Committee of the ANZHNG arises and again they would feel that they would need equal voting rights. At this stage the Committee is very early on in its formation and any such question would need to be discussed at a meeting. Following discussion, it was decided that Dr Williamson would write to Peter Atkinson to advise that the Executive supports the idea of the participation of technical and nursing hyperbaric staff and would like them to remain associate members of SPUMS, also that they should express their views through the ANZHMG. The Executive was clear that we do not want another separate Standing Committee.

7 DIMS

Dr Acott advised that this program has now been accepted by DAN in the USA and has become a international study.

8 Correspondence received

The question of the name SPUMS being used by Dr David Miller in relation to an expedition in Western Australia was discussed. The letter written on behalf of the Society by the Secretary had been circulated. It was noted that Dr Miller had attempted to use SPUMS name in connection with other projects, however, at this stage it was agreed that the response was adequate. A letter to Dr Collison in response to his inquiry was forwarded by Dr Davies. These letters have been circulated and it was agreed it was very adequate.

A letter from Chris Penhol. Dr Knight thought it would be excellent to have unbiased assessment of diving equipment when it came on the market. He noted that diving magazines tended to describe all new equipment as wonderful. It was agreed that Dr Knight would write to Mr Penhol and suggest that he forward an article for publication and would point that they would be looking for the same sort of input that is given regarding items of anaesthetic equipment in Anaesthesia and Intensive Care. Dr Gorman said that the fact of our conference them this year indicates that we take this subject very seriously.

9 Business without notice

Dr Williamson stated that, at a future teleconference, the question of approved courses in Australia and New Zealand should be raised. There has been correspondence from Queensland about the difficulties of training medicos to perform diving medicals. He also advised the Committee that the Darwin Hyperbaric chamber is currently under threat of closure. He said the Broome chamber should come on line in the next 12 months.

Dr Davies has received a directory of doctors doing diving medical examinations in Western Australia, published by the Western Australian Government. It categorised them into two groups, the first being those who have qualifications and the second category being those doctors who have not completed an appropriate course but have experience in the field. He has subsequently received advice from the AMA that this contravened the Western Australian Medical Act.

Dr Knight advised that Standards Australia have circulated an altered draft medical. All alterations we discussed at the last meeting have been put in the draft received. He has written to Carol Foster. The AMA requested representation on the Committee and their nomination of Dr Millar has been accepted.

ANNUAL GENERAL MEETING SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY HELD AT KURUMBA VILLAGE RESORT, REPUBLIC OF MALDIVES at 1700 hours on Friday 7th June 1991

1 Present

All those attending the meeting.

2 Apologies

Drs J Williamson, D Walker, A Veal.

3 Minutes of the previous AGM

These having been previously circulated in the SPUMS Journal were taken as a true and accurate record of the previous AGM. Proposed by Dr J Knight and seconded by Dr G Barry.

Carried unanimously.

4 Change of the Constitution.

The proposed changes of the Constitution have been circulated in the SPUMS Journal with an explanation of the reason for such change. Three motions were put by the Executive to the meeting as worded in the SPUMS Journal.

All three motions were carried unanimoulsy by the Meeting. The proposed changes will be put to a postal ballot in the near future.

4 President's report (printed on page 157)

The President also made a statement on behalf of the Executive Committee thanking Dr Lori Barr for the enormous amount of work that she has achieved particularly in regard to workshops and meetings. The Secretary will write formally on the Executive's behalf. Appreciation was also expressed for the large amount of work that Dr Ray Rogers had done in establishing the North American Chapter and for his report to the meeting.

5 Secretary's report (printed on page 159)

6 Annual financial statement

Dr G Barry, the Treasurer, presented a Statement of Accounts (printed on page 158). It was moved by Dr D Davies and seconded by Dr J Knight that the Treasurer's report be accepted.

The motion was carried unanimously.

7 Election of Executive Committee

There was only one nomination for each of the named positions and only two for the Committee member positions. These nominees were declared elected. With the resignation of Dr John Robinson as Secretary and Dr Darrell Wallner's acceptance of nomination for the position, there was a vacancy for a Committee member. A call for nominations was made at the meeting, two nominations were received, a secret ballot was carried out and Dr Sue Paton was elected to the Committee.

The Committee now comprises:

President	Dr D Gorman
Immediate Past Present	Dr A Stark
Secretary	Dr D Wallner
Treasurer	Dr G Barry
Editor	Dr J Knight
Public Officer	Dr J Knight
Education Officer	Dr D Davies
Committee	Dr C Acott
	Dr S Paton
	Dr J Williamson

8 Entrance fees and annual subscriptions

Dr G Barry put the motion that an entrance fee of $25.00 as provided for within the rules of the Constitution be instituted at the Committee's discretion at a future date. The motion was seconded by Dr G Davis. In response to a query from Dr Lloyd it was made clear this involved all classes of membership. Dr J Knight spoke against the motion indicating it complicates procedures and felt if further funds were required it would be better to increase the annual subscription. Dr W Douglas queried the need for a joining fee. Dr J Robinson spoke against the motion as he thought this would be a disincentive to join the Society.

The motion was defeated on a show of hands.

9 Future annual general meetings

The Executive proposed that for the 1994 AGM should in Papua New Guinea. If possible the meeting should be Rabaul, however, if the hotels do not come to standard the alternative is to meet at Madang where facilities are known to be adequate.

10 Auditor

Executive proposed that David Porter FCA be reappointed as Auditor.

This was carried unanimously.

There being no business with notice, the meeting was closed at 1815.

PRESIDENT'S REPORT

The last year has been a good one for our Society with growth in Australia, maintenance of numbers in New Zealand and the South Pacific and the formation of a North American Chapter. This formation, along with that of the Australian and New Zealand Hyperbaric Medicine Group (ANZHMG) as a standing committee of SPUMS deserves special mention, along with the Journal and next year's Annual Scientific Meeting.

My role as President has been greatly facilitated by our retiring secretary, John Robinson, and my friend and confidante, our ex-President, Tony Slark. I wish to pay a special acknowledgement to John and Tony.

SPUMS Journal

The SPUMS Journal is one of the great successes of this year. John Knight's efforts as Editor, and along with John Williamson in peer review, are such that the Journal now looks and reads better! Indeed, the Journal should be a great source of pride to us all, and the success of its reformation has clearly demonstrated that it is possible to have a Journal of some academic standard and still maintain the Society's primary orientation to recreational diving and to members who are not fully employed in diving and hyperbaric medicine.

North American Chapter

It is this orientation and our determination not to become a South-Pacific version of UHMS or EUBS that underlies the evolution our North American Chapter. Simply, there are many American physicians who are not well served by UHMS and who are not particularly interested in the convulsion-thresholds of Sprague-Dawley rats that dived to 650 msw. The evolution of this chapter has not been a spontaneous event and indeed has been a recreation of Genesis, with Ray Rogers well cast as Adam and Lori Barr as Eve. Again, I would like to congratulate and thank them both.

Australia and New Zealand Hyperbaric Medicine Group (ANZHMG)

An attempt to initiate an Australian Hyperbaric Medicine Group several years ago was unfortunately unsuccessful; this year and thanks to the efforts of Dave Tuxen and John Williamson the ANZHMG has been launched as a standing committee of SPUMS. The Society has agreed to fund the ANZHMG telephone-conferences and to publish its proceedings in our Journal. For those who are unaware, ANZHMG membership is limited to the Clinical Directors of Hyperbaric Medicine Units. Some of the Group's roles and functions are to agree to indications for hyperbaric therapy, to advise Governments on remuneration, to initiate and maintain a training programme and to conduct multicentre trials. John Williamson is the inaugural chairman and Dave Tuxen, the secretary of the committee.

Annual Scientific Meetings

SPUMS continues to be well-served by Geoff Skinner and Allways Tours. In that context, our decision to plan future Annual Scientific Meetings (ASMs) well in advance is proving beneficial and the 1992 ASM looms as our most popular yet. John Williamson is co-ordinating the meeting at Port Douglas and the meeting theme is the ecology and biology of the Great Barrier Reef. John already has a draft programme with a dazzling array of marine biologists from facilities such as the Australian Institute of Marine Science in Townsville. Diving will be on the outer reef and from sole use of the MV Quicksilver.

In 1993, we will return to offshore meetings, at new locations such as Rabaul, Northern Tonga and Hawaii, and of course returning to Palau in 1993.

In conclusion, I would like to thank all members of the Executive Committee for their assistance. I believe the telephone-conference system of management to be highly cost-effective and one that we should continue. I look forward to seeing you all in Port Douglas next year.

Des Gorman
President

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY INCORPORATED
STATEMENT OF RECEIPTS AND PAYMENTS FOR YEAR ENDED 30 APRIL 1991

	1991	1990
Opening Balance		
Standard Chartered Finance Ltd.	1,000	1,000
National Mutual Royal Bank	8,305	4,228
National Australia Bank	441	1,503
Cash on hand and stamps	112	10
	9,858	6,741
Income		
Subscription	49,588	33,001
Interest	1,579	2,260
Journal sales and advertising	730	1,845
	51,897	37,106
	$ 61,755	$ 43,847
Expenditure		
Secretarial	10,217	3,016
Stationery	2,657	570
Journal	13,790	14,739
Postage	5,883	6,017
Travel and phone conferences	11,086	5,774
Equipment, see note	4,583	2,454
Miscellaneous	2,685	550
Bank charges	331	311
Returned cheques	-	-
Audit 200	175	
Legal expenses	812	-
Donation to DES	-	-
Uncashed cheques	304	351
	52,548	33,989
Closing Balances		
Standard Chartered Finance Ltd.	-	1,000
National Mutual Royal Bank - Savings A/c	6,023	8,305
National Mutual Royal Bank - Savings A/c	2,963	-
National Australia Bank	-	441
Cash on hand and stamps	221	112
	9,207	9,858
NOTE: Equipment is written off as purchased		
	$ 61,755	$ 43,847

AUDIT REPORT

I have conducted various tests and checks as I believe are necessary considering the size and nature of the Society and having so examined the books and records of the South Pacific Underwater Medicine Society Incorporated for the year ending 30th April 1991 and report that the above Statement of Receipts and Payments has been properly drawn up from the records of the Society and gives a true and fair view of the financial activities for the year then ended.

David S.Porter, F.C.A., Chartered Accountant
(Registered under the Public Accountants Act, 1946 , as amended)

21st May 1991, Newport Beach, NSW 2106.

SECRETARY'S REPORT

The year has seen considerable change in the internal organisation of SPUMS. Members will recall at the last AGM it was decided to employ the Science Centre Foundation (SCF) to alleviate the increasingly heavy routine workload of the Secretary. This experiment proved a costly failure. The SCF's high charges continued even when little use was made of the facility. As a result arrangements were made with the Australian College of Occupational Medicine (ACOM) to act as mailing address for SPUMS. Mail is redirected by the College on a weekly basis to the secretarial agency of the Secretary's choice, currently the Brighton Executive Centre. This centre sorts the mail and attends to routine enquiries as well as providing secretarial services. This arrangement has proved efficient and far more cost effective. In future when the Secretary changes this can be done without changing the address of SPUMS. This new arrangement has reduced the workload on the Secretary from up to 20 hours per week to several hours only. I feel this is important as with the previous workload I doubt the Society would continue to attract a volunteer to be Secretary.

This year a large number of matters have come before the Committee. The decision at the last AGM to plan the next three conferences has proved a success, and enable both the Convener and travel agent to be well advanced in their plans for the 1992 meeting. I am sure the next AGM will be an outstanding success and I will be surprised if the Academic programme John Williamson is putting together does not attract a large attendance from both Australia and overseas. It was decided at Palau to abandon the former practice of executive meetings in person and use Telecom's teleconference facility. This has proved very successful enabling the Committee to meet more frequently and at a substantial saving to the Society. Without this facility the Committee could not have accomplished nearly as much.

Following the AGM last year is has been formally resolved that only financial members of SPUMS may attend our AGM without further charge. Other interested people are encouraged to attend but at an additional cost of $75 which goes to the Society.

New letterhead and application forms have been designed. This has been necessary because of the changes of address and the opportunity has been taken to simplify the application form to provide only essential information. Investigations with Corporate Affairs have shown that we can continue to use the logo SPUMS on our letterhead without adding Inc.

Members will recall that one of the functions of the Science Centre Foundation was to create a data base. Despite much expense this was not achieved and eventually the project was cancelled. The current situation is that the Editor keeps on his computer a complete list of members, including a file of SPUMS members who do diving medicals. This is updated on a regular basis. I would like to say no issue has caused more dissent and complaint than the publication of a list of doctors who do diving medicals.

As a result I have stated in the Journal that only financial members of SPUMS who have undergone an acceptable level of training in Underwater Medicine shall have their names published on this list. In taking this position SPUMS is not purporting to publish a complete list of qualified people for diving medicals or attempting to set standards for any other group. It is merely a statement of those members of our organisation that the Committee considers qualified to carry out such examinations. In addition, the Committee feels that to be an expert witness the minimum level of training is 6 months in a recognised hyperbaric unit and/or to be a holder of the Society's Diploma.

During the year there were two meetings of Standards Australia's CS83 Committee. SPUMS has representation on this Committee and sponsored a working party under John Knight's direction. Whilst not totally satisfied with the outcome, I think it fair to say without our input the result may have been disastrous. I feel that the two year window for doctors to obtain satisfactory training for Diving Medicals is compatible with our policy on the list of Diving Doctors.

I have to advise members, with regret, that negotiations for a joint meeting with the Indonesians have been unsuccessful, solely due to their failure to answer correspondence.

In response to an article by Val Taylor I wrote on behalf of the Society to Prof. Ovington and Val Taylor expressing support for the establishment of a marine park at Osprey and Bougainville Reef. I regret to report neither thought it worthwhile to respond to our efforts.

During the year the Australian and New Zealand Hyperbaric MedicineGroup was formed. John Williamson has been a prime mover in this and I congratulate him him on his efforts. The group is a forum for those actively running hyperbaric units. We expect their first report at the Port Douglas meeting. David Tuxen is the group's secretary. The Committee decided that SPUMS should sponsor the group's activities, for example by paying the costs of teleconferences. By coming under the umbrellas of SPUMS we can assure the viability of this group which clearly is always going to have limited numbers.

I would also like to take this opportunity to congratulate Darrell Wallner on his initiative in arranging the Coffs Harbour meeting. I think this type of meeting enhances our Society greatly.

Further correspondence has been received concerning the cost of AGMs. I would like to reinforce previous statements that discount flights are only available to very small groups and not to groups the size of SPUMS. I hope this issue will not continue to be raised. I would like to take this opportunity to say how very impressed I have been with the professionalism of the staff of Allways Travel and their unfailing helpfulness and pleasing manner. In particular I would like to thank Adrienne for her assistance and patience.

Recently it was drawn to my attention that a group in WA attempted to imply SPUMS was supporting a dive trip, presumably to attract taxation benefits. I have written to the member concerned, making it clear any such sponsorship can only occur when authorised by the Committee. The advertising material was subsequently withdrawn.

I have found the Secretary's job an interesting experience. Your Society continues to grow at an almost alarming rate and I am informed by the Editor that at last count he sent out nearly 950 copies of the Journal. It will not be long until we have in excess of a thousand members, which highlights the need to continue with the type of arrangement we now have with ACOM and the Brighton Executive Centre. I regret not being able to continue due to other commitments. I would like to thank David Davies and John Knight for their every ready assistance and advice whenever requested. Last I have to say it has been a pleasure to work with Des Gorman, whose knowledge always impresses and whose enthusiasm is contagious.

John Robinson
Secretary SPUMS

SPUMS ANNUAL SCIENTIFIC MEETING 1992
30th OF MAY TO 6th JUNE
Raddison Royal Palms Hotel
PORT DOUGLAS

The theme of the meeting will be **Australia's Wonder of the World, the Great Barrier Reef**.

Dr John Williamson, the meeting convenor, has produced a full and fascinating program with speakers from the Australian Institute of Marine Studies, which is based near Townsville, covering every aspect of the Great Barrier Reef. There is also a full -day symposium on diving safety.

There are a few spaces left in the program for free papers. Anyone wishing to contribute a paper must contact Dr Williamson no later than New Year's Day 1992 and preferably before then.

Dr John Williamson's address is Director, Hyperbaric Medicine Unit, Royal Adelaide Hospital, North Terrace, Adelaide, South Australia 5000. Telephone (08) 224 5116. Fax (08) 233 4761.

SPUMS MEETING MARCH 14th AND 15th 1992
TATHRA, NEW SOUTH WALES

Following the success of the meeting at Coffs Harbour last year and the support shown at the AGM in the Maldives, a weekend meeting of SPUMS will be held at Tathra on March 14th and 15th.

The organisers will be Dr John McKee, P.O.Box 256 Bega, NSW 2550, phone (064) 921 297, and Dr Geoff Long, P.O. Box 276 Bega, NSW 2550, phone (064) 922 922. Both telephone numbers are business numbers.

The format will be similar to that at Coffs Harbour. Two dives on Saturday morning, lectures Saturday afternoon, dinner with a speaker on Saturday evening and two dives on Sunday morning. A BBQ will be arranged for Sunday lunch.

The venue will be the Tathra Hotel which sits on a cliff overlooking the ocean. Accommodation is single motel style units and the price will be very competitive.

The Sapphire coast has spectacular beaches and headlands. The weather in March is usually excellent and the seas are warm (5 mm wet suits are all that is required). The diving is very good and includes the seals off Montague Island, the wreck of the Empire Gladstone and magnificent sponge gardens. The actual locations will depend on the weather conditions.

Anyone wishing to present a paper at the meeting should contact Geoff Long as soon as possible. Early expressions of interest to attend will also make the organisation much easier. A registration form appears on page 188.

CONSTITUTIONAL CHANGE

No objections to the changes to the Rules of the Society had been received by the Secretary by 14.9.91, so in accordance with the notice on page 89 of the SPUMS Journal, Vol 21 No 2 1991, it has been assumed that the motions have been passed by the necessary three fourths majority of the full and life members and so come into force.

A copy of the Statement of Purposes and Rules, amended September 1991, is enclosed with this issue of the Journal.

Darrell Wallner
Secretary SPUMS

LETTERS TO THE EDITOR

DIVER EMERGENCY SERVICE

Diver Emergency Service (DES)
Royal Adelaide Hospital
North Terrace
Adelaide, South Australia 5000.

3 July 1991

Sir

I would like to thank SPUMS on behalf of the Diving Emergency Service for the donation of $2,500. This money will contribute to the continuation of the Emergency Service.

Since the collapse of the National Safety Council in 1989 DES has been supported financially by the AUF, the Federal Government, DITAA, FAUI, NAUI, PADI, and the Australian Patient Safety Foundation.

Recent meetings held with the Divers' Alert Network (DAN) in the USA, have secured cooperation between DES and DAN and laid the groundwork for the formation of International DAN. DES in the near future will be called DAN Australia and will be part of an international network of data sharing and diving emergency services. Membership of DAN Australia will ensure the diver of help and advice anywhere in the world.

The formation of International DAN will include an International Diving Insurance package which only DAN members will be able to purchase. This insurance will cover the diver for diving illnesses world-wide. With this insurance Australian divers overseas will no longer have to concerned whether their travel insurance covers diving accidents.

All divers will benefit from International DAN. It will be a "big safety net" (a "Jesus line" and "Safety Sausage" combined!!!).

This shift towards a membership and insurance based organisation has been a survival necessity. Funding for the emergency service is continuously sought, particularly as one of our previous supporters can no longer see their way clear to support DES.

The 008 number (008 088 200) will always be there.

Thank you again for your generosity.

C. J. Acott
Co-ordinator DES (Australia)

DYSBARIC OSTEONECROSIS

We reproduce below for the interest of readers, and with the writer's permission, the text of a personal letter in reply to one from the Editor. We would emphasise that the letter is only an exchange between friends and is in no way an official statement of policy from the MRC.

Rockdale
40 Petworth Road
Haslemere
Surrey GU27 2HX
United Kingdom

16th August 1991

Dear John,

In answer to your enquiry for advice on where to get a second opinion on an X-ray reported as possible dysbaric osteonecrosis.

The Health and Safety Executive took over the responsibility for the MRC Decompression Sickness Registry ten years ago, and then they shut it down within two years as an economy measure! Since then there has been no continuation of the research into possible causes of necrosis, particularly those related to the changing patterns of exposure.

There are still some who render a person with bone necrosis unfit to dive. This is old-fashioned paternalism. No diving accident, and certainly no diving fatality, has ever been attributed to bone necrosis. All professional divers should be aware that ***if*** they get bone necrosis, then there is a 1:10,000 or so chance of malignant change. Apart from that, a shaft, neck or head "B" lesion should not make any difference, but any decision to give up diving should be theirs alone.

A juxta-articular "A" lesions is of course totally different in that for a relatively small percentage of divers it will develop into a sub-chondral fracture, with pain and risk of serious disability. This will not put the life of the diver at risk when underwater and so the decision still belongs to the diver though the medical advice, to give up diving for the sake of future health, should be strongly given and should be recorded in the notes.

If you need an opinion for diagnostic purposes I suggest that you write to Dr John K Davidson, 91 Newlands Road, Newlands, Glasgow G43 2JG, Scotland.

David Elliott

BOOK REVIEWS

RECOMPRESSION CHAMBER LIFE SUPPORT MANUAL

Dick Rutkowski
Hyperbarics International, Inc.
125 pages, soft cover

Review copy from
Best Publishing Company
P.O.Box 30100
Flagstaff, Arizona 86004
U.S.A.
Price $US 30.00, postage $ US 5.00 (approximately $ Aust 45.00 in all) Mastercard and Visa credit cards accepted.

This manual is described as and instructor/student guide for the use of breathing gases during hyperbaric exposure. It is not a chamber operator's manual, nor does it pretend to be, but the manual does fulfil its role as a guide to hyperbaric breathing gases. The text is arranged in an easy to read fashion and is divided into a description and application of the concept followed by a homework assignment. this method of learning and review works well to reinforce the text.

The book is full of the useful formulae and conversions frequently required by people working the in hyperbaric field. The chapters cover the basic clinical and operational aspects of chambers, fundamentals of hyperbaric therapy, gas laws, oxygen toxicity both central nervous system (CNS) and pulmonary. Also covered are the treatment tables and the use of nitrox, oxygen, heliox and gases required for therapies, including saturation treatments.

A useful concept of using fictitious clocks for accrued decompression, CNS and pulmonary oxygen toxicity time is used in the manual. Using the clock concept, when one switches from air to oxygen at depth one stops the decompression clock but starts the oxygen pulmonary and CNS toxicity clocks. This clock concept is useful for considering implications of some hyperbaric treatments. There is a good idea in the "Viable Treatment Options Table" to be used when one has deviated from the normal treatment table and has become lost in the flowchart maze when tempted deeper than 18 m during therapy. The viable options to continue decompression are represented on this chart. The names of these tables may be a bit unfamiliar to the Australian reader, but are in most cases equivalent to tables operators will have available.

While the manual is predominantly good in text and illustrated figures, the photographs are of poor quality and some of the figures and graphs are awkward to decipher. In the section of pulmonary oxygen toxicity there is a dive profile of a USN table 6 showing the 9 m stop as having 6 cycles of 20 minutes on oxygen followed by a five minute air break. In Adelaide the 9 m stop is usually conducted as two cycles of air followed by 60 minutes on oxygen. Perhaps our copy of the USN tables is out of date ! All measurements are imperial, which is a pity as metric could easily have also been included. Mr Rutkowski uses terminology that reflects his years with the National Oceanic and Atmospheric Administration (NOAA) and either this terminology should be explained or a glossary included for the non-NOAA initiated.

This publication has a logo on the front cover which includes the initials of the National Board of Diving and Hyperbaric Medical Technology (NBDHMT) and the Undersea and Hyperbaric Medical Society (UHMS). Other than in the acknowledgements there is no mention of either UHMS or NBDHMT to explain their inclusion on the cover.

In summary this is certainly a useful guide for the student and a good reference for experienced hyperbaric personnel. One of my colleagues summed the book up as "almost the book I would have written". I think that there is room for improvement in some areas but it certainly is the best book on this subject I have seen to date.

Rob Ramsay
Senior Hyperbaric Technician.
Royal Adelaide Hospital

NITROX MANUAL

Dick Rutkowski
International Association of NITROX divers

Review copy from
International Association of NITROX divers

This manual is an instructor/student guide to the use of nitrogen-oxygen mixtures as a diver's breathing medium. This of course includes compressed air. Actually the manual is for the use of oxygen enriched air in diving. This has been common practice in navies to take advantage of the lesser decompression requirements of higher oxygen mixtures compared with compressed air at the same depth. However latterly some of the scientific and recreational diving community in the United States has become interested in using Nitrox to extend their bottom time. They have had use of equivalent air depth tables and tables written specifically for a 68% nitrogen with 32% oxygen mixture, called NOAA Nitrox I or NN1. NN2 is also available with 36% oxygen.

Dick Rutkowski draws attention to the dangers of the higher concentration of oxygen, convulsions from oxygen toxicity if depth limits are exceeded and these will occur at

Continued on page 174

SPUMS ANNUAL SCIENTIFIC MEETING 1990

SINGLE PHOTON EMISSION COMPUTERIZED TOMOGRAPHY (SPECT)
New Insights into the Pathology of Cerebral Decompression Sickness

Greg Adkisson

Background and Development

The Undersea Medicine Division at the Institute of Naval Medicine, Alverstoke, England, in conjunction with the Royal Naval Hospital, Haslar, began a series of studies in late 1987 to evaluate the use of a newly developed method of measuring cerebral perfusion in the investigation of pressure related accidents.

First applied to cerebral arterial gas embolisms (CAGE), it was soon extended to divers suffering from various degrees of decompression sickness (DCS). Work is continuing but the initial studies have provided new insights into the pathology of cerebral DCS.

$^{99}TC^{m}$-HMPAO

Hexamethylpropyleneamine oxime(HMPAO), marketed under the brand name Ceretec by Amersham International Plc in England, was developed in an effort to allow for routine imaging of cerebral perfusion following a variety of cerebral ischaemic events. While agents have existed previously, they have been difficult to use or expensive. HMPAO proved to be a simple and reliable ligand for use in such studies. When combined with Tc-99m, an isotope used in 80 percent of all nuclear medicine procedures, HMPAO penetrates the blood-brain barrier, distributes in proportion to cerebral blood flow and becomes fixed in cerebral tissue with no significant redistribution over the imaging period. Due to its rapid distribution but prolonged half-life, imaging can be performed within minutes or be delayed several hours. Imaging gives a picture of cerebral perfusion pertaining at the time of injection rather than at the time of imaging. Single photon emission computerized tomography (SPECT) is performed using an orbiting gamma camera of the type found in most nuclear medicine departments. A three-dimensional sinogram is acquired that can be examined in axial, saggital or coronal planes. Repeat studies can be performed to monitor changes in perfusion patterns.[1]

Initial Studies

The outcome of a patient with CAGE or DCS is often dependent upon the rapidity with which treatment is instituted. Recompression therapy should not be delayed while secondary examinations and testing are conducted. HMPAO seemed to be an ideal agent for evaluating diving related accidents in both the acute and follow up settings.

A patient could be injected with HMPAO without delaying treatment and subsequently scanned in the controlled setting of a nuclear medicine department. The scan, however, would tell us what was occurring prior to the treatment. In the long run, this proved to be less valuable than first imagined but may be important for future studies.

The first three patients examined with HMPAO were found to have cerebral perfusion deficits that appeared to correlate with their clinical signs and symptoms.[2] Over the next year, 50 divers were studied following incidents of DCS, CAGE or where an unusual event occurred which left the diagnosis in question. 47 patients showed positive scans correlating with suspected injury. 3 patients with negative scans had suffered from Type I DCS or were diagnosed as being non-diving related injuries. 28 of these first 50 patients were reported on showing significant correlation with their diving injury and their cerebral findings.[3]

Specific criteria were established for evaluating this first series of divers. There had to be a definite diagnosis of DCS or CAGE treated by a recognized USN or RN recompression table and the patient had to have been studied with HMPAO within one month of the incident. One month was chosen to avoid the possible effects of resolution over a longer period of time.

22 divers were excluded based on the following reasons: unconscious or rapid ascent with disputed diagnosis (5), scans performed at greater than 1 month (4), definite incidents with no or inadequate initial treatments (10), oxygen toxicity (1) and cases determined to be non-diving illnesses (2).

The 28 patients selected represented a range across the spectrum of dysbaric illness. Of the 23 reported cases with neurological DCS, 4 had severe manifestations with 1 paraparesis, 1 paraplegia and 2 hemiplegias. 3 patients showed widespread motor and sensory symptoms and signs, 5 had evidence of mild motor and sensory involvement and 5 had subjective sensory changes only. 5 of the 8 patients with altered mentation had vague or absent associated symptoms and 1 patient had inner ear DCS.

In all patients with either CAGE or neurological DCS, there appeared to be a significant correlation with the cerebral perfusion deficits noted on the HMPAO scan and their presenting symptoms and signs. In the few cases of non-neurological DCS, the scans appeared normal.

Pathology of DCS

The similarity of scan results in the CAGE and neurological DCS groups may indicate a similar etiology. While the presence of autochthonous bubbles cannot be ruled out, the pattern suggests a microembolic event of homogeneous nature affecting selected areas of the brain, primarily the regions supplied by the anterior and middle cerebral arteries.[4] This does not preclude the presence of spinal cord involvement but, rather, expands upon our understanding of the often vague cerebral manifestations. In CAGE, the cerebral insult acts alone to cause clinical manifestations while in DCS, it may be that spinal and cerebral insults act alone or in combination.

Astrup and Symon proposed a model where cerebral hypoxia, due to decreased cerebral flow, could lead to reduced or absent function without cellular demise. Reversible and non-reversible areas of damage occur depending upon the degree and duration of the hypoxia.[5,6] Hypoperfusion, caused by either CAGE or DCS might lead to reduced function with subsequent symptoms and/or signs. Recompression with increased perfusion may lead to clinical resolution of a diver's symptoms whilst subclinical cortical hypoperfusion remains.

Follow Up Studies

In a follow up study of 18 of these divers, it was shown that the perfusion deficits shown on initial scanning were remarkably persistent.[7] While some improvement occurred, and indeed complete resolution in a number of cases, it was not uncommon for lesions to worsen or remain unchanged over periods of a year or more. Several divers showed worsening scans with apparent extension of their initial deficits. These findings increase concern that neurological damage caused by diving may be more significant than previously believed and may be of a more permanent nature despite prompt and clinically effective therapy. Underlying damage remains and raises the question of what further diving will do to an already damaged brain. Are these divers at increased risk of further incidents? If injured a second time, will their injury be harder to treat or is it likely to leave greater residual damage? No one can answer these questions at the present time. People have been diving for years following repeated incidents of CAGE and DCS without revealing any definite trend. Long term neurological changes have been documented in the spinal cord[8] and have been suspected to occur within the brain for some time. As our methods of studying these divers becomes more sensitive and accurate, these questions may be answered.

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TESTING THE RECREATIONAL DIVE PLANNER

Raymond E.Rogers

Summary

In phase 1 M. R Powell, PhD, tested 911 dives, 518 in the chamber and 393 in open water. The broad cross section of subjects had wide variations in dive profiles. All dives were past RDP limits. There were no cases of decompression sickness and minimal bubbling. The increase in vacation diving paralleled development of the Recreational Dive Planner (RDP). As multi-day diving was largely unstudied Diving Science and Technology (DSAT)

imprinted warnings on RDP and did the phase 2 study.[1] The test plan covered 4 dives per day, to mimic resort activity, two dives in the morning, one in the afternoon and one dive at night, with the dive day spanned over about 13 hours. Each dive was to the limit of the RDP (except for the last). The last dive was shallow, for about one and a half hours and was single-level. This was to elevate gas pressure in slow tissues.

Phase 1 testing

The point has been made that no new tables and no new equipment should be introduced without adequate testing. That is a relative term. How much is enough? We tested it a lot. Probably there can never be "enough" testing, but one strives for adequacy.

The first phase was chamber testing, with Dr Michael Powell as the principal investigator, at the Institute of Applied Physiology and Medicine (IAPM) in Seattle, Washington. This was followed by open water testing. All divers were Doppler monitored after the dive.

There were 911 dives done, 518 in a chamber, 393 in the open water. There was a broad cross section of subjects, from old people to young people, inexperienced to very experienced, fat, thin, male, female. They were volunteers, and we took whatever we could get. There was a variety of variations in the dive profiles. We tested a total of 25 different profiles across the whole spectrum of the recreational range. Every dive was tested beyond the no-stop limit of the Recreational Dive Planner, and beyond the no-stop limit of the US Navy tables, and probably even further beyond the limits of DCIEM tables or the BS-AC tables. No decompression dives were done.

Phase 1 results

In all these 911 dives, there was no case of decompression sickness, and only negligible bubbling. There were no bubbles detected after 92.6% of the dives, 6.3% of the dives had bubbles in the grade one range, while grades 2 or 3 were found in fractions of 1% of the divers. There were no grade 4 bubbles nor any decompression sickness.

Slow tissue compartments which have extended half-times can play an important part in recreational diving, but only in multiple long shallow dives with short surface intervals. Obviously if one defines a slow compartment as one which reacts very slowly across the time spectrum one has to talk about long dives. The only time when long dives are permitted in no-stop diving is in shallow water, and even then there is the problem how long can anyway one tank last? If one keeps going back to the boat and getting another tank, and repeats this long enough, eventually one can push up the pressure in the slow compartments. It is only with this pattern that the theoretical model says that one might have a potential problem. The combination of short surface intervals and long, shallow dives, randomly selected, would eventually cause some compartments to pass their theoretical limits. Once we established what these dives were, we then asked the computer how to prevent overpressures. The answer was two simple rules.

The first reads:

"If you plan three or more dives in a day, beginning with the first dive, if your ending pressure group after any dive is W or X, the minimum surface interval between all subsequent dives is one hour."

The second rule is almost identical:

"If you plan three or more dives in a day, beginning with the first dive, if your ending pressure group after any dive is Y or Z, the minimum surface interval between all subsequent dives is three hours."

These rules are simple. They are so simple they might have been made up artificially. That is not the case. They are based on huge numbers of computer calculations which examine all sorts of profiles that recreational divers might use.

Slow compartments have little influence on most dives and bottom times have to be very long, and the dives shallower than 60 feet, to achieve repetitive groups W, X, Y and Z (Figure 1). It takes multiple dives and one really has to work at it, but if one tries hard enough, one can get down into the "magical" W-X-Y-Z groups. But notice how few time boxes there are down there, hardly any at all. For dives to 70 feet and deeper, one could not do it. Before the 60 minute compartment pressure can get too high, the no-stop limits of the faster compartments get one out of the water. These groups can only be reached after a repeated sequence of closely spaced long and shallow dives.

Divers very seldom finish in these high pressure groups, but if they do, the long surface interval causes pressures in the slow tissues to decrease to acceptable levels before the start of the next dive. I am not suggesting that there is no gas in the slow compartments, of course there is, there always is, but time gets it down to a tolerable level.

With these rules in place, can the model be exceeded if all the rules are observed? If one follows the W or X or Y or Z rules if they apply, if one monitors one's ascent rate and one does not go too fast, if one takes a safety stop, if one does all these things, can one break the model? Yes, one can. But one has to work at it. I found an example of how one can do that. If one goes to 35 feet for 120 minutes and then has a surface interval of 66 minutes, then repeats that, the operational rules now require a safety stop at 15 feet, and the table requires another 66 minute surface interval, etc. The reason

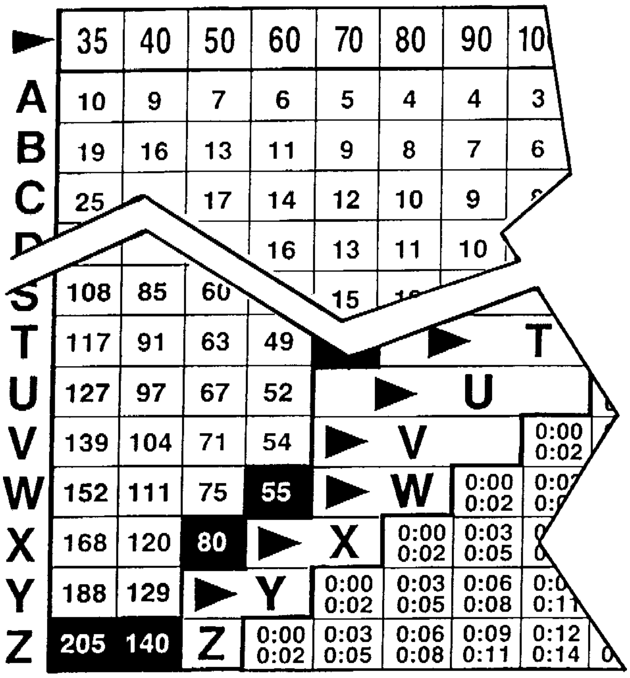

FIGURE 1 Taken from the PADI Recreational Dive Planner. Depths are across the top line. Bottom times have to be very long, and the dives shallower than 60 feet, to achieve repetitive groups W,X,Y and Z.

I used 66 minutes is that it sets up a cycle, between pressure group X and pressure group H and according to the RDP one can do this for ever, for days if one wants to. But when one surfaces at the end of the sixth dive, after six consecutive dives of 2 hours each to 35 feet, one would be slightly over the theoretical limits in three of the slow compartments. But to achieve that feat, one would have been in the water for over 12 hours of the previous 18. I consider that sort of diving a trifle on the unrealistic side, so I am going to ignore it.

Multi-day diving

But it was good that we included these procedures in the model as it came along, because it takes time to develop things, and from the moment the idea popped into somebody's brain until the product was actually available to the public, something interesting happened, quite coincidentally. Out of nowhere, we had a brand new issue, vacation diving.

Divers are everywhere. People are jumping on aeroplanes and going all over the world to all sorts of exotic places, and when they get there they want to dive as much as possible. And many people advertise "unlimited diving".

What was really known about multi-day diving? The answer is essentially nothing. Two facts were known, that a lot of people were doing it and that most were getting away with it. But there was no data and no research had been done. No one knew whether it was safe or risky.

TABLE 1

THE DIVE TO BEAT THE RDP RULES
(Feet / Minutes)

Dive	Stop	Surface interval
35 / 120,		0 / 66
35 / 120,	15 / 3,	0 / 66
35 / 120,	15 / 3,	0 / 66
35 / 120,	15 / 3,	0 / 66
35 / 120,	15 / 3,	0 / 66
35 / 120,	15 / 3,	0 / 66

About the time this issue came to notice, PADI introduced the RDP. It carried this warning: "Note: Since little is presently known about the physiological effects of multiple dives over multiple days, divers are wise to make fewer dives and limit exposure toward the end of a multi-day dive series". In 1988 that little was known about it.

We know a lot more than we did then. Not as much as we would like to or are going to know. That warning looks extremely vague, and deliberately so, because so little was known about the subject, we could not be more specific than that. Repetitive diving is considered to be a risk factor, but most recreational diving is repetitive diving. Also it has been surmised that it may not be the gas uptake of multi-day diving which is the problem, but giving the diver more opportunities to make a mistake.

When multi-day diving became popular the warning was in place. DAN said that we had adequately tested for three dives a day, but what about doing this day after day?

Maybe we could have left it alone, with just the warning, but we were were not willing to have it left unexamined. So it was back to the chamber. In the interests of those who might be using the RDP, and in the interests of those who might be doing recreational diving anywhere we decided to research the subject.

Phase 2 testing

We set up a test program of four no-stop limit dives per day, for six consecutive days, 24 dives for each subject. This test program used 20 different subjects which meant a planned total of 480 different dives.[1] There were a few incidental ear squeezes, but we did 475 dives out of the planned 480.

Table 2 shows the subject data. We had 12 men and 8 women. The men ranged in age from 21 to 61, with an average of 39 years. The women had an average age of 36, ranging from 24 to 45. The weights were all over the place, some of the men were almost twice as heavy as the others. Body fat was all over the place too. We were not selective. We did not just use young, athletic-type males. We supplied a TV set up outside the viewing port and there was a rowing machine in the chamber to stop people from going "stir crazy".

TABLE 2

AGE, WEIGHT AND % BODY FAT OF THE SUBJECTS (12 MEN AND 8 WOMEN)

		Age		
Male	39.08	±	11.62	(21 - 61)
Female	36.38	±	7.76	(24 - 24)
		Weight (kg)		
Male	78.3	±	14.76	(59.1 - 111)
Female	61.5	±	7.96	(50.0 -75)
		% Body fat		
Male	20.54	±	5.90	(15.5 - 36.0)
Female	26.74	±	5.28	(21.6 - 35.3)

Table 3 shows the actual test profiles. You can see that it is a combination of multilevel diving and single level diving. We (I do not know where one would find an an open sea environment that would let one do this) tested three levels, four levels, two levels and, as a matter of policy, we decided we would finish every day with a long shallow dive. The last dive the first day was 90 minutes at 40 feet. I have to confess that when I said that every dive was to limit, it was not entirely correct. 90 minutes was an arbitrary cut off point, as it was probably long enough. We set out to mimic resort-type diving, two dives in the morning followed by an afternoon dive and then a night dive. We tried to simulate reality, as well as to do another thing. Finishing with a long shallow dive, tends to elevate the tissue pressures in the theoretical slow compartments as well as to reduce the overnight surface interval. The dives spanned about 13 hours from start to finish. The surface intervals between dives are shown. The last number each day is very large, it is the overnight surface interval.

There were some very long dives with total bottom times (surface to surface) of 106 minutes and 91 minutes. These are very long dives. Most of the dives one could not do with a scuba cylinder but a chamber, of course, has an unlimited air supply.

The last dive on day two was to 45 feet for 92 minutes. The natural limit of the system was 92 minutes, so we went ahead with that for 45 feet instead of rounding it down. In the second group, it was not too much different. The pattern tends to repeat in order to increase the rigor of the test. When we got to dive number 24, the last dive in the series, we threw in an extra 10 minutes to round off to 100 minutes for the final dive.

If the surface interval was long, the subjects were monitored several times. The practice was that if there was any doubt about whether a bubble was observed, it was a Grade 1. If there was any doubt as to the magnitude of the grade, it was always scored as the higher. Every monitoring was taped, for confirmation by an independent observer, and this later confirmation revealed that Dr Powell was anything in the world but conservative. The true grades were probably lower than he reported.

Bubbling in phase 2

Over 90 per cent of the readings, despite the arduous diving, were Grade 0. We did not get any Grade 4 bubbling, and only small numbers of Grades 1-3. The most important thing of all is that there were no cases of DCS.

There are various ways to define how to score Doppler Grades. Table 4 is probably the most popular one world wide, the one we actually used. The definition of no-bubbles in 10 cardiac cycles for grade 0 is a little bit restrictive. Typically, if no bubbles were detected, Dr Powell would monitor somewhere between one and two minutes with his test probe and try to elicit the sound of a bubble. He was not checking for just ten heart beats and then taking it off.

TABLE 4

DOPPLER BUBBLE GRADES

Grade 0	No bubbles in 10 cardiac cycles
Grade 1	Occasional bubbles in 10 cycles
Grade 2	2 - 4 bubbles in some cycles
Grade 3	Several bubbles in every cycle
Grade 4	Bubbles are heard continuously

Before we began we tried to find out what data was available. There were a number of studies, that were all over the place, as far as results are concerned. Graphing decompression sickness as a function of bubble grades showed a high degree of inconsistency from one study to another. DCS increased in a highly variable manner with an increase in bubble grade, but they all had one thing in common: The DCS rate was relatively flat with grades 0, 1 and 2. The studies shown in Figure 2 represents three to four thousand dives reported over several years from a number of places, and almost every one of them involved stage decompression dives, serious heavy duty dives, sometimes on mixed gases,

TABLE 3

MULTI-DAY, MULTI LEVEL DIVES TESTED IN PHASE 2

Day	Dive	Level 1	Level 2	Level 3	Level 4	Surface interval	Total bottom time
1	1	120/13	71/11	50/14	35/13	80	56
	2	80/16	50/13	40/25		180	58
	3	60/48	35/54			180	106
	4	40/90				689	91
2	1	95/22	65/05	50/13	35/26	72	70
	2	70/22	40/37			180	63
	3	55/59				180	63
	4	45/92				716	96
3		90/25	55/09	35/40		87	78
	2	60/38				92	42
	3	50/61				180	65
	4	40/90				802	94
4	1	110/16	70/08	50/13	40/15	66	57
	2	75/17	50/11	35/55		180	87
	3	60/49	35/41			180	94
	4	40/90				682	94
5	1	100/20	65/06	50/13	35/26	80	70
	2	70/24	40/49			180	77
	3	50/73				180	77
	4	45/92				680	96
6	1	85/27	50/17	35/26		95	74
	2	65/31				117	35
	3	55/53				60	57
	4	40/100				-	104

all kinds of things that we do not do in recreational diving. These studies were of limited value to a recreational diving investigation. As for a database of known outcome in recreational diving, with its very limited depth/time exposure matrix, it was virtually non-existent In all the dives that have been Doppler monitored and reported, that I have been able to find, and I have looked long and hard, there are probably a maximum of two dozen which fit within recreational no-stop limits. So when comparing our testing compare with databases of known outcome, please keep this in mind.

I made a composite report, just for my own edification. I pretended that all the data that was available represented a single study. I added all the DCS together, all the subjects together, all the different Doppler events together and came up with a body of data just as if there had been only one study, and the arrow in Figure 3 points to the dramatic increase in DCS that occurs as one goes past grade 2 bubbling. Analyses have shown that statistically grade 2 is not much different than grade 1 in DCS incidence.

Bubbling was not the primary determinant we were following in our study. The primary determinant was the presence or absence of decompression sickness, with Doppler as merely a mechanism which permits us to fine tune a bit.

It is well known with Doppler monitoring that one can have signs and symptoms of severe decompression sickness without detectable bubbles. It is also well known that it can sound like Niagara Falls without developing DCS. But as a general indicator it does give a bit of sensitivity which does not exist,when one simply uses the presence or absence of decompression sickness as the end point. It gives us a little bit of extra data, and if one accumulates enough dives monitored in this way it can be helpful.

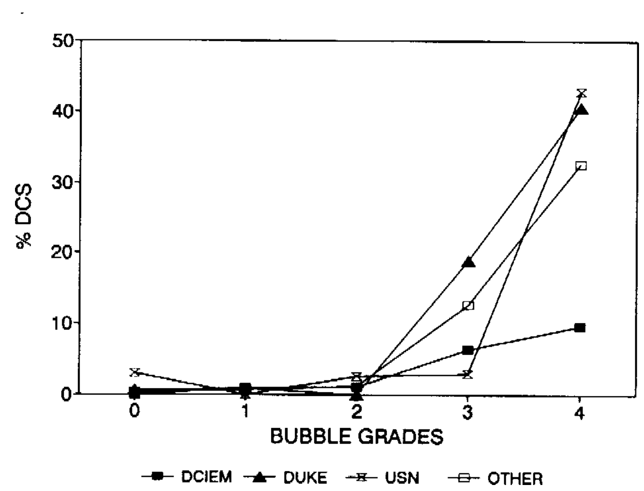

FIGURE 2 Graph of Doppler bubble grades and DCS from studies by the US Navy, the Defence and Civil Institute for Environmental Medicine (DCIEM), Duke University and others. Most of these dives were not the sort of dives done by recreational divers.

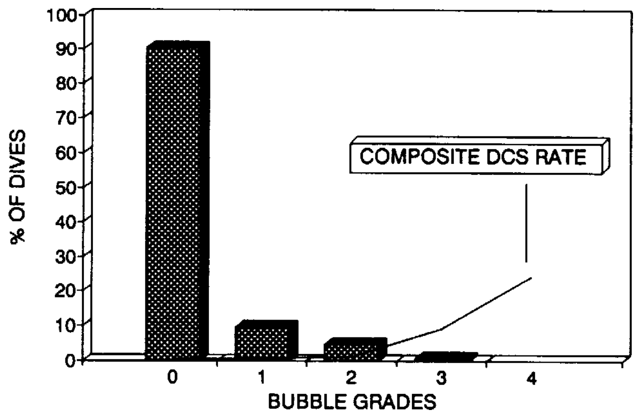

FIGURE 4 The bars show the bubble grades recorded in the IAPM multi-day studies. The composite DCS rate curve is from the combined studies shown in Figure 3. The curve rises at the point where the bubbles in the IAPM study virtually disappear.

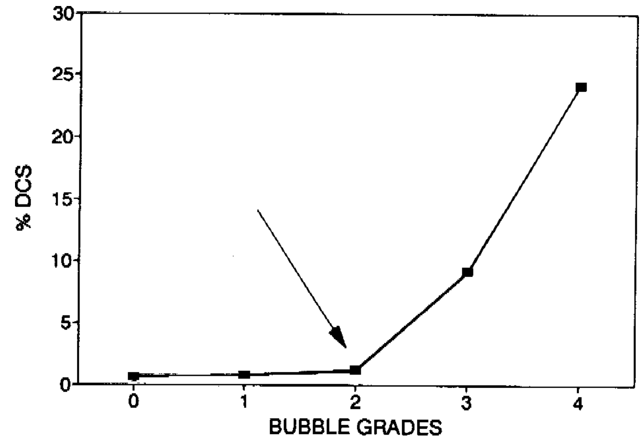

FIGURE 3 The studies of DCS graphed separately in Figure 2 have been grouped together to provide this graph. The arrow shows the bubble grade above which decompression sickness was more frequently recorded in these studies.

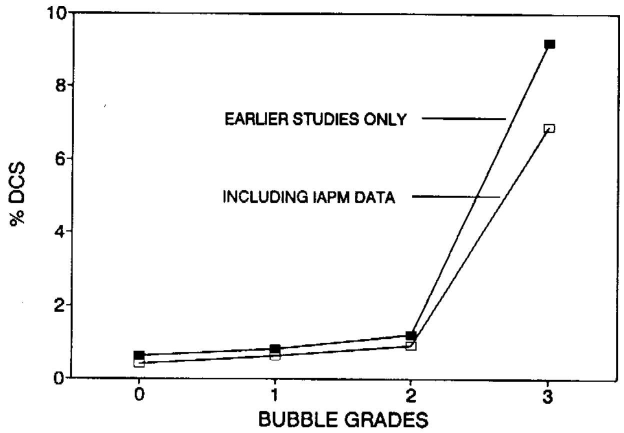

FIGURE 5 DCS incidence in earlier studies (top graph) is reduced by adding another 1,386 Doppler monitored dives (IAMP series) to the data base, but the shape of the curve is not changed.

Dr Powell monitored the subjects at rest, and then had them do deep knee bends and monitored them again. That would usually generate higher scores, but not in every case. The highest score that he was able to elicit was the one that was recorded.

There were only four subjects altogether who had grade 3 bubbles at any point in the dives, less than one percent.

I want to impress the point that there was a big change at grade 2. Figure 4 shows the bubble grades recorded at IAPM with our multi-day dives and the composite DCS rate curve from the combined studies. The curve begins to kick upwards, where it becomes an area of concern, at precisely the point where the bubbling in our study virtually disappears. I was happy with the outcome, but it was one that did not come as any surprise to us. We expected this, but it was necessary to demonstrate it.

We have had no cases of decompression sickness in the 1,386 dives, which have been When we add it in to the existing studies (Figure 5) the curve comes down. It does not change the character of the curve. Why did we do so much better than the other studies ? Some of them had shown up to 30 or 40 % decompression sickness. They were studying

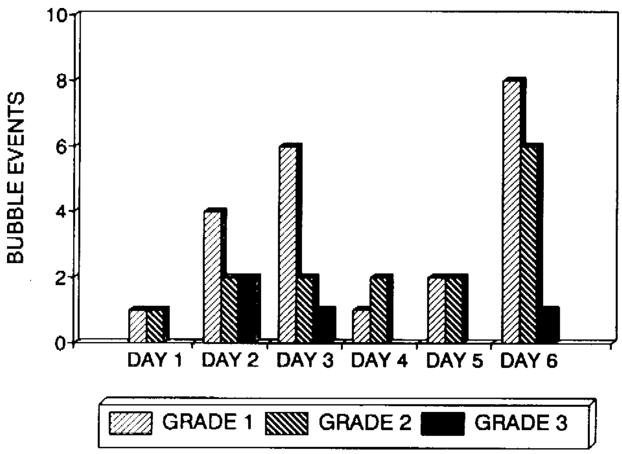

FIGURE 6 Number of bubblers and grades from day one to day six.

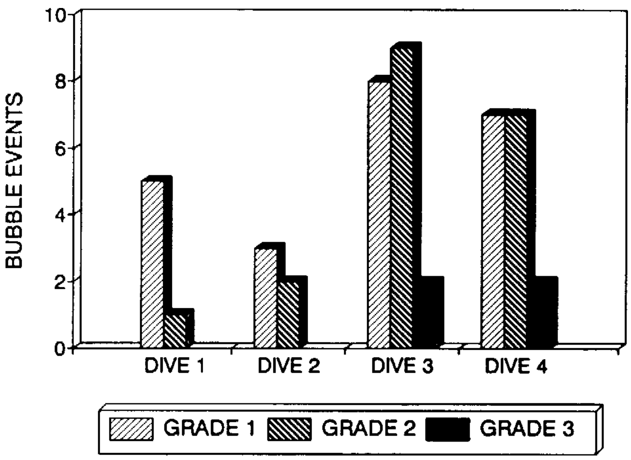

FIGURE 7 Total bubble numbers and grades, totalled for the six days, for each of the four daily dives.

staged decompression, severe exposures, mixed gases, etc. We were studying benign exposures, relatively trivial exposures, the kind of thing recreational divers can do every day. We made safety stops at 15 feet for 3 minutes every time, because the test design would take us to the no-stop limits, and had long surface intervals. In Phase 1 we did not do the stops. In Phase 2 we did routinely apply the stops, and when the rules which related to long surface intervals were relevant, they were also applied. The effects of these three things added together are what made the difference between this study and all those which preceded it.

What we were trying to determine was whether there is any trend if one went through six straight days of diving. For example could a dive, which is usually considered safe, become risky, just from sheer repetition, because one is doing it over and over again? That is what we wanted to find out.

I broke the results down by bubble grade. Figure 6 shows bubbles distribution from day one to day six. All the grade 1 follow an interesting pattern, they are approximately parallel to the number of multi-level dives, but since grade 1 is basically incidental bubbling, I do not think that means too much. It would appear from a look at grade 2 that there is a definite trend towards the end of the week, although very low, it appears to pick up towards the end. The vertical axis counts the number of events, actual occurrences, not percentages. There was some grade 2 bubbles, but they are only important due to their proximity to grade 3. Of the cases of grade 3 bubbling, three occurred early, and only one in the second part of the week. So I call that a random distribution of bubbles, and it would not appear from the available evidence to date that the feared trend was developing. But there is another way we can consider it.

Figure 7 shows each of the six days' dives, added together, and there does definitely seem to be a trend as one goes through the day, which was no great surprise. But to confuse the issue, it was not greatest at the end of the day, but appeared to peak at the end of the third dive and then fall off towards the fourth dive. Any statistician would laugh at conclusions drawn too strongly from this, as the numbers are so similar. But at any rate there was not a straight line increase across the board. It was a random pattern. So it does not look like a high risk situation.

Now (June 1990) in-water trials are in the planning stage. Every thing takes longer than it should, but it has been going for about a year trying to figure things out. Sometime toward the end of 1990 we will be doing in-water trials.

DAN in December 1989 recommended:

A maximum of four dives a day for six days and preferably no dive on the third or fourth day and

No more than three dives a day.

Why make that last recommendation ? Because we have already tested for three dives a day.

Will these recommendations be eased on the completion of the in-water trials? Assuming the in-water trials are as successful as everything to this point, will the recommendations be altered? Maybe, but it is not for me to decide. I suspect that they will not be changed. Table 5 shows how ideas, recommendations, concepts, and rules dribbled out on us, a piece at a time, as we learn more, as things evolve, and sometimes we forget how old concepts might be.

The idea of stopping at fifteen feet for three minutes is five years old in the PADI Divemaster instructional manual. Informally they recommended a safety stop a great deal earlier than that, but officially it has been in the book for over five years (Table 7). We have been hearing a lot about planning of dives ever since we heard that "Recreational

Dive Planner" would be the name of the instrument. Nowadays people are regularly talking about Dive Planning. Some people have always talked about it, but not many. One never used to hear about it as much as we do now. It is over two years since the multi-day limitations were introduced. Over two years ago the S.A.F.E.Diver campaign "Slowly Ascend From Every Dive" was introduced. In the middle of 1989 was the introduction of the idea, for the dinosaurs who just do not want to give up their beloved USN tables, which had been paid for, to at least mark them down to the limits which were tested in Seattle. Later in 1989 the 15 feet stop was extended to include all ascents to the surface.

Also in 1989, the limitation on deep repetitive diving were issued, once we found out there were crazy people doing things like making repetitive dives past 100 feet we said "Quit doing it, it is just not a safe practice."

TABLE 5

PADI'S EVOLVING PRACTICES

Mid 1985	Stop at 15 feet for 3 minutes
Jan 1988	Popularized term "Dive planning"
Mid 1988	Limitations on Multiday diving
Mid 1988	AFE Campaign (Slowly Ascend....)
Mid19 89	Reduced USN NDL's to RDP limits
Mid 1989	Extended 15/3 stop to ALL dives
Mid 1989	Limitation on deep repetitive dives

Sometime in the first quarter of 1990, there was a new rule that henceforth, if one goes past 130 feet in one's dive, that will be considered in the same category as exceeding the no-stop limit. It puts one in an emergency decompression status, and one should not dive for the next six hours, after one exonerates oneself with a 15 foot stop for 8 minutes. So we are getting quite bit stricter. With these established trends, it is highly likely that the limitations will remain.

Reference

1 Powell MR, Spencer MP and Rogers RE. *Doppler ultrasound monitoring of gas phase formation following decompression in repetitive dives.* Santa Ana, California: Diving Science and Technology Corporation, 1988.

This is an edited transcript of a lecture given at the 1990 Annual Scientific Meeting of SPUMS.

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AN INTRODUCTION TO PALAU'S REEFS

Steven R. Dent

Palau is one of the richest coral reef areas in the world. Biologists define a location's richness in terms of its biological diversity or the number of species inhabiting a defined area. Within Palua's 370 km^2 it is estimated that there are over 1000 species of fish and 700 species of corals and anemones.[1-3] In contrast, the fish fauna of the entire state of Queensland is believed to number approximately 1600 species[4], 1500 of which occur within the 332,000 km^2 of the Great Barrier Reef Marine Park.[5] A further illustration of this richness is the collection by marine biologists of thirteen new species and one new genus of fish on a Palauan reef during a two hour period. While this may not seem like a large number to some people, one needs to consider that annually there are only 75 to 100 new species collected worldwide.[3]

The reasons for this high degree of diversity are believed to be twofold; first the archipelago has a long history of a steady, tropical climate and second is the presence of a wide variety of habitats within a relatively small area. The 340+ islands are volcanic in origin and capped by porous coral limestones. Every type of reef structure is represented here. To the north of the inhabited islands are small atolls and bank reef areas. A barrier reef encloses the lagoon while fringing reefs grow along the shore of many of the islands. Within the lagoon are many patch reefs, seagrass meadows, level sand and mud bottoms. These habitats are further subdivided into microhabitats due to the porous nature of the reef and limestone. The blue holes, caves, crevasses and smaller interstices provide great spatial heterogenity and enable more organisms to exist in a smaller area. Freshwater run-off adds to the diverse habitats by producing streams and extensive estuarine mangrove habitats. There are also a number of lakes which range from freshwater to marine conditions.

The unique nature of this reef system was recently acknowledged by CEDAM (an acronym for Conservation, Education, Diving, Archeology and Museums) International when that conservation organization placed Palau on its list of the seven underwater wonders of the world. The New York based CEDAM recognized Palau along with the Great Barrier Reef, northern Red Sea, the Belize barrier reef, Lake Baikal in the USSR, the Galapagos Islands and deep ocean vent communities. Among the criteria used in selecting the sites were scientific research value, environmental significance, unique marine organisms, natural beauty, geological significance and how representative the site was of a particular region.

The corals that construct these reefs are animals whose tissues are packed with symbiotic algae. These algae, called zooxanthellae, combine sunlight, and wastes (carbon dioxide and ammonia) from the coral animal to produce oxygen and carbohydrates which are then used by both zooxanthellae and the coral polyps in growth. This interrelationship is extremely important to both participants since the clear, blue tropical waters in which they thrive are extremely low in nutrients. The zooxanthellae allow corals to flourish in waters which are virtually biological deserts. Zooxanthellae not only act as nutrient sources and waste removal systems, they also facilitate the production of the calcium carbonate skeleton secreted by the coral. Reefs are only produced by corals containing zooxanthallae as no other corals are capable of depositing enough calcium carbonate to build massive skeletons.

The hermatypic or reef building corals have very particular ecological requirements. They require warm, clear, relatively sediment-free marine water and a hard substrata. Clear water allows sunlight to reach the zooxanthellae. Water of low turbidity is also important because corals have only a limited ability to cleanse themselves of potentially smothering silt. The physiology of the coral requires salinities close to that of undiluted sea water and a temperature range between 16° and 36°C, although a range of 23° to 25° is most conducive to reef growth. For successful larval settling and growth, a hard, sediment-free substrata is needed.

Corals exhibit a wide range of growth rates and forms. These forms and their rates of growth vary between different species and even within the same species. Geographic location and water depth are among the major contributors to this variability. For example, some species form massive, boulder-like heads in shallow water, while other colonies of the same species which live at greater depths appear more plate-like. Generally the branching corals grow the fastest (5-8 cm per year) while the massive, boulder-like species may only add several millimeters of calcium carbonate per year.

Competition for space among corals and all attached reef invertebrates is very intense. Corals have developed aggressive reactions to organisms encroaching upon their territory. They extrude their digestive surfaces, termed mesentaries, out to cover competitors and digest them away.

Coral reefs are places where biology and geology become very entwined. The organisms fabricate the limestone and sediments and these, in turn influence the distribution of the organisms. Reefs are huge, shallow water accumulations of calcium carbonate (limestone) which are composed of several structural components. Corals construct the main framework. Voids within the framework are filled by small particles of calcium carbonate secreted by a host of different organisms: green algae, mollusks, foraminifera (protozoans), and the corals themselves. The most important producers of fill, based on volume alone, are the calcareous green algae. These plants are often not even noticed by most divers. Massive coral skeletons are turned into "fill" material by boring organisms (algae, sponges, worms, mollusks and crustaceans) and grazing mollusks, urchins, and fish. These assaults can be of a chemical or physical nature. Most boring algae and sponges dissolve away the host material while mollusks use a combination of chemical dissolution and mechanical abrasion to erode away a refuge or graze on encrusting algae. Urchins and fish all use mechanical methods of destruction. The mushroom profile of the Rock Islands owe their morphology to the combined action of these bioeroders. The unconsolidated fill material and framework are bound together by encrusting organisms such as sponges, soft corals, sea fans, tunicates (sea squirts), colonial anemones, and calcareous red algae.

The fish fauna of coral reefs is what initially attracts the majority of divers. As mentioned above, Palauan reefs have a myriad of colorful and interesting fish. The clear water of coral reefs is believed to have greatly contributed to the evolution of reef fish colors. Good visibility allows fish to rely heavily on visual cues, unlike fish from dark or turbid waters which must depend upon olfactory, auditory, and gustatory cues to differentiate potential mates, meals and predators. Colors allow fish to discriminate between individuals of the same species and determine the reproductive state of another fish. Reds and oranges can act as warning colors, as with the poisonous butterfly cod. Other fish will change colors to produce a threat display or disrupt its outline among the corals. Some fish have markings which resemble eyes on their posterior flanks that are suppose to confuse potential predators as to which end is the head. A related ploy is to have a dark colored bar across the eye to obscure it.

The reproductive behavior of reef fish is quite varied. The majority of parrotfishes and wrasses have the ability to change their sex. These populations are divided into two groups; the initial or primary phase individuals (male and female) whose sex is immutable, and the terminal stage or secondary phase males which are transformed females. Such changes are controlled by the social structure of the school, the presence of a secondary phase males suppresses sex changes in other females. If these males are absent or low in numbers, the dominant female will transform into a male. Some groups, such as clownfish are protandrous hermaphrodites, beginning life as males. A typical group consists of a single reproducing pair and numerous sexually immature individuals all associated with an anemone. The largest fish is female and, if it should disappear, the mature male changes to a female while the largest juvenile becomes the next sexually mature male.

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This paper is based on a lecture given at the 1990 Annual Scientific Meeting of SPUMS at Palau.

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EDITED QUESTION AND ANSWER SESSION.

Q How can man stuff it all up? Have they any program here to prevent him from doing it?

A As far as damaging the reef? Development impacts on reefs largely by making changes in freshwater run-off. If there is an alteration in an area's drainage pattern additional freshwater inflow and silt can kill off coral. Also an increase in sewage effluent is another major contributor to reef problems. Sewage provides additional nutrients that stimulate algae blooms. These blooms can kill existing coral by overgrowing it and exclude coral larvae from recolonizing an area.

Snorkelers and scuba divers can and do damage reefs. Indiscriminate anchoring practices by vessels contribute to coral destruction. Divers have a negative impact by walking, kneeling or resting their hands on live coral. Corals are quite susceptible to physical damage, being simply thin layers of tissue overlaying a hard skeleton which has numerous sharp protrusions. Any pressure upon the coral polyp squeezes it down on to the skeleton resulting in tissue damage. Sometimes the wound may heal, but often the site becomes infected and the death of the entire colony can result. High concentrations of divers are blamed for extensive damage to popular reefs in many parts of the world.

Q I believe the Crown of Thorns starfish did a lot of damage here for a while. What is there that can deal with the Crown of Thorns in areas where it is a real problem?

A Unfortunately, most of my experience has been in the Caribbean so the following information is based only upon what little I have read. Some people believe that the outbreaks are natural fluctuation in the population, based on geological studies of starfish remains within the sediment. However, this type of study is hard to do, because often areas of unconsolidated sediment will be churned up by the actions of burrowing organisms. As far as controlling the starfish, the only method I know involves divers hunting down and injecting starfish with a copper sulfate solution. This technique has been found to be impractical because it can cover only a limited area and is very labor intensive.

Q Many of the fish are obviously very voracious predators but there was not a single sign of one fish eating another that I could see. Is this because it is not feeding time? Or conversely, why the hell are they all so busy?

A First, they are probably very busy trying to dodge predators. Fish are looking for food and trying to avoid becoming someone else's dinner. Generally, an assemblage of reef fish can be divided into diurnal and nocturnal components. During the day one set of fish are out and about while the nocturnal shift rests within the reef. Shift change occurs and the most active feeding periods coincide at sunrise and sunset.

Q Another thing I noticed was that none of the smaller fish seemed to be concerned with the bigger fish. They were not moving out of the way at all.

A Many of the smaller fish and even quite a few of the larger fish we see feed on the small drifting organisms (plankton) or particulate matter. You see the smaller fish move into the cover of the reef only when a large groper or another predator swims into an area. They seem to recognize who has an interest in them and who does not.

Q Why are there corals in the cooler waters off southern Australia?

A While I do not knowing the specifics, two possibilities do come to mind. The first involves temporary range extension of a species. It is important to remember that animals do not always do what you expect. For example, on the Texas Gulf coast we have reef fish living close to shore during the summer. Many of these animals arrive as planktonic larvae transported in seasonally by currents from the tropics. Mild winter weather will make conditions favorable for the survival of these new arrivals and they may be present for a year or more. When the normal winter conditions return these animals perish.

There are also cold water corals, however they are generally smaller and do not form reefs like their tropical cousins. I have dived off California and seen such cold water corals, so perhaps the southern Australian ones are related to those.

Q We were told that the jellyfish in jellyfish lake do not sting. Is it true and why have they lost that ability? Also, why are some people more sensitive to stings than others?

A The sting strength can often be relative, at least with the less venomous Caribbean types with which I am familiar.

For instance, jellyfish have not stung my hands but have stung me on the face and chest. The jellyfish in the lake are rather unique from what I have read, and do not sting. Whether or not they have lost the stinging ability due to a lack of predators in the protected lake environment is a matter of speculation. These jellyfish contain zooxanthellae similar to corals. The zooxanthallae provides nutrients for the jellyfish and may make the animal less dependent upon the stinging cells for trapping animal food. This dependence on sunlight explains the jellyfish's movements around the periphery of the lake following the daily path of the sun.

Q So they are no longer carnivorous?

A I do not know, they may just rely on photosynthesis.

Q We observed a fish closely following a stingray along the bottom, why was it doing that?

A The ray may have been feeding along the bottom and stirring small crustaceans out of their hiding places in the sediment. This would make them easy prey for the fish. The process is analogous to birds following large grazing animals and feeding on the insects disturbed by the grazers.

Q The giant clams appear to be nestled down in the reef rock, are they using a chemical means of boring?

A I think the giant clam's boring habit is more a mechanical.action of grinding its shell back and forth. The planktonic larvae most likely find a small depression in the rock soon after they have settled. They continosly rock back and forth as they grow and gradually enlarge the hole. They may also have a chemical agent to dissolve the rock, but I do not know. There are other types of boring clams in the coral and rocks around Palau which do use a chemical method to excavate a dwelling space. These clams extend their gallery by first applying a specialized portion of their body to the rock for several hours. Next the body is retracted and the softened rock is scraped away with its shell..

As an aside, the giant clams contain zooxanthellae within their tissues. This is also believed to impart a great advantage to the clams and may be a great contributor to the clams ability to attain such a large size.

Q After an ecological disaster, how long does it take for coral to regrow?

A It is hard to say since the rate of coral growth varies with a number of factors, among them run-off, silt, predators, water depth, and if the agent that caused the disaster is still present. Even if conditions return to what they were prior to the perturbation, regrowth will be a matter of years. Remember, the fastest growing corals are only increasing by a matter of centimeters per year, while others are only enlarging by millimeters. So it may take a period of ten years, maybe 15 to 20 years or much longer to return to its former state.

Q All the corals died some years ago around Morea in Tahiti. That was quoted, by the locals, as being due to freshwater runoff. I just wondered if there is a sewage element there.

A It is possible, but I have not been there. I have heard someone mention a while back that the reefs around Tahiti were damaged by a typhoon dumping large amounts of freshwater on the island, and which in turn, ran off into the reef.

You can see the effects of adverse water conditions on local reefs. Yesterday I had lunch at Turtle Cove and did some snorkeling. There was an area where the tide was draining off a very shallow intertidal flat. The bottom from the flat and to the edge of the dropoff had very little coral on it, however, 10 meters on either side of it was profuse coral growth. I imagine after heavy rains during a low tide a considerable amount of freshwater would drain out through here also.

We stopped in Guam on the way over and snorkeled in one its small bays. Several hours prior to this there had been intense rains on the island and we could see and feel cooler freshwater welling up through the sand.

Q You are probably aware that there are areas of the Great Barrier Reef that are denuded of coral. Will this regenerate, or will the coral go elsewhere?

A Great Barrier Reef corals all seem to spawn at one time. This results in huge quantities of gametes in the water providing many new potential colonies. I would guess that as long as the large concentrations of the Crown of Thorns are absent from an area it would regenerate as long as there was nothing else disturbing the environment. Sometimes a coat of algae will develop and it may prevent the coral larvae from settling and growing. If conditions are favorable the corals should grow back, however it may take 10 to 100 years.

A final recommendation, as a biologist and diving instructor, to enhance your coral reef diving experience. Take your time, swim slowly and look carefully. These actions will reduce your air consumption and allow you to observe and approach smaller fish and invertebrates. It also makes a great way to spend your time during a safety stop.

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depths that are safe from this aspect breathing air. He also covers the unwisdom of diving with air and with Nitrox on the same day. The problems of achieving the correct mixture in the diver's scuba cylinder are well covered, as are those of using incorrect mixtures and ad hoc mixing techniques.

It is an interesting book and easy to comprehend. I hope that, when Nitrox for recreational divers arrives in the South Pacific, there will be available a metricated version of this book, for otherwise our hyperbaric units are in for more work.

John Knight

ARTICLES OF INTEREST REPINTED FROM OTHER JOURNALS

DECOMPRESSION SICKNESS IN FISH FARM WORKERS: A NEW OCCUPATIONAL HAZARD

J.D.M.Douglas and A.H.Milne

Fish farming is a new industry that needs divers to maintain the cages in which the fish are kept. Dead fish in a cage provide a focus of infection for healthy fish and must be cleared out regularly. Some fish farmers think that the most effective method of clearing dead fish is with divers, but this new diving practice also has its problems. We report three anomalous cases of decompression sickness.

The medical problems of compressed air diving are reviewed elsewhere.[1] Decompression sickness is caused by the release of dissolved nitrogen from tissue during and after the ascent phase of the dive. The principal manifestations are joint pain or impairment of central nervous system function shortly after surfacing. Delay in starting recompression treatment may cause spinal paraplegia or cerebral damage. Using decompression tables reduces the likelihood of decompressions sickness by predicting ascent rates and stoppages for given times and depths.

Case reports

CASE 1

In a series of nine descent and ascents and from 18 m without decompression stops, dived and cleared six cages and after a surface interval of three hours cleared the other three. His total time in the water for the nine dives was 44 minutes (figure). His subsequent neurological and musculoskeletal decompression sickness was successfully treated with hyperbaric oxygen according to the US Navy table No. 6.

CASE 2

Five descents and ascents to and from 15 m took diver 2 a total of 48 minutes and were completed without decompression stops. Subsequent musculoskeletal decompression sickness was successfully treated with reference to US Navy table No. 6.

CASE 3

Over two weeks diver 3 made 14 dives a day in rapid succession with no decompression stops. The first six dives were to 18 m with an average time spent on the bottom of 10 minutes, followed by eight dives to 9 m with times spent on the bottom ranging from five to 10 minutes. He continued to dive to this pattern despite developing neurological decompression sickness. When his illness was brought to medical attention he was successfully treated, 56 hours after surfacing from his last dive, according to an extended US Navy table 6 and had follow up hyperbaric oxygen treatments.

Comment

Three professionally trained divers followed widely used decompression tables but sustained decompression sickness from depth considered shallow and from total times at depth within safe limits for a single descent and ascent. Repeated descending and ascending along the series of cages was the factor that caused decompression sickness.

The absorption, distribution and release of nitrogen from the body during a dive with normal air is a complex event. Doppler studies have shown that "symptomless" bubbles are formed even after shallow dives, which do not cause decompression sickness.[2] On "yo-yo" diving, on subsequent descents bubbles may not be completely returned to solution, and they may become coated by clotting proteins.[3] These rheological seeds may grow more quickly with subsequent dives in a sequence and cause tissue damage through embolisation of blood vessels. Symptomless patent foramen ovale causing arterialisation of bubbles has been postulated as a mechanism of bubble distribution,[4] and clinical studies suggest permanent neurological deficits may remain after treatment for decompressions sickness.[5]

The long term health hazards of diving are not completely known; we believe that the diving techniques used in fish farming are dangerous. A dive conducted while the increased nitrogen from a preceding dive is still being off loaded introduces a more complex pattern into decompression than is catered for in current decompression procedures.

Fish farm diving carries risks from contaminated water and from net entrapment, which has already resulted in the death of a diver. These problems can be eliminated by fish husbandry methods that use special nets rather than divers to clear dead fish.

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SHOULD ONE DIVE ALONE?
The unexpected risk

Dennis Graver

Note by the Editor of Undercurrent.

It is no secret that an awful lot of divers dive alone. Some shun buddies outright. Others ostensibly enter the water with buddies, but pay little attention to them. Photographers keep their noses in reefs, only occasionally paying attention to whomever they are diving with. On many liveaboards, as soon as two divers descend, allegedly as buddies, they split and do their own thing. Diving alone is reality.

Although we first wrote about it ten years ago, solo diving is not taught and it is seldom discussed. Only recently have general publications tackled it. Most recently, Bill Gleason has editorialized about it in Skin Diver and it has been discussed in the pages of NAUI's forum.

Dennis Graver, former NAUI Director of Education and former PADI Director of Training, has agreed to give us his personal views about safe solo diving.

Diving alone has been a controversial topic for many years. Proponents claim that many divers engage in the practice, that instructors with students are essentially alone, and that diving alone is preferable in some instances. Those who oppose the concept base their opinion primarily upon traditional safety practices.

What are the risks of diving alone? Entanglement? Entrapment? No air? Equipment difficulties? Being swept away by a current?

While these are concerns, the real issue is potential loss of consciousness, which can occur for many unforeseen reasons. I know of divers who have been knocked out when struck on the head by anchors or weight belts or who have been swept against a rock by strong surge. No matter how much experience a diver might have, as he ages he becomes increasingly susceptible to heart irregularities which might suddenly incapacitate him. Furthermore, over exertion by an over-zealous diver is sufficient to cause blackout.

So, this very significant factor of loss of consciousness must be kept in mind when considering diving alone. There would be no buddy around to render aid before you would drown.

Regardless, a lot of divers want to dive alone. They feel they need to do things where they believe a buddy interferes with their objectives, (hunting and photography, for example). Divers also want to dive alone because the buddy system is a hassle and difficult to execute properly. Solo divers feel they often have buddies who are a liability rather than an asset. The bottom line rationale to diving alone is to experience aloneness, which to some people, is a deeper level of freedom.

There are ways for a good buddy to enhance hunting and photographic efforts. There are buddy system techniques that allow divers to remain together successfully. Yet, the diver in search of the exhilaration of aloneness rejects buddies under any circumstances.

Do divers have the "right" to dive alone? Some divers feel they should be permitted to dive alone because they are not endangering other divers. Those who disagree say that those who dive alone pose a risk to those who have to assist or rescue them because they do not have a buddy.

Even if we accept that people have the right to dive solo, the right is not a straightforward matter, it is circumstance-dependent. The following are circumstances, in my view, under which solo diving might be considered appropriate.

1 The diver is well-rested, well-nourished, physically fit, in excellent health, and completely free of the effect of residual effects of drugs, alcohol, illness or medication.

2 The diver is familiar with the area being dived.

3 The diver has a leadership rating or substantial diving experience (more than 100 dives) in a wide range of conditions.

4 The diver is equipped for self-reliance according to the circumstances: e.g., a back-up air supply for deeper dives.

5 The diving conditions are good, for example no strong currents.

6 The diver refrains from diving alone when in the presence of students in training and newly-certified divers. This is done to avoid setting a bad example for those who need to dive with a buddy.

7 The individual clearly establishes that he or she accepts any and all risks associated with diving alone. He or she signs a statement to that effect.

This would mean divers could choose to accept the risk of diving alone when in a group of experienced divers if they let everyone know they accepted full responsibility, if they were physically fit and healthy, if they were properly equipped, if they knew the area, if the diving conditions were not hazardous, and if they had the documentation to prove their self-reliance as divers. It also means a diver could legitimately accept the risk of diving totally on his or her own with no one else around. (And, it might also be desirable to add to the list the wearing of a helmet to prevent head injuries from causing a loss of consciousness).

Now, suppose the practice of permitting solo diving when the suggested criteria were met were established. It could remove the criticism of those who choose to dive alone or who ignore buddy system procedures. It would transfer the risks of solo diving to those who choose to engage in the practice. It would establish when and where such behaviour is appropriate. It is quite likely the advantages of such a practice would outweigh the disadvantages of the current situation in which the buddy system is routinely violated or ignored.

If divers do have the right to take risks, and if they are willing to accept increased risks, it seems appropriate to permit solo diving based upon clearly-defined criteria.

But, until criteria are developed and approved by authority, divers will continue to dive alone in violation of accepted practices. Because of liability reasons, they will continue to be discouraged from doing so by charter boats, training agencies, and others to whom the liability for injury and death might extend. In a court of law, the buddy system is firmly entrenched as the proper diving procedure.

So, think long and hard before you consider accepting the risk of diving alone. If you are an experienced diver who meets the above criteria, you may be able to handle most of the problems you might face. However, as a solo diver, should you fall unconscious while underwater, remember: you are out of luck.

Note

The opinions expressed in this article are the personal views of Dennis Graver and do not represent the position of any diving organizations.

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The address of UNDERCURRENT is P.O. Box 1658, Sausalito, California 94965, USA.

RESCUING YOUR BUDDY WHEN YOU'RE NOT TRAINED TO DO IT

Dennis Graver

If you have not taken a rescue course and are not certified as a rescue diver, what will you do if a serious diving emergency occurs?

These are the actions to take. They are not a substitute for rescue training, which I recommended for all divers. But, the information may prove invaluable until you are able to acquire rescue certification:

1 See if the person is OK. If you suspect a person might be in trouble, shake him or her. If no response, take immediate action.

2 Make the victim buoyant. Pull his or her weight belt clear and discard it.

3 If the victim is submerged, get him or her up. Do not worry about air expansion. An unconscious person will not embolize.

4 Control your own rate of ascent. If you get bent, you won't be of much use to the victim. When decompression sickness is a concern, send the victim up, then follow at a safe rate of ascent.

5 Open the victim's airway. Tilt the head back. Often this is all that is needed to allow the person to breath.

6 Look, listen and feel for breathing. Look at the victim's chest while you put your ear next to the person's nose and mouth to listen and feel for the movement of air.

7 Perform rescue breathing. If the person is not breathing, seal your mouth over the victim's mouth and breathe into it. Blow, firmly, but not forcefully. Watch the chest rise. Allow the victim to exhale, then inflate him or her again at a rate of one ventilation every five seconds. In the water, two ventilations every ten seconds may be more effective. Keep water out of the victim's mouth. If water enters, turn the head and drain the water before ventilating the person again.

8 Call for help and begin towing the victim to the boat or shore. Put one hand behind the victim's head and the other on the forehead and begin kicking. This head tow allows you to continue ventilating the victim while towing him or her.

9 Administer oxygen if possible. Oxygen is desirable first aid for any serious diving accident. As soon as the victim is breathing, administer oxygen in the highest possible concentration. It is not difficult to operate an oxygen system. Get someone to show you how, before you need to use the unit.

10 Get the victim medical attention. Even if the victim recovers and says he or she feels fine, any diver who has lost consciousness in the water should be examined by a physician. If medical assistance is not readily available, monitor the person closely and continuously and request that the boat or resort call for immediate medical assistance.

These simple steps can mean the difference between life and death. Visualize them in your mind until you are familiar with the sequence. If an emergency does occur, you will have a plan of action by simply recalling ten basic steps.

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The address of UNDERCURRENT is P.O. Box 1658, Sausalito, California 94965, USA.

By Ed SPUMS J

We hope that this is an unnecessary reprint, but years of teaching First Aid to hospital medical and nursing staff does not fill us with confidence that every reader of the Journal would be at ease helping a diver in trouble.

The following paper is simplistic but the report from the Alfred Hospital Hyperbaric Unit printed on pages 135-142 shows that far too many divers require treatment for a decompression illness.

WHAT NOT TO DO AFTER DIVING

Richard Vann and Chris Wacholz

Will exercise or beer bend you?

Conventional wisdom has it that certain activities following diving can be detrimental to one's health. This wisdom is based, in part, upon theory and anecdotal experiences tending to lend a scientific cachet to them. Most have not been studied in a controlled, experimental manner. We sought the facts in interviews with Dr Richard Vann and Chris Wacholz at Duke University's Diver Alert Network.

Valid concerns

NO EXCESSIVE EXERCISE PRIOR TO OR FOLLOWING A DIVE

A rule of thumb is no heavy exercise for six hours before or 12 hours after a dive. Excessive exercise can include: weight lifting, jogging, high-impact aerobics, mountain climbing, heavy stair climbing, active swimming or a hard game of basketball.

Heavy exercise creates a high demand in muscles for oxygen, drawing it from the bloodstream and leaving a higher concentration of nitrogen. Furthermore, the friction or shearing action of muscle against muscle and tendon against muscle creates a void that is filled with both oxygen and nitrogen. The end result can be a higher potential for bubble formation and decompression sickness.

NO MAJOR CHANGES IN ALTITUDE FOR 12 HOURS FOLLOWING DIVING

Actually, the rule that now obtains is that one may fly commercially four hours after a single dive lasting no longer than one hour to a depth not greater than 60 feet. One should wait 12 hours if there is a different dive profile.

A 24-hour wait will not hurt. Some people susceptible to DCS have demonstrated bends systems after 24 hours.

A great risk is evident if one changes altitude immediately after a dive. Wacholz reports that last year two cases of bends occurred after a 1000-foot change in altitude immediately after diving. It can happen in California by driving home over Donner Pass after diving in Lake Tahoe. It can happen on Maui or Hawaii after diving in the morning and taking a drive up the volcano. Or on Saba by taking a mountain hike after a dive. David Day, one of our readers, stayed in Saba at Scout's Place, 1600 feet above sea level. "Now I know what the pain in the shoulders was about one night", he reported.

Many Bahamas operations are flying people to Miami on private craft directly after diving. DAN recommends altitudes no greater than 800 feet.

Questionable Concerns

NO CONSUMPTION OF ALCOHOL OR CAFFEINE FOLLOWING DIVING

This is still up for grabs. One theory is that both caffeine and alcohol are diuretics and tend to increase the body's outflow of liquids. As liquid is lost, there is less volume of blood to carry off gases. Platelets, which carry the gas bubbles, tend to clump, so the bubbles tend to link up into larger bubbles and create problems.

Compounding the diuretic action of either caffeine or alcohol is the diuretic effect of immersion (creating urine which is expelled) and from breathing the dry air in the tank. Thus the body is already somewhat dehydrated prior to the consumption of either caffeine or alcohol. Under this theory cola drinks, coffee, tea and hot chocolate are suspect.

The folks at DAN point out that there have been no controlled experiments to determine the validity of this theory. But they are quick to advise that alcohol does have an adverse affect on both mental and physical performance. So if you consume alcohol do it after the last dive of the day and do it in moderation.

NO HOT SHOWERS, HOT TUBBING, SAUNAS, OR STEAM BATHS FOLLOWING DIVING

There is little or no evidence to support the notion that these activities bring about DCS. The theory is that heat is a vasodilator, thus expanding blood vessels in the heated area while increasing blood flow. This creates a greater potential for DCS by forming a pocket in the warmed area for the collection of nitrogen.

NO CONSUMPTION OF CARBONATED BEVERAGES FOLLOWING DIVING

This is not supported by any valid theory. It was once assumed that carbonated beverages increased "bubble formation" in the blood and thus were a no-no. However, carbon dioxide is highly soluble and is also expelled rapidly.

Conclusion

Underlying all DCS problems is the lack of experimental data. No one knows what each individual's physiological propensity for DCS is, nor how it may vary from day to day. As more data is gathered we can anticipate that more useful guidance will come about. But until that time, common sense is still the best preventative program.

And this common sense should be extended to the use of computers as well as with the Navy tables. While DAN has noticed an increase in DCS among those who use computers, they also point out that the overall incidence of bends has not dropped since computers came on the scene. Thus it appears that divers are still diving close to, or at, the limits of no decompression.

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The address of UNDERCURRENT is P.O. Box 1658, Sausalito, California 94965, USA.

ALL YOU NEED TO KNOW ABOUT DIVE COMPUTERS AND THEN SOME

Since the advent of dive computers, I have listened with intense concentration to various experts tell me why their computer is the best. They told me about how 12 tissues computers are better than 6. About how tissue half times are the controlling factors in decompression now and M values as they relate to bubble formation.

Rather than clarifying things, each expert seemed to confuse me more. I felt like Boswell when he said, "Thank you sir, you have just explained Latin with Greek."

Thanks to Ken Loyst's new book, *Dive Computers: A Consumer's Guide to History, Theory and Performance*, it's no longer Greek. Not only has he demystified much about the theory of these devices, but also he has proceed to evaluate 24 computers, telling what's right about them - and what's wrong about them. Loyst, who is the publisher and editor of the magazine Discover Diving, enlisted the able assistance of co-authors Karl Huggins (a co-developer of the Edge computer) and Michael Steidly (who co-authored an earlier version entitled *Diving with Computers*).

To understand what computers are attempting to accomplish, it's important to understand "tissue theory" and to recognize that "tissues" do not exist, per se. They are theoretical constructs, created to justify and explain how decompression theory works.

Decompression theory is not a natural law, not yet anyway, and so the notion that there are 6 or 16 tissues and that they saturate with nitrogen at certain rates is only a theory that scientists use to build decompression models. The only thing that is really known is that if someone is exposed to pressure for a given length of time he may get decompression sickness. Then again, he may not.

These various computers use different mathematical models to attempt to replicate what the designers of each think may be happening to the human body underwater. Anyone relying on a meter to prevent DCS should keep in mind one sentence from this book, “All any of the models attempt to do is keep most divers safe most of the time.”

With these notions in mind, it’s interesting to review Loyst’s chart comparing how each computer defines “half times” (i.e. the theoretical amount of time it takes for a specific tissue to fill half way with nitrogen). For example, Orca’s computers presume 12 tissues, with half times ranging from 5 minutes to 480 minutes. The Aladin Sport and Aladin Pro presume 6 tissues with half times up to 320 minutes. The U.S. Navy Tables presume 6 tissues with half times up to 120 minutes.

Say Loyst: “Some researchers question weather (sic) the 120-minute tissue half-time (U.S. Navy) is applicable to multi-day, multiple diving. Some slow tissues may take 48 hours or more to decompress,” while the Navy tables presume a diver is free of bubbles in 12 hours (multiplying the half times by six to get the decompression time means that Orca goes to 48 hours, Aladin to 32 hours).

Loyst continues with guidelines for using computers, a description of multilevel diving, and a valuable chart on power sources and maximum battery life: Orca Delphi, 750 hours and replaced by the user; Beuchat Aladin, 6-7 years and replaced by the factory; and the Tekna Computek, 1500 hours and replaced by the user.

He includes information on using computers at high altitudes, flying after diving (24 hours between multiple dives and flying), and treatment of bends.

The section readers may find most interesting and useful, contains the descriptions of each computer, their construction, power activation, features, price, and limitations. No punches are pulled. To give you an indication of the depth, candor, and nature of the analysis, let me offer Loyst’s comments about the Aladin Series:

Aladin

Activation must be performed correctly or it will go into an error mode.

It does not scroll no-decompression limits before the dive. This irritating when planning subsequent dives because there is no indication of how much time is available for each depth.

There is no ascent indicator warning for exceeding the Aladin specific rateof 33'/min. Depth is displayed in feet of fresh water, not sea water like most dive computers.

The manual provided with the Aladin has instructions showing functions in meters but the computer displayed in feet. This can lead the user to confuse important information such as decompression stops.

The no-decompression time available during a dive is expressed in a minus number. All other dive computers express time remaining in numbers without signs and decompression stop time is usually shown in minus numbers.

There is no indication of how much time must be spent at each decompression stop. The dive computer is not recommended for decompression diving.

The manual is very small and not very complete.

Aladin Sport

A much improved version over its predecessor is the Aladin. It has fixed all of the items listed under remarks except there is no time for five for decompression stops.

There is no total ascent time given. If a decompression profile is indicated, the Sport will not give total time required to surfaced nor will it give you the required time at each stop. Not a total decompression dive computer.

The manual provided with the Sport shows examples in meters and the computer displays in feet. These inconsistencies could prove confusing.

The Wait to Fly indicator does not indicate how long to wait before flying. The Sport must be monitored until the no flying icon fades from the display.

The Aladin Sport must be put in the Dive Plan mode for it to show no decompression limits and surface interfaces. It does not automatically scroll these limits as other dive computers do.

Aladin Pro

The best of the Aladin line from Beuchat and one of the most sophisticated dive computers on the market. A very good choice for advanced divers.

Waiting time prior to flight is calculated to 8000 feet and tends to be shorter than the current recommendations.

A (sic) excellent dive computer for high altitude, decompression or repetitive diving.

In addition to these three models, Loyst analyzes 21 other computers that entered the market prior to the 1991 DEMA show.

About the only drawback to this book is the lousy proof reading. Loyst reports that to meet a printing deadline to have copies available for the DEMA show last February, they burned the midnight oil. They didn't burn it long enough. If you're one of our loyal readers who have scoffed at Undercurrent's errors, the mistakes in this volume will make our proof reader look keen-eyed.

Other than that, if you're a computer diver or about to become one, the book is a must. If you're a skeptic, this book will convert you.

Order from Atcom at 2315 Broadway, New York, NY 10024, U.S.A., for $US 12.94 plus $US 4.50 shipping and handling.

C.C.
Travel Editor *UNDERCURRENT*

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REPORTS OF INTEREST

THE THIRD CONGRESS OF THE INDONESIAN HYPERBARIC MEDICAL SOCIETY HELD AT SURABAYA , INDONESIA, NOVEMBER 2nd AND 3rd, 1990

David Davies

For the several years that I was Secretary of SPUMS, I wrote regularly to the president and the Secretary of the Indonesian Hyperbaric Medical Society (IHMS), trying negotiate a joint meeting with SPUMS. Communications have been slow, repetitive and, at times, quite frustrating. To try stimulate a little activity I asked Geoff Skinner to call into Jakarta on his way back from the Maldives in 1990 and make contact with the President of IHMS, Dr Prayitno, but the meeting never came to fruition. However Geoff did get quite a lot of information about accommodation, venues and organization while he was there.

Late in October 1990, I received an invitation to attend the IHMS Congress as Guest Speaker. I noted at the time that the letter had taken nearly a month to travel from Jakarta to Perth. Fortunately, I was able to accept the invitation and there was then a series of frantic telephone calls and faxes to arrange flights and accommodation. Considering the time and practice constraints, the only convenient route was to fly to Singapore, overnight there and then on to Jakarta and Surabaya the next day.

I wrote to the Secretary General of IHMS, Dr Sasongko, accepting his invitation and posted this, at a cost of $18.00, to fly special, urgent overseas delivery (guaranteed by Australia Post to be in Jakarta in two days). That letter arrived the day before I was due to depart, so they knew I was coming. I had tried to ring Dr Sasongko by every means known to Telecom but he was never at the number I had been given so there were messages left all over Jakarta. A fax arrived, sent from a real estate agent's office, acknowledging my acceptance and suggesting a couple of topics for my talks.

After one and a half hours delay in leaving Perth, the plane arrived in Singapore around midnight. So I got bed about 0100. The Jakarta flight left early so I was back at the airport shortly after 0600. Thereafter, things started looking up. I was met in Jakarta by a young Naval Medical Officer who expedited my transfer across to the domestic terminal and in a rather ingenuous way pumped me for information. Similarly, at Surabaya, I was greeted by three Naval Officers who escorted me to the hotel and on to the conference venue.

There, I met the office bearers of the Society and we then held discussion over lunch as to what they expected of me and for how long I was expected to talk. We also discussed the possibility of a joint SPUMS/IHMS meeting in 1992 or 1993. I had to be a bit cagey here as they wanted me to make a definite commitment, both of time and venue, but I did lay down what we required in the way of accommodation, conference facilities and diving.

In the afternoon I attended the later half of the one day refresher course in diving and hyperbaric medicine. All papers were presented in Indonesian but many of the slides were in English which made the whole thing much more comprehensible. The Indonesians, especially at this level of education, read and understand English but they may have some problems with expressing themselves. There are also many words of jargon in medicine that are untranslatable into Indonesian so it was not too hard to understand the gist of the talk though the finer details were lost.

Further discussions were held during the course of the afternoon on SPUMS' requirements for a joint meeting, where it should be held and what we needed for the diving side. I expressed the desire that they come to our meeting in the Maldives in 1991 to see what we do and hear what we say. Many present expressed a wish to join SPUMS so I undertook to send Dr Sasongko a pile of application forms.

The conference itself was held on Saturday and started promptly at 0800. The talks were broken up into units of four followed by question time. Questions were all presented in written form so that while one member of the group was speaking the others could prepare their answers. I presented two papers, one on the evacuation of diving casualties and the other on the role of hyperbaric oxygen in soft tissue infections. Each speaker was then presented with a certificate crediting him with a certain number of postgraduation education points.

At the end of the day's proceedings, awards were made to the President of the Society, the Guest Speaker, and other deserving citizens. Lucky ticket numbers were then drawn in a raffle to encourage attendance.

I was then taken on a tour of the city by Harri Mahdi and his wife. Surabaya is a town about the size of Adelaide but with a population of about five million. The streets were very crowded, the main roads were of good quality but the lesser roads were in dire need of repair.

In the evening the post-conference dinner was held, at which the entire evening's entertainment was provided by members of the audience who were all Naval Medical Officers and their spouses. It was most enjoyable and notable for the fact that no alcohol was available at all. Much cold tea, sold as a soft drink, was consumed in its stead.

I left Surabaya at 0700 next day on my way home via Denpasar. Had I been travelling later in the day I would have joined the dawn excursion to visit the peak of the local volcano, Bromo, which is said to be an ideal spot to view the sunrise. It was on this journey that the car which was carrying Dr Sasongko, his wife and another plastic surgeon left the road and plunged over a cliff. Dr Sasongko was killed and the other two suffered severe multiple injuries. I had developed quite a rapport with Dr Sasongko so I wrote on behalf of the Society expressing our sorrow at the sad loss of an exceedingly fine man. He had recently been promoted to Admiral in the Indonesian Navy.

In Indonesia there are said to be about 15 hyperbaric chambers, a few of which belong to oil companies, some belong to the Navy and the rest are at civilian establishments, rather like in Australia. My information is that these units are working flat out most of the time and as in Australia, divers make up only a small proportion of the work load.

My impressions of the visit are:

1 The medical fraternity are pleasant, friendly and very generous and seem right up to date with the latest information. I met a couple of people who had been at the UHMS meeting in Amsterdam a few months earlier.

2 All can read and write English and many are fluent English speakers. English is taught in all the schools. Their English is much better than my Indonesian.

3 The IHMS is keen to host a combined meeting with SPUMS. It will require a lot organisation on a personal level. They do not seem to appreciate organisation at a distance, it has to be on a face to face basis.

4 They say that the diving side of the conference can be readily organised by the Navy who could be easily coerced into providing the necessary backup, tanks and dive guides.

5 My impression is that there is no shortage of modern equipment in Indonesia, but I do have severe reservations about the standard of maintenance of such equipment.

6 Communication is slow by mail and there are few fax machines yet. I had great difficulty getting people on the telephone.

7 There are resorts being built around the Indonesian archipelago at the moment to cater for the diving tourist and some of these are being equipped with their own recompression chambers. These may well prove to be excellent potential venues for a combined meeting at some future date.

Dr David Davies' address is Suite 6, Killowen House, St Anne's Hospital, Ellesmere Road, Mount Lawley,Western Australia 6050.

GUIDELINES FOR THE SALE OF COMPRESSED MEDICAL OXYGEN TO DIVERS

These guidelines have been developed by CIG Medishield in association with the Hyperbaric Medicine Unit, Royal Adelaide Hospital.

Compressed Medical Oxygen is sold to divers on the basis that it is used for First Aid at atmospheric pressure and is NOT used in water decompression or recompression therapy.

Breathing oxygen at pressures greater than atmospheric pressure renders the user liable to a real risk of having an oxygen convulsion. This is further enhanced by being in the water.

It should be understood that the breathing of oxygen is a first-aid measure and must never be substituted for the recompression required in cases of decompression sickness or arterial gas embolism.

When administering oxygen it is important to:

1 Ensure that the area is well ventilated and that there is nothing burning in the immediate vicinity (including cigarettes)

2 Ensure that the patient breathes air for 5 minutes after each 25 minutes on oxygen (unless the diver's condition deteriorates when taken off oxygen)

3 Carefully record the periods of oxygen breathing

4 Carefully record the patient's response to oxygen

The purchaser has to sign, and have the signature witnessed, a certificate that he or she has "read and understood these guidelines and hereby indemnify The Commonwealth Industrial Gases Limited and its agents and servants against all loss, injury or damage of whatsoever nature arising from the use of oxygen for diving or associated purposes". The second copy of the certificate is to be returned to CIG Medishield Gases Department.

GLEANINGS FROM MEDICAL JOURNALS

DIVING

Balancing recreation and safety: equipment requirements for Queensland scuba divers.
Wilks J. *J Occup Health Safety - Aust NZ* 1991; 7(3): 221-227

Abstract
Under Queensland occupational health and safety legislation, recreational scuba divers are required to have certain pieces of equipment when diving in commercial settings. For safety reasons it would be preferable for divers to own their equipment, but realistically many choose to rent, borrow or even dive without, certain items of scuba gear. This study questioned certified divers about their equipment and also about their awareness of the new legislation. Results showed that most divers owned basic snorkelling gear but that key safety items were usually rented. Less than one-third of respondents were aware of the new safety legislation. Possible implications of these findings for achieving a balance between recreational interests and safety in the diving industry are discussed.

Key Words
Safety legislation, scuba diving, equipment requirements, diving industry, Queensland.

From
Key Centre in Stregic Management, Queensland University of Technology, Bribane, Australia.

Beyond the C-Card: Continuing education among Queensland scuba divers.
Wilks J. *The ACHPER National Journal* 1991; Winter: 10-13.

Abstract
In this study qualified scuba divers from throughout Queensland were questioned about any training courses they had undertaken since their open water certification, their reasons for not taking further training, and specialty areas where they would like to continue their diving education. Results showed that only 33% of divers had taken courses beyond basic training. Reasons given for not continuing focused mainly on time constraints and costs. However, 89% of the divers expressed interest in taking additional courses, particularly wreck diving and underwater photography. The implications of these findings for continuing education, safety, and the reduction of diver dropout are discussed.

From
Key Centre in Strategic Management, Queensland University of Technology, Bribane, Australia.

By Ed SPUMS J
ACHPER stands for Australian Council for Health, Physical Education and Recreation.

Women and scuba diving
Cresswell JE and St Leger-Dowse M. *Brit Med J* 1991; 302: 1590-1.

A discussion of body fat and decompression sickness in women divers, diving in pregnancy and advice for women divers.

TRAUMA FROM FISH

Catfish trauma
Andrews CJ, Morris A and Pearn JH. *Med J Aust* 1991; 155: 130.

Letter:
Usually severe necrosis from a catfish sting. Exploration and debridement recommended.

HYPERBARIC OXYGEN

Beneficial effects of hyperbaric oxygen therapy in Nocardia brasiliensis soft-tissue infections
Walker RM, Ashdown LR and Maguire EI. *Med J Aust* 1991; 155: 122-123

Abstract

Objective: To report the success of hyperbaric oxygen therapy in the treatment of *Nocardia brasiliensis* mycetoma We believe this to be only the second report in the medical literature of hyperbaric oxygen therapy used in the therapy of nocardial disease.

Clinical features: A 78 year-old man presented to a general hospital outpatient clinic after eight months with a painless swollen left foot. There was no significant medical history, no trauma had occurred, and no foreign body had been detected. The dorsum of the foot had a discharging sinus, from which *N. brasiliensis* was isolated.

Interventions: after unsuccessful treatment with surgical debridement and high-dose antibiotic therapy, hyperbaric oxygen therapy was administered in a multiple recompression chamber (one hour of treatment at 1.8 atmospheres absolute followed by a 30 minute ascent to surface pressure). A total of 19 treatments were administered.

Outcome: In this case of *N. brasiliensis* mycetoma involving the lower extremity, the conventional management of surgery and antibiotic therapy was unsuccessful, and only with the addition of hyperbaric oxygen therapy did clinical recovery occur.

From

Townsville General Hospital, Eyre Street, Townsville, QLD 4810

ABSTRACTS FROM THE SECOND INTERNATIONAL MEETING ON HIGH PRESSURE BIOLOGY
Toulon, France
August 1990

Use of hydrogen-oxygen mixture as a diving gas.
Rostain JC, Gardette-Chauffour MC and Naquet R.

The use of hydrogen in diving breathing mixtures has a double advantage; a low density comparative to the other gas mixtures and a narcotic potency that may reduce some of the HPNS symptoms. Experiments in man have shown that the narcotic potency of hydrogen was too high for it to be used alone in the mixture. Consequently we have to know the maximum partial pressure of hydrogen we can use in He-H_2-O_2 mixture without problems. For this purpose, experiments were performed with He-H_2-O_2 (PO_2-0.4) on macaca fascicularis up to 37 bar and in man up to 30 bar. No tremor was recorded but the results obtained with EEG show some changes different from those recorded with other mixtures. They consisted of a decrease of power spectra in all the EGG frequency bands except the theta band which did not change or slightly increased. These changes, which seem to square to the monorhythmicity of EEG activities described in the baboon with H_2-O_2 mixture, occurred around 30 bar in the macaca and between 21 and 24 bar in man, and seem specific to hydrogen. These results and those obtained with psychometric and behavioral studies indicate that partial pressure of hydrogen over 25 bar is not recommended in He-H_2-O_2 mixture.

From

CNRS URA 1330, Biologie des Hautes Pressions, Faculte de Medicine Nord, 13015 Marseille Cedex 15, and CNRS, Laboratoire de Physiologies Nerveuse, 91190 Gif sur Yvette, France.

Psychometric performance and behavior during a human dive with hydrogen-oxygen mixture to 300 msw (Hydra IX).
Lemaire C and Martinez E.

Psychomotor and intellectual tests have been extensively used throughout the world to test diver performance under different hyperbaric environments. Our experience in the field led us to consider that the best breathing mixture among the ones tested was hydrogen-helium-oxygen, with a partial pressure of hydrogen not exceeding 25 bar at 450 msw (54%, Hydra V), the narcotic effects of hydrogen being not forgotten. The compression of the Hydra IX dive with 4 divers was interrupted by stops of 2 days at 70, 180, 210 and 270 msw, before reaching 300 msw after 15 days. The results of the psychometric tests indicate that manual dexterity is not affected by the dive conditions, all 4 divers having the same behaviour. Vigilance tested by visual choice reaction time is slightly decreased as early as the 70 m stop and after the compression to 240 msw. In the same way, a decrement instead of the increase due to learning is noted with the number ordination test, at the 70 msw stop. Only one subject increased his performance along the experiment, when 2 others had a decrement of 23% at the arrival at 300 msw. The same decrease is observed with the mental and promptitude test, beginning at 240 msw. The results, associated with the analysis of the behaviour of the divers, show that the breathing mixture used during this dive is not adapted to the depth or the compression rate at these depths, and these diving methods would require a less important partial pressure of hydrogen.

From

OCTARES, 171 Av. Clot Bey. F. 13008 Marseille, France.

Titan XI- A recent human high pressure exposure at 62.5 bar on heliox.

Wenzel J.

During April and May 1990, 3 subjects participated in a deep experimental dive on heliox in the deep facility TITAN of DLR in Cologne, Germany. In a compression of 11 days a maximum depth of 615 m (62.5) was reached with relatively low decrements of performance. The divers were able to conduct a number of experiments both dealing with mental and physical performance during a bottom time of 7 days. The total decompression time was 21 days, summing up to a total dive duration of 39 days. The dive could show that heliox may still be considered for deep depth diving; a thorough comparison is necessary to reveal the differences between different diving mixtures and compression profiles to prepare a sound basis for future developments in human deep diving.

From

DLR Institute for Aerospace Medicine, D-5000 Cologne 90, Germany.

SELECTED ABSTRACTS

Reprinted from the Program and Abstracts
of the
UNDERSEA AND HYPERBARIC MEDICAL SOCIETY ANNUAL SCIENTIFIC MEETING
11th-18th August 1990

The address of the Undersea and Hyperbaric Medical Society, Inc. is 9650 Rockville Pike, Bethesda, Maryland 20814, U.S.A.

DECOMPRESSION SIKCNESS

Analysis of 100 cases of decompression sickness among sports divers

Unsworth IP. *Undersea Biomed Res* 1990; 17 (Supp); 89

Decompression sickness among sports divers in Australia appears to be on the increase. This analysis contains particulars of divers admitted to this Unit, including sex, age, experience and covers the clinical type of DCS, time to onset and treatment, in addition to possible contributing factors 82% of divers were aged between 20 years and 39 years, with a M.F. ratio of 3.1. The incidence of uncomplicated pain-only DCS was 40% while 60% of cases had neurological involvement, either peripheral, central or both. This represents either a real increase in Type II cases or greater diagnostic accuracy than in earlier reports on DCS incidence. Times to onset of symptoms were examined and varied from immediate up to greater than 24 hrs post dive, the majority of cases appearing between surfacing and the end of the first hour. Times to recompression treatment varied from 3 hours up to more than 1 week. Suggested reasons for an apparent increase in the serious type of DCS are put forward and include improved diving equipment with greater underwater endurance, improved thermal insulation and an insidious diver attitude of machoism to deep and repetitive dives. This must be countered by diving doctors as stupid in the extreme.

Hyperbaric Unit, The Prince Henry Hospital, P.O. Box 233, Matraville, Sydney, 2036, Australia.

Design of experiments to detect differences in decompression risk

Survanshi SS, Weathersby PK and Thalmann ED. *Undersea Biomed Res* 1990; 17 (Supp);31-32

The intrinsic binary nature of decompression sickness (DCS) data (DCS or not DCS) makes numerous exposures necessary before a statistically significant conclusion can be drawn about differences in DCS risk due to environmental effects, e.g., dry/wet, high/low temperature, exercise level etc. Sequential trials (i.e., subsequent exposures depend on recent outcome) suit the ethical and operational concerns while minimizing the number of exposures. Too safe or conservative sequential rules will result in “wasted” exposures since such a resulting data set will not show risk differences even if they exist. Complex simulation procedures can be devised to test the effectiveness of sequential trial rules. A number of simulated data sets can then be obtained for assumed risk differences,m assumed underlying dose-response curve, and a given set of sequential rules. Maximum likelihood analysis methods can be used to estimate the underlying risk difference. Sequential trial rules that require the trial to end after 10 or fewer cases of DCS frequently do not lead to a statistically significant conclusion. The chances of insignificant results can still persist in trials of 400 dives with 25 DCS cases. Finding even a relative risk of two-fold (condition “a” twice as dangerous as condition “b”) is very difficult with less than 400 man-dives. These methods should be used for more rational planning of decompression experiments.

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Naval Medical Research Institute, Bethesda, Maryland and Naval Submarine Medical Research Laboratory, Groton, Connecticut.

COURSES IN DIVING AND HYPERBARIC MEDICINE

ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE UNIT

November 1991

Basic Course in Diving Medicine

Content
Concentrates on the assessment of fitness of candidates for diving. HSE-approved course
Venue
Royal Adelaide Hospital
Date
11th to 15th November 1991
Cost
$A 500.00

Advanced Course in Diving and Hyperbaric Medicine

Content
Discusses the diving-related, and other emergency indications for hyperbaric therapy.
Venue
Royal Adelaide Hospital
Date
18th to 22nd November 1991
Cost
$A 500.00
$A 800.00 for both courses

For further information or to enrol contact
Royal Adelaide Hospital Courses,
Dr John Williamson, Director, HMU,
Royal Adelaide Hospital, North Terrace
South Australia, 5000.

BIOMEDICAL SEMINARS

On the Antillean Island of Bonaire in the Caribbean.

The fundamental principles and prevention of diving accidents
23rd-30th November 1991

The management of diving illnesses.
30th November-7th December 1991

Course Fees for the above £ 250.00 per week

Copthorne Hotel, Aberdeen, Scotland

Fit to Dive ?
3rd to 5th of April 1992.

This course is planned to meet the needs of the medical examiner of professional divers, will focus on cardio-vascular fitness. It will also be relevant to doctors concerned with sports diving.

Application for accommodation should be made direct to the Copthorne Hotel (Telephone (UK 44) 224 630404. Fax (UK 44) 224 640573) before October 30th 1991 after which the competitive prices cannot be assured.

Course Fee £ 104.00 plus VAT.

For all courses apply in writing to
Biomedical Seminars,
7 Lyncroft Gardens,
Ewell, Surrey KT17 1UR
Fax (UK 44) 81 786 7036

DIVING MEDICAL CENTRE COURSES SCUBA DIVING MEDICAL EXAMINATIONS

A course will be conducted to instruct medical practitioners in diving Medicine, sufficient to meet the new Queensland Government requirements for **Recreational** Scuba Diver assessments, at

Sydney New South Wales
17th to 19th April 1992

For further details contact
DIVING MEDICAL CENTRE,
132 Yallambee Road,
Jindalee, Queensland 4047
Phone (07) 376 1414

PROPOSED CIRIA INTERNATIONAL CONFERENCE

ENGINEERING AND HEALTH IN COMPRESSED AIR WORK

Provisional venue and date
St Catherine's College, Oxford, UK.
September 1992

For further information contact

Mr F M Jardine, Research Manager, CIRIA
6 Storey's Gate,
London, SWLP 3AU, U.K.

SPUMS MEETING AT TATHRA MARCH 14th AND 15th 1992

REGISTRATION FORM

Name Phone number ( )

Address

Accommodation needed Share twin Single (extra charge) Family

Arrival date Time Departure date

Travel Car / Plane* / Bus* * Transfers to Tathra required ? Yes No

Diving Number of divers

Saturday morning 1 dive 2 dives

Sunday morning 1 dive 2 dives

Do you wish to present a paper? Yes / No Topic

Please send, with your cheque for $10.00 made out to SPUMS, Tathra Meeting, to:
Dr Geoff Long, P.O. Box 276 Bega, NSW 2550. Phone (064) 922 922