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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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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 illness (DCI), and thereafter czn be referred to as DCI.

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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Any report of experimental investigation on human subjects must contain evidence of informed consent by the subjects and of approval by the relevant institutional ethical committee.

Editing

All manuscripts will be subject to peer review, with feedback to the authors. Accepted contributions will be subject to editing.

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ARTICLES OF INTEREST REPRINTED FROM OTHER JOURNALS

GLEANINGS FROM MEDICAL JOURNALS

Abstracts from the Undersea and Hyperbaric Medical Society Annual Scientific Meeting 1992

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Dr D. Walker
P.O. Box 120, Narrabeen, N.S.W. 2101.

The Editor's Offering

This is an important year for SPUMS, the first when the general membership has been asked to help with the formulation of SPUMS policy. It is in fact a return to the very early days of SPUMS when there were only a dozen or so members, all of whom agreed on their views on diving safety. With the growth of the Society this unity of purpose was diluted and the Executive Committee had to take decisions on behalf of the membership. Now the members and associates have been asked to put forward their views about the teaching of emergency ascent procedures. Dr Des Gorman's invitation to put ones views forward at the Annual Scientific Meeting does not preclude those who, for any reason, cannot attend the meeting in Palau from putting their ideas in writing and sending them to Dr Gorman to be aired at the workshop.

The central nervous system is the focus of our original articles. Dr Hodgman discusses, and dismisses, most of the elaborate imaging techniques available to study those who have had decompression illness (DCI) settling for careful clinical and neuropsychological examinations. The paper from Auckland shows that far too many (74%) treated divers have problems a year after treatment. Especially worrying is the fact that while 48% had neuropsychological sequelae another 26% developed problems in the year after their treatment. This is quite the opposite of the received wisdom, which says that the residual symptoms disappear with time. Perhaps Australasian divers have a different form of DCI from those in other countries, but this is unlikely. The early reports of finding neurological signs in cases of pain only decompression sickness came from Australia. Dr Sutherland has been bringing his patients with neuropsychological problems to the attention of SPUMS members for many years. In order to show the sorts of symptoms that can ruin divers lives after DCI we have included two appendices describing the problems faced.

We would congratulate Dr Wilks on his negotiating skills which have allowed him access to the confidential figures of the various training organisations. As a result he had come up with a minimum figure of dives carried out in Queensland each year. This is the first time that such a figure, albeit imprecise as five of his categories have no figures, has been available in Australia. We wish him well in his attempts to count the other dives.

Dr Millar reports on the Worksafe Code of Practice for Occupational Diving. It is a vast change from the form of AS2299. For reasons only known to the higher echelons of Worksafe Australia the bureaucratic decision was to have only one code of practice. In our editorial opinion, but not necessarily that of SPUMS, it would have been easier, and more sensible, to have developed codes of practice for the different forms of occupational diving. The production of the Code has been hurried and there has been inadequate consultation time. It is important that all those with an interest in diving safety try to read the draft and comment on it in order to improve it.

Among the SPUMS notices is a statement of the requirements for candidates for the Diploma of Diving and Hyperbaric Medicine. This will be reprinted regularly.

The program for the 1993 Annual Scientific Meeting appears on page 19. We look forward to publishing these papers in due course.

The Letters to the Editor continue the saga of the need for training for doctors who do diving medicals. The AMA provided a long reply to the questions raised in the last Journal and interesting letters have come from others. The SPUMS view, that doctors do need special training to do diving medicals, comes from the fact that diving medicine is not adequately covered in the medical course, and often is not even mentioned.

Dr Rooney's paper from the 1992 Annual Scientific Meeting contributes to the discussion on the need for training as part of a discussion about the medical care of divers and shows that most of those trained to dive in North Queensland never dive again. Professor Callanan and Dr Fallowfield from Townsville General Hospital advise us about the treatment of injuries from coral and the treatment of divers with DCI.

We print the annual British Sub-Aqua Club diving incident report, a review of American DAN DCI figures, three papers from NAUI about the very common symptom of DCI denial. For the first time we have two papers from *Guidelines*, the newsletter of the Cave Divers Association of Australia (CDAA). One deals with incidents while the other deals with redundancy of systems, this time the buoyancy compensator. Our final reprinted paper is from the Scottish Sub-Aqua Club. Their definition of an incident is much the same as that used in the Australian Diving Incident Monitoring (DIMS) study. Over 300 incidents were due to malfunctions of the power inflator of buoyancy vests. Seventy five per cent of the Scottish divers wore dry suits.

Among the Gleanings from Medical Journals has been included one on writing clearly so that ones message is easily understood. The Fog Test is a simple way of checking that one has kept sentences short and easy to understand. This improves most medical writing !

There are abstracts from last year's Undersea and Hyperbaric Medical Society Annual Scientific Meeting. They cover carbon monoxide poisoning, neurological sequelae in divers, decompression tables and how sports divers do not know how to use them, with asides on table testing and evaluation of decompression stress. There are studies of diving deaths and the pathology of dead divers brains and spinal cords. Included are a study of transcutaneous oxygen measurements in non-healing wounds and a study of hyperbaric chamber mishaps.

With this issue comes an updated list of SPUMS members, in Australia and New Zealand, who have the proper training to do diving medicals and where to find them. We intend to publish this list at regular intervals in future. This will need your co-operation by keeping us up to date.

Emergency ascent training

The utility and safety of emergency ascent training has long been controversial. Is it necessary? Is it effective? Is it dangerous? The controversy has already affected diving training "ditch and recovery" exercises have been essentially abandoned. Some Instructor Agencies teach emergency ascents horizontally, that is, the emergency ascent training does not involve an ascent! In at least one centre, the ascent is performed as rapidly as possible. The diving manufacturers and retailers have been quick to react to the problem of running out of air, the usual problem underlying the need for an emergency ascent, and have produced a plethora of "rescue apparatus". These include Octopus regulators and Spare Air Cylinders. While there is no doubt that this has been of considerable benefit to the manufacturers and retailers, there is no real evidence that these apparatus have benefited the diving community in general. Nevertheless, one solution to the "emergency ascent problem" is to have enough levels of redundant air supply to avoid such an ascent altogether. In practice however, this logic is flawed and the sharing of air often results in both the diver and his buddy having to perform an emergency ascent.

As in almost any other area of diving safety, opinions about emergency ascents abound, but data on the cost-effectiveness of various techniques and training are limited. Indeed, most risk-data are obtained from submarine escape training, a not altogether analogous situation. The careful pre-training medical screening of submariners and their close surveillance during the emergency ascent training in clear warm water probably contribute to a significantly lower risk in this group (about one in every two thousand ascents is complicated by pulmonary barotrauma and usually arterial gas embolism of their brains).

Not surprisingly, the regulators of recreational diving in Queensland, "had trouble" reaching a consensus on emergency ascent training. The debaters divided themselves, predictably, into a medical fraction ("It's too dangerous") and a diver instructor fraction ("We've been doing it for years and haven't had any problems"). Obviously, reality lies somewhere between these two extreme stances.

SPUMS was consulted for its policy on emergency ascent training. In the past, such Society policy has been developed by an appointee of our Executive and has consequently not always been a "consensus opinion". This may or may not be a bad practice; one outcome of this approach is however that groups within SPUMS who disagree with the policy feel both aggrieved and obliged to scream loud and long and often. It was decided then, to develop a SPUMS policy on emergency ascent training via a Workshop, and further, that each future SPUMS Annual Scientific Meeting would feature such a Workshop on a major issue from which a SPUMS policy would be generated. The Workshops will be open to all SPUMS members and associates, in a "turn-up and put-up, or shut-up" approach.

The Workshop on emergency ascent training is programmed for this year's Annual Scientific Meeting in Palau and will be co-chaired by myself and Drew Richardson (SPUMS member and a Vice-President of PADI). The format will include an introduction, presentations giving a training agency and a medical perspective on emergency ascent training, and then an open forum for discussion. A draft SPUMS policy will subsequently be developed for ratification by the Executive Committee and publication in the SPUMS Journal.

Clearly, the SPUMS diving medical and diving community should become involved in such debate and hence contribute to the policies of this Society. Just as clearly, this is yet another good reason for interested physicians and divers to join SPUMS.

As for emergency ascent training, wait and watch this space (in *Dive Log New Zealand*).

Des Gorman
President SPUMS

Dr Des Gorman is the Director of the Royal New Zealand Navy Hyperbaric Unit, HMNZS PHILOMEL, Devonport, Auckland, New Zealand.

ORIGINAL PAPERS

NEUROLOGICAL INVESTIGATIVE TECHNIQUES IN DECOMPRESSION ILLNESS

Martin Hodgson

Abstract

This paper reviews the neurological assessment of the diver after completion of treatment for decompression illness (DCI). An impaired neurological status is the factor most likely to prevent a return to diving. Investigative procedures available to assist in delineating the neurological injury include magnetic resonance imaging (MRI), computerised tomography (CT), hexamethylpropyl amine oxime (HMPAO) scans, electroencephalography (EEG), neurophysiological and psychometric testing These techniques rarely provide more information than a detailed clinical examination for the individual patient. Collectively, their application has provided valuable insight into the pathogenesis of DCI.

Pathogenesis of decompression illness

Our understanding of the pathological events in DCI is incomplete. As a reduction in ambient pressure forces the tissues to reduce their dissolved gas load, inert gas bubbles are formed in intra- and extra-vascular spaces. Vascular bubbles arise predominantly from the venous side, although de-novo arterial bubble generation is possible. Venous gas emboli, which are produced in many asymptomatic dives, are believed to be filtered out by the lungs up to some unknown critical point. Pulmonary overload or shunting will allow bubbles to enter the arterial system. They then travel by flow and buoyancy to the cerebral circulation in the upright person. Inert gas bubbles form columns which lodge at arteriolar bifurcations producing occlusion, distal ischaemia and neurological manifestations. The majority of these columns clear within 10 minutes, due to a rise in mean arterial blood pressure, but their transit produces endothelial damage with increased permeability of the blood brain barrier.[1] Leucocytes migrate through the endothelium as a result of chemotactic factors and platelet activation occurs.[2,3,4] Activation of complement and coagulation pathways occurs in severe cases and can evolve to disseminated intravascular coagulation.[5] Prostaglandins, histamine and serotonin are released in a manner indistinguishable from the acute inflammatory reaction.[6]

Extravascular, or tissue, bubbles will exert local effects dependent on the volume of the bubble and the type of the tissue affected. Adipose tissue can tolerate large volumes of gas without symptoms. Small bubbles within tightly bound connective tissue will produce pain. The myelin sheath, a prime site for bubbles because of its high fat content, will require only a small critical volume before there is interference with conduction of nerve impulses. In most cases of spinal DCI the production of such autochthonous bubbles would appear a more likely causal mechanism than venous stasis.[7]

These complex pathogenetic mechanisms act to a variable extent, in combination, at the different levels of neurological function (cerebral, spinal, peripheral). The majority of DCI cases suffer a multifocal, central nervous system insult.

Neurological assessment

Assessment of the extent of neurological damage that has been produced by DCI is important if sensible advice is to be given to the diver after completion of treatment. The diver will be interested not only in the likely prognosis, but also in whether a return to diving can be recommended. Causative factors will need to be considered, as will the nature and severity of the insult and the response to treatment. However, the neurological status is the factor most likely to prevent a return to diving.

In those divers where response to treatment is incomplete and who have residual clinical abnormalities, the aim is to determine the site and extent of neurological damage. This information will provide the basis for prognostic advice on potential recovery and outcome. The biggest gains in neurological recovery are seen in the first two to three months, with smaller improvements continuing for up to two years.[8] In some patients gradual deterioration has occurred after a static period of some years. This may be due to natural senescence superimposed on a diminished neurological reserve. If there are residual neurological signs a return to diving is unlikely to be recommended. Any further episode could erode a reduced functional reserve and be devastating.

Where there has been an apparent full clinical recovery, the objective is to elicit signs of subclinical damage. Determination of fitness to return to diving will depend on the assessment of susceptibility to DCI. This is variable both between individuals and for the same individual on different occasions. If DCI was produced without obvious precipitating factors and with minimal decompression obligation, then increased susceptibility must be assumed. Any advice concerning a return to diving would have to be cautious.

Incidents which result in a severe or neurological presentation probably produce subclinical damage, regard-less of favourable treatment outcome and freedom from clinical signs. A post-mortem study showed spinal cord lesions in a case of recovered DCI.[9] Subtle neurological changes have been found in cases diagnosed as musculoskeletal DCI.[10]

Mounting evidence of neurological damage in DCI has provoked uncertainty about the safety of diving in general. There are concerns that subclinical damage may reduce functional neurological reserve in the asymptomatic and incident free diving population. Retinal fluorescein angiography has been used to examine the eyes of 84 divers, 12 of whom had a past history of DCI.[11] The investigators found low retinal capillary densities at the fovea, microaneurysms, small areas of capillary non-perfusion and increased abnormalities of the retinal pigment epithelium. The extent of these abnormalities correlated with the length of the diving history. However, no subject had any demonstrable visual loss. But since the retina is generally felt to be "the window into the CNS", the authors suggested that their findings may imply that asymptomatic CNS injury occurs as a result of diving. Post-mortem studies of the CNS of divers have demonstrated abnormalities in some who have no recorded history of DCI.[12,13]

As doctors and divers become more aware of the potential for neurological damage, there is an increasing trend to investigate. The delineation of the neurological injury will depend on the limitations of the available investigative techniques. This review evaluates the role of magnetic resonance imaging (MRI), computerised tomography (CT), hexamethylpropyl amine oxime (HMPAO) scans, electroencephalography (EEG), neurophysiological and pyschometric testing in the assessment of the diver.

Magnetic resonance imaging

MRI provides detailed resolution of the brain and spinal cord. A study of 14 patients with barotrauma demonstrated brain MRI abnormalities in three out of the four patients with cerebral presentations.[14] Two of the abnormalities detected corresponded to the neurological deficits on clinical examination. There were 12 patients with spinal cord presentations, but only three had abnormal spinal cord MRI scans.

The Duke University Medical Center experience is similar, with abnormal brain MRI in 56% of cerebral DCI cases and abnormal spinal MRI in 17% of cases with clinically suspected spinal cord damage.[15] Abnormalities of T_2-weighted images were found, compatible with regional oedema.

Two divers with severe neurological DCI demonstrated the difficulty in isolating the level of injury.[16] Both were reported to have a Brown-Sequard pattern of deficit at the thoracic level with bilateral lower extremity weakness. Thoracic cord MR images were normal in both cases, with the one case where a cervical MRI was performed, also normal. This suggests that either the cord was spared, the level missed, or that the resolution of the MRI was insufficient to demonstrate isolated tract or partial column damage. There was certainly no evidence of a hemisection of the cord. Diffuse cerebral pathology was suggested in both cases by abnormal brainstem and somato sensory evoked potentials. One case showed slowing of the EEG waking background rhythm. The brain MRI showed multiple foci of high signal intensity in the peri-ventricular white matter of the parietal region in both cases. One patient also had right lentiform nucleus and internal capsule foci.

A MRI study of 105 divers and 49 controls showed no significant difference between the two groups, despite the fact that 51% of the divers had a history of DCI.[17]

CT scan

CT scanning techniques are less sensitive than MRI for detecting foci of cerebral ischaemia and in the spinal cord are unable to provide adequate definition of the soft tissues. In a study of 47 CT scans performed within one month of DCI, the concordance between the initial CT report and a blinded independent radiologist was 87%.[18] Only one scan had abnormalities reported by both radiologists; small low density areas. A retrospective review of the case notes disclosed 24 cases with symptoms suggestive of cerebral involvement. No CT abnormalities could be correlated with the clinical presentation. Although small low density areas have been separately demonstrated in two serious cases of dysbaric illness,[19] the CT scan is not a cost effective tool for the post-treatment evaluation of DCI. The majority of neurological DCI cases are not sufficiently severe to produce areas of cerebral infarction.

Electroencephalography

As part of a follow up study of 72 post DCI patients, EEGs were performed after completion of treatment, and one month and one year later.[10] EEGs were reported as normal, doubtful or abnormal. Slow wave abnormalities were detected with increased theta wave activity. Focal abnormalities were not found. A definite trend of improvement in the 48 (67%) who returned at 1 month was found with eight of the 11 reported as abnormal improving. At one year, five of the 23 who returned had shown improvement. Problems with the study, included epidemiological concerns about the high drop out rate and lack of independent and blinded EEG reporting. Recommendations for a further study included objective, more frequent analysis of the EEG and quantification of subjective assessment of slow wave activity in the treatment and early recovery phase following DCI.

Psychometric testing

Psychometric evaluations were conducted as part of a neurological sequelae study.[10] The Australian Council of Education and Research Word Learning Test provided expected performance parameters for the Benton Visual Retention Test. This is a test of visuo-spatial perception and short term memory. Of 56 patients tested in the month following treatment for DCI, 16 showed significant impairment. Only four of the 16 returned at one year, an unacceptably high drop out rate, when two were normal and two abnormal. A further analysis found the percentage of EEG abnormalities was the same in both normal and abnormal psychometric groups. This study's preliminary findings[20] are much quoted, yet are inconclusive.

Neuropsychological tests have mostly been used in saturation diving for the assessment of the effects of extreme hydrostatic pressure and the high pressure neurological syndrome.[21] They have been used to monitor recovery following DCI and have also been applied to diving operations where concerns about neuropsychological safety are held.[22] Their sensitivity is far greater when repeated assessments of the individual are made. However pre-morbid results have rarely been available in the clinical setting. More frequent assessment after the incident would also help to delineate the role of this form of testing.

Despite the concerns of the pathologists[12], no convincing evidence of long term psychometric deficits has been demonstrated in abalone divers who are known to dive well beyond standard tables and who have a high incidence of DCI [23]

HMPAO scan

This nuclear medicine technique demonstrates cerebral blood flow. Hexamethyl propylene amine oxime (HMPAO) labelled with $^{99}T_c^m$ is injected and measured with single photon emission computerised tomography (SPECT). $^{99}T_c^m$ HMPAO crosses the intact blood brain barrier with 3-8% becoming fixed to neuronal nuclei in the grey matter in proportion to blood flow at the time of injection. The technique gives an instantaneous picture of cerebral perfusion. Scans were performed on 28 cases of neurological DCI.[24] Cerebral perfusion deficits were reported in all 23 cases of neurological DCI and in all four cases of cerebral arterial gas embolism (CAGE). No deficits were present in the single case of musculoskeletal DCI. As cases of presumed spinal cord disease showed these deficits, it was concluded that neurological DCI is a diffuse multifocal CNS disease. A small follow up series of 18 patients who were rescanned at varying intervals found that the majority had persistent deficits.[25] Criticisms of both studies included the absence of a control population and incompletely blinded interpretation of the scans.

A case control study was performed to investigate further the use of the HMPAO scan.[26] Four groups of 10 subjects were studied:

a Divers scanned days after treatment for neurological DCI
b Divers scanned years following neurological DCI
c Diver controls
d Population controls

All groups were matched for age and the divers were further matched for general diving experience. The scans were randomised and reported blind to the history. Despite a trend towards larger numbers of deficits in individuals who had suffered DCI, the four groups were statistically indistinguishable. Furthermore no correlation was found between the location of the perfusion deficits and the clinical presentation. This particular technique requires further evaluation before significance can be ascribed to perfusion deficits found in divers.

Somatosensory evoked potentials

Somatosensory evoked potentials (SEPs) were measured on a sample of 30 divers who had received recompression treatment for DCI at the Royal Australian Navy School of Underwater Medicine.[27] The median nerve at the wrist and the posterior tibial nerve at the ankle were stimulated and SEPs recorded. Median nerve studies were normal, but nine of the 30 subjects had abnormal tibial SEPs, with an increase in the interpeak latency for N20-P37. This suggested pathology affecting the postero-lateral and posterior columns between the lumbar and low cervical regions. Two divers had bilateral and seven had unilateral abnormalities. Six had normal neurological examinations. In two of the three with abnormal signs there was a correlation between the SEP abnormalities and signs of weakness or sensory loss. Despite the inconclusive numbers it was suggested that SEPs were more sensitive than normal methods of neurological examination for detecting neurological sequelae of DCI.

A more recent study performed SEPs on 23 divers with varying degrees of residual disability from spinal cord DCI.[28] Only the four wheelchair bound patients who had absent SEPs were statistically significantly different from normal. The nine with obvious neurological deficits had SEPs within the normal range. The authors conclusion was that careful neurological examination is a more sensitive measure of residual deficit and SEP studies may only be useful in very severe cases.

Conclusion

Neurological investigative techniques have been important in the development of our current understanding of DCI. CT and MRI scans have demonstrated lesions in cases with a severe cerebral insult, but not in the majority of cases. Psychometric testing, EEGs and HMPAO scans have all indicated potential sensitivity but require further development and evaluation to determine their roles. For the individual patient, none of these techniques is as sensitive as a careful neurological examination. Sensible advice can be given based on clinical findings and analysis of the initiating factors without the need for detailed investigation. However, in major centres where a large number of patients are being reviewed, it is important for new and refined techniques to be applied as they become available.

There is exciting potential for further research. Positron emission tomography (PET) will probably become the "gold standard" of functional imaging. The resolution of PET is better than that of SPECT because it detects the pair of gamma photons emitted simultaneously from the positron-electron interaction. Metabolic activity can be monitored by labelling biological substrates. Activation studies can demonstrate real time metabolic reactions as the nervous system is stimulated. Evolution and refinement of the technique is continuing, but limited by the expense of the cyclotron necessary to produce the short half-time isotopes.

Computerised EEG mapping techniques should overcome the difficulties encountered with subjective interpretation of EEGs. It also provides a far more comprehensive and reproducible assessment. Evoked potential physiological studies are becoming more sophisticated and sensitive. It is only through this continuing research for clearer elucidation of the neurological insult that we will further our understanding of the pathogenetic mechanisms in DCI.

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NEUROPSYCHOLOGICAL PROBLEMS IN 25 RECREATIONAL DIVERS ONE YEAR AFTER TREATMENT FOR DECOMPRESSION ILLNESS

Allan Sutherland, Andrew Veale and Des Gorman

Abstract

Twenty-five recreational divers were treated for decompression illness at the Royal New Zealand Naval Hospital in 1987 using the the United States Navy treatment algorithm. Twenty-three of these divers were reviewed one year later. At discharge from hospital, 11 (48%) had obvious neuropsychological sequelae. None of these had recovered fully by one year. In contrast, 6 of the 12 who had no problems at the time of their discharge either developed or were noted to have problems during the next year. These late sequelae were mostly in the form of personality changes. The overall morbidity rate at one year was 74%. Alternatives to the United States Navy treatment alogrithm should be developed and tested, and a review as late as one year after DCI may be needed to assess outcome accurately.

Introduction

The treatment of Australasian recreational divers with decompression illness (DCI) using the United States Navy (USN) treatment algorithm[1] is associated with treatment failure rates at discharge from hospital and one month later of between 32 and 45%.[2-5] However, it is believed that most sequelae of decompression illness will resolve during the subsequent year.[3-6] To test this belief, a defined population of recreational divers who were treated for DCI were surveyed one year later to determine the progression and prevalence of neuropsychological sequelae.

This survey was based on questionnaires and clinical examinations, as careful neurological examination appears a more sensitive measure of outcome than available evocative, recording or imaging techniques of the nervous system.[7,8]

Methods

In 1987, a total of 25 recreational divers were treated at the Royal New Zealand Naval Hospital (RNZNH) for DCI that developed after one or more air dives. The USN treatment algorithm was universally employed. One year after their discharge from RNZNH, letters were sent to all these patients, requesting general information about their invalidity, time off work, compensation or insurance claims, and, if any, specific disabilities. Any replies suggesting problems were followed by further contact with the patient (including an examination, if possible), their spouse, family, family doctor and/or diving physician.

Two patients who claimed significant neuropsychological disability were further assessed by extensive psychometric review[9] at Auckland Public Hospital's post-concussion clinic.

Results

Twenty-three of the 25 patients (92%) responded to the questionnaire. The 2 patients who could not be contacted had no overt problems when they were discharged

TABLE 1

SPECIFIC PROBLEMS AND DISABILITIES ONE YEAR AFTER TREATMENT FOR DECOMPRESSION ILLNESS.

Problem, disability	Number of patients (% of total patients)	
Normal health	**6**	**(26%)**
With problems	**17**	**(74%)**
Mood disorders *	14	(60%)
Impaired cognition **)	12	(52%)
Headache	10	(43%)
Sensory disturbances	6	(26%)
Impaired balance	6	(26%)
Motor weakness	6	(26%)
Arthralgia & myalgia	4	(17%)
Visual disturbances	3	(13%)
Dysphasia, dyslexia	2	(9%)
Bowel & bladder problems	2	(9%)

* Includes mood changes from uncontrollable irritability to depression, lassitude, and social withdrawal.

** These patients had impaired short-term memory and often other problems such as difficulties with arithmetic etc.

form RNZNH. The dive profiles, presenting symptoms, time to treatment and other relevant history for these divers has been described previously.[2]

At the time of their discharge, 11 of these 23 patients (48%) had neuropsychological sequelae. None of the 11 had recovered fully by one year. In particular, focal neurological deficits did not change significantly. Of the 12 who were well on being discharged, 6 had deteriorated over the year and had obvious problems. At the one year review 17 of the 23 patients (74%) had sequelae of their episode of DCI. None of these 17 patients had any relevant past history.

The specific disabilities prevalent in these divers at the one year review are listed in Table 1. It is noteworthy that the personality problems (e.g. mood disorders) largely became evident after discharge, varied in severity from day to day and had a greater effect on family life, relationships and employment than the neurological deficits.

The 2 patients who underwent extensive psychometric assessment were both shown to have a considerable cognitive disorder typical of recent organic brain damage. Both have been the subject of individual case reports.[10,11]

Discussion

The longitudinal study reported here shows that use of the USN treatment algorithm[1] in a group of Australasian recreational divers with DCI had an unacceptably high failure rate. This is consistent with other reviews of similar groups of divers.[2-5] It also underlies the urgent need to develop and test alternative methods of treatment.

However, our results contrast with those studies which show an continuing resolution of DCI sequelae during the subsequent year.[3,6] In this study, neurological deficits did not change significantly and many psychological/personality problems became apparent only after discharge. Indeed, six of the twelve patients who had no complaints at discharge, had overt problems after one year. This natural history is very similar to that described by Rozsahegyi[12] in a population of caisson workers who developed DCI and were given a single hyperbaric air treatment.

It follows that a late review, perhaps as much as one year after an episode of DCI may be needed to assess outcome and to determine if the patient is fit to return to diving.

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Appendix 1

A letter from the wife of one of the patients describing the sort of personality changes discussed in the paper.

Dear Dr Sutherland

I am hoping you will remember treating my husband approximately a year ago at the Naval Base. I am writing to you as I am still rather anxious and concerned about him.

He still suffers from frequent depression, mood changes, lack of concentration, and occasionally his memory.is quite bad even after a short time of me telling him something. These symptoms can occur months apart or as often as 3 to 5 times a week. I notice they are worse when he is tired or under stress.

I finally persuaded him to go along to his GP and he has prescribed him some anti-depressants. He has been taking these for 8 weeks now and when he got adjusted to the tablets I found his moods were much happier but still some of the other symptoms are present. Now he is sleeping better and is more motivated in activities which he hasn't been for a long while e.g. running, indoor cricket and general household chores etc.

My husband is usually a quiet, placid person and I definitely know that he is not the type to complain but I can see that he gets very frustrated with not being able to cope with his symptoms. I feel that you are in the best position to advise me on this matter and I would be very grateful if you could give me some guidelines on what and where do we go from here.

I am writing this letter in the strict confidence as for some reason my husband wasn't too keen on me writing to you when I approached him on this matter.

I realise it is very difficult for you to assess him through a letter and I would be happy to give you any further details if I haven't been specific enough.

As this confidential, could you please send a reply to my work address.

Thank you for your time which I realise is very limited and I understand that correspondence takes second place.

Appendix 2

These two case reports are based on the neuropsychological assessment reports and illustrate the disabilities patients are suffering. Both men were severely disabled by their residual brain damage.

Case A

A sustained 2 episodes of decompression illness (DCI). The first mentally muddled him up, and the second physically damaged him. After the first episode he lost his way a lot, was forgetful, had to write everything down, found it hard to concentrate on things, mentally blacked out during conversations or if things were happening fast and had difficulty sleeping and was very irritable and argumentative. He found irritability difficult to cope with as he had been previously very easy-going. It has had a detrimental effect on his relationship (his partner and 2 sons).

On the dive which caused his second episode of DCI he became disorientated at the end of the dive, came straight to the surface, and has no memory of the following events. Apparently he was pulled from the water and taken to the Naval Hospital. His problems, which persist, include severe pain in the back, hips, shoulders, and headaches. The cognitive difficulties that he experienced following the first episode persisted and added to the severe physical pain of the second episode, caused him to feel irritable and to have increased difficulty controlling his anger. He had difficulty with relationships, coping with noise, and family relationships. Not surprisingly he became depressed and this further affected his sleep. He has dreams. Antidepressants did not assist him and he had bad days most days of the week.

The neuropsychologist's report included the paragraphs below.

"This man's neuropsychological profile is not straightforward with considerable variability within the test limits. These are caused because physical pain and depression are present as well as the cognitive difficulties. The neuropsychological profile does resemble that found in individuals who have an organically-based dysfunction of the brain. There were some tasks on which his performance fell well in the average range for the population. In contrast, he had slowed reaction times which reflected a slowing down of the cognitive process, a markedly reduced rate of information processing, and a reduced ability to concentrate over time. This was consistent with his subjective complaints and is consistent with the kind of profile found in individuals who have diffuse brain damage.

The findings have direct implications as to the patient's ability to cope with daily activities, including his home environment, and his ability to resume work. With cognitive problems of this type, any situation that is noisy, requires quick thinking, doing several things at once, or concentrating over long periods of time, will pose major difficulties. One direct example of this is his inability to tolerate much of the behaviour of the children, which is caused, to a large extent, by his deficits in information processing ability.

Recovery from deficits of this sort is hindered when an individual is regularly in situations where he becomes over-loaded and unable to cope. Appropriate management and strategies within the home and work environments are essential, involving:

a Physical, especially pain;
b Cognitive deficits;
c Depression

These areas inter-react with each other and thus it is best to deal with each problem in isolation from the others.

Although the factors contributing to the neuropsychological profile are complex in this case, I have no doubt that there is an organic dysfunction to the brain similar in its effect to the closed head injury which underlies the patient's performance."

A was re-assessed 19 months later which was two and a half years after suffering his second episode of DCI. As most recovery of cognitive function occurs in the 2 years post-injury, with other forms of non-progressive injury (e.g. closed head injury and carbon monoxide poisoning), it is appropriate to investigate any residual cognitive disability.

At the time of this assessment, the patient "claimed he still had a lot of difficulty concentrating and was unable to cope very well with any situation where things are happening fast. Such situations included those where there was a lot noise, several people talking, or more than one thing happening at once. This difficulty affects his family relationship, social relationships, and has implications on his ability to work. When his children are noisy, or racing around, he gets very irritated and can't handle it. Similarly, in many social situations, he is unable to follow conversations and just switches off. Consequently there are many social contacts he now avoids.

The patient has expressed a wish to write, but after a short period finds that it all gets jumbled up and that words he has written down get messed up and parts do not make sense. This is most likely related to impaired concentration ability, rather than a language deficit. Although he is able to drive a car, he does not do it often as he has to put a lot of effort in and after driving feels like a "wreck". A significant change for someone who had a commercial drivers licence.

He continues to have difficulty sleeping and usually feels worn out even after sleeping. His ability to handle alcohol is markedly reduced from before his diving accident. Now he becomes drunk very quickly on little alcohol. The intense frustration and anger that concerned him during the first assessment occurs less frequently because he has adapted to the changes, using the words "I don't care" more frequently. He has developed a strategy of removing himself from situations which frustrate him."

The results of the neuropsychological tests were similar to that achieved previously. "The patient has had some relief from pain and this has significantly reduced his irritability and depression and changed his lifestyle and expectation of his abilities. He will have to be involved in a process of grieving for his major loss of lifestyle before he will be able to construct a life that adapts to such changes. There has been come improvement in his cognitive abilities, giving some capacity to develop strategies to cope with his many difficulties.

The findings of the second assessment were much more clear-cut than on the previous occasion. "The patient being left with the kind of cognitive impairments that frequently follow other forms of diffuse brain damage and the pattern of his neuropsychological profile is strongly suggestive that he has organic dysfunction of the brain. This continues to have a profound impact on his family relationships, his ability to work, and his ability to enjoy life.

Case B

B's first assessment described him as having a gross problem with attention and memory. "The difference between his average to his above-average performance on the vocabulary and perception tests, and his poor performance on these measures, is strong evidence that the deficits have resulted from some CNS insult. They are consistent with the history of the diving accident last year."

When re-assessed a year later, it was reported that it was “a pleasure to see and test this man again because he had made so much progress. He had improved on almost all measures and although he said that he still gets tired and has lots of headaches, he seemed to be managing his taxi run well."

Three tests had improved. The digit span reaction time and word fluency to within the normal range. Tests which had improved, but still demonstrated an impaired score, were visual memory and verbal memory. It is unlikely that this man would make as much progress in the next 2 years as he has in the last, but even if he makes no progress at all, his cognitive function is now at a level where he should be able to cope reasonably well.”

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THE WORLD AS IT IS

CALCULATING DIVER NUMBERS: CRITICAL INFORMATION FOR SCUBA SAFETY AND MARKETING PROGRAMS

Jeffrey Wilks

Introduction

A question frequently asked of the recreational scuba diving industry is “How many active divers are there?” The answer to that question is, of course, that “there are no reliable estimates of active divers within Australia”.[1] While the question is asked by different people, for different reasons, two broad interest groups can be identified.

The first group is interested in establishing the size of a potential customer market. This group may include tourism authorities, insurance agents, equipment wholesalers and retailers, training agencies, the media and various government departments. In fact, marketing enquiries form the majority of requests for diving statistics.

The second group seeks information on the number of active scuba divers to provide a background or perspective on safety. This group may include medical practitioners, health and safety authorities, dive industry associations, lawyers and the scuba training agencies. To some extent there is an overlap between the groups as those concerned with marketing will also be interested in safety, since it is an important component of the diving product.

Obtaining accurate estimates for the number of certified divers is a difficult process, as evidenced by the continuing debate in the United States.[2,3] One of the main barriers to calculating accurate figures is the fact that scuba certification cards do not expire. Once a diver has completed his or her entry level qualification there is no easy way to determine whether they continue on as an active diver or drop out from the sport. Even the definition of an “active diver” varies, though the accepted consensus, used in this paper, seems to be “at least one dive in the previous 12 months”.[4,5] There are some who consider that the figure should be 5 to 10 dives a year as fewer dives would fail to maintain the diver’s skills.

Identifying groups of divers

One approach to the question of diver numbers is first to identify unique groups, then attempt to count participants. Ten separate groups have been identified in Queensland. A brief description of each group follows, along with initial attempts to determine the number of dives made by the groups during 1991.

The intention of this project was to estimate the number of dives made in Queensland over a one year period, rather than the number of divers. Pilot studies had clearly shown that it would be impossible to track individual divers, especially if they were members of groups which had no contact with training agencies or commercial dive facilities. In addition, the total number of “safe” dives completed was considered a more appropriate figure for the purpose of placing accident statistics in their proper perspective.

1 NEW DIVERS TRAINING FOR ENTRY LEVEL CERTIFICATION

The first group consists of new divers who have recently completed an open water course. Confidential figures were obtained from all four Australian training agencies on the number of open water courses conducted in

TABLE 1

FORMAL TRAINING DIVES CONDUCTED IN QUEENSLAND DURING 1991

Training level	No. of courses	Average No of dives	Total
Open water	26,883	4	107,532
Advanced	5,169	5	25,845
Specialties	1,109	3	3,327
Rescue	839	5	4,195
Divemaster	469	20	9,380
Assistant Instructor	48	14	672
Instructor	174	20	3,480

Queensland during 1991. The combined figure for new certifications issued was 26,883. This figure can be multiplied by a minimum of four open water training dives to give the total number of dives made by the group.

2 DIVERS IN CONTINUING EDUCATION COURSES

Continuing education programs are offered by all four training agencies. Following entry level certification divers can take specialty courses such as photography, deep diving, night diving and equipment maintenance. Leadership programs (divemaster and instructor) are also available for those wishing to work in the recreational diving industry.

Table 1 is based on confidential figures supplied by the training agencies and shows the number of different certifications issued in Queensland during 1991. An average number of dives associated with each type of course has also been included to allow for a calculation of the total number of dives made by the group. The average number of dives assigned to divemaster and instructor training programs is intentionally very conservative.

3 RESORT OR INTRODUCTORY COURSES

Resort scuba programs are an important part of the Queensland recreational diving industry.[6,7] The objective of these non-certification courses is to provide the student with a safe, enjoyable introduction to diving under the direct supervision of an instructor.

Because these courses do not result in a certification being issued, the training agencies do not routinely register participants or keep records of the number of courses conducted. To gain this information an independent study was undertaken. All dive operators in Queensland (retail shops, resorts and charter operators) were contacted and asked to provide information on the number of resort course dives they conducted during 1991. A total of 111 companies participated, with a reported 85,000 dives. Given that several companies specialising in this area refused to participate, the figure obtained is considered very conservative.

4 CERTIFIED SOCIAL DIVERS USING COMMERCIAL SERVICES

Based on the replies of the 111 Queensland companies there were 383,742 non-training recreational (social) dives conducted during 1991. This figure is considered very conservative since there are many small charter vessels operating along the Queensland coast that were not included in the study. Also, many dive clubs and independent instructors conduct social dives, but do not necessarily have contact with the main commercial diving services. The figure does, however, give some indication of the size of the main tourist diving market being serviced along the Great Barrier Reef.

5 INSTRUCTORS

As at 30th June, 1991 there were 636 registered instructors in Queensland. Instructors dive in a number of categories: as teachers of open water and continuing education courses; as supervisors of resort courses; as guides for certified divers; and as social divers in their own right. Table 2 presents calculations of the approximate number of dives that may be attributed to this group, based on instructor-student training ratios. Additional figures for private or social diving, and for the number of dives made as a guide for certified customers, cannot even be guessed at. The figures for the instructor group are therefore very conservative underestimates.

TABLE 2

ESTIMATES OF INSTRUCTOR DIVES IN QUEENSLAND DURING 1991

Open water training dives *	26,883
Continuing education dives **	6,461
Resort course dives ***	21,250
Guide for certified divers	Unknown
Private or social dives	Unknown

* Based on an average class group of 4 students with 4 training dives.

** Based on an average class group of 4 students with 5 training dives.

*** Based on an average class group of 4 students each dive.

6 DIVEMASTERS

The number of dives made by divemasters is even harder to calculate because, as a group, they do not issue training certifications. They are, however, involved in training programs by acting as certified assistants to an instructor. Divemasters also lead orientation dives, and can take resort course students on their second dive of the day. Finally, they dive socially themselves. Unfortunately, without a comprehensive study of all divemasters in Queensland the potentially large number of dives made by this industry group remains unknown.

7 CERTIFIED DIVERS OBTAINING COMMERCIAL AIR FILLS, BUT NO OTHER SERVICES

Currently there is no requirement for retails shops or other commercial suppliers to record their number of air fills. Since many certified divers have their own equipment, including tanks, the only contact they may have with commercial facilities is for an air fill. Given this situation, there is no way to calculate the size of this independent group, nor their number of dives.

8 CERTIFIED DIVERS WITH THEIR OWN AIR, REQUIRING NO COMMERCIAL SERVICES

As with the previous group, the number of independent divers with access to private compressors for air fills is not known.

9 UNCERTIFIED RECREATIONAL DIVERS

There are probably still substantial numbers of uncertified recreational divers in the community. This group includes people who are self-taught and have never taken a formal course, through to new divers trying scuba with a certified friend without an instructor rating. When a certified diver has more than one tank filled at a commercial outlet there is no reason or requirement for staff to question whether the extra tanks are to be used by certified buddies.

10 POOL EXPERIENCES ONLY

In contrast to the commercial resort course programs run along the Queensland coast, there are also many one-off pool scuba experiences conducted each year. "Splash parties" are popular in the United States as a way of creating interest in diving, and are often used by instructors as part of general advertising and public relations. Similarly, it is common for large groups of school students to be offered an introductory pool experience as part of an educational program. Since these courses are not registered with the training agencies it is virtually impossible to estimate the number of dives conducted each year.

TABLE 3

SUMMARY OF CURRENT KNOWLEDGE FOR THE NUMBER OF SCUBA DIVES IN QUEENSLAND DURING 1991

Open water training dives	107,532
Continuing education dives	46,899
Resort course dives	85,000
Certified social dives (through commercial services)	383,742
Instructors	54,594
Divemasters	Unknown
Certified dives (air fills only)	Unknown
Certified dives (own air)	Unknown
Non-certified dives	Unknown
Introductory pool experiences	Unknown

Summarising Queensland diver numbers

Table 3 presents a summary of current knowledge for the number of scuba dives made in Queensland during 1991. A very conservative total of 677,767 dives was recorded from the five categories where data was available.

Several large companies specialising in resort diving declined to participate in the company study. Based on industry information, the figure for resort dives per year is probably in excess of 100,000. Similarly, the figure for certified social divers using commercial services is a very low estimate, given that there are many charter vessels and independent instructors operating along the Queensland coast who did not participate in the company study. As Telford notes, some industry sources suggest that there are conservatively 500,000 dives made in the Cairns area alone each year.[8] In addition, the Queensland Dive Tourism Association reports that there were 884,000 recreational dives made in the state from July 1989 to June 1990.[9] Unfortunately, the report does not provide details about the sampling and methodology used to determine this number of dives.

Assuming that most working instructors in Queensland would make at least five dives per week during a 40 week year, a more realistic approximation of instructor dives (based on 636 instructors) is 127,200. Assuming further that divemasters make at least half the number of instructor dives (Table 1 shows there were almost three times the number of dive masters certified in 1991 compared to instructors) then the "known" figures for Queensland exceed 800,000. By adding in the certified divers across the state who have little or no contact with commercial facilities, as well as the many introductory pool experiences offered each year, the final figure is probably closer to one million recreational dives made in Queensland each year.

While recognising that the figures in Table 3 are very conservative, a particular concern for the Australian recreational dive industry should be the fact that no information at all is available for five of the ten identified diver categories. Without this information any diving accidents that do occur cannot be placed in their proper perspective. This makes policy negotiations with insurance companies more difficult for divers, and for the industry in general. It also makes marketing of the sport less effective if the total number of safe dives conducted each year is not known.

At the present time, training agencies and government departments are understandably reluctant to breach client confidentiality and risk legal action by releasing details (or numbers) of accidents that have been recorded. However, in the absence of reliable figures the media will continue to perpetuate myths that diving is a dangerous activity. By gathering complete data on the number of recreational dives made each year, and comparing these figures with the relatively small proportion of accidents occurring, some definitive statement could be made about safety.

This initial report suggest that there are 10 diving categories where data should be collected. There are minimal statistics available for five categories and no information about the other five. Cost-effective strategies that guarantee commercial confidentiality, while gaining much needed information about the five unknown categories, are currently being investigated.

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WORKSAFE AUSTRALIA CODE OF PRACTICE FOR OCCUPATIONAL DIVING.

Ian Millar

A draft Code Of Practice for Occupational Diving is under development. The working group meetings have been completed and a document is to be circulated to the reference bodies, including SPUMS, before release for public comment. The following briefly describes the context and progress of this development which is to provide a replacement for Australian Standard AS2299 - 1992

"Worksafe" is a shorthand name for the National Occupational Health and Safety Commission, a tripartite body (employers, governments and unions) established by the Federal Government to develop, facilitate and implement a national approach to occupational health and safety.

Among other roles, it develops "Codes of Practice" for the control of risk associated with specific workplaces and activities. These must then be applied by the States. However, with general agreement upon the principle of national uniformity of Occupational Health and Safety (OH&S) legislation, it is expected that any national codes of practice should be applied in a uniform manner from 1994 onwards.

Modern OH&S legislation now applies in all states, and differs significantly from the prescriptive approach taken previously. In the past, specific laws allowed government bodies to set regulations that were legally binding upon employers. These regulations often set very specific requirements, in some cases by calling up existing standards such as Australian Standards. Breach of any requirement (clauses containing ”shall”) of a Standard called up by law or regulation was a breach of the law. Under this system, changes in recommended equipment or practice were not legal until the regulation or Standard was changed. Also if the activity of concern was not mentioned in the law or regulations, then there were no requirements upon the employer.

By comparison, modern OH&S legislation primarily creates a “duty of care” upon all involved at a workplace, employers and employees. Standards and Codes of Practice can be set, but are not binding in themselves. “Shall” clauses thus all become recommendations. The onus to provide a safe place of work allows for the use of alternative strategies to those published in Standards and Codes of Practice, provided it can be shown that the resultant level of safety is as least as good as that arising from compliance with the published guidelines.

The ultimate test of this applies in the courts when either a civil suit for damages or a prosecution under the Health and Safety Act will use the published Standards and Codes of Practice as evidence to establish whether a safe place of work has been provided. When considering this question, OH&S legislation allows consideration of “practicability” and the standard of a “reasonable person” although the exact provisions differ slightly between States. It is within this framework that the present Code of Practice for Occupational Diving is being developed.

AS 2299 has applied to various section of occupational diving for some time. It was not, contrary to some beliefs, developed for the offshore oil industry. Rather it initially used the experience of the oil industry and the Navy, among others, to develop a Standard to provide guidance to the coastal and onshore commercial diving sector where a high accident rate appeared to result from inadequate diving equipment, training and practice.

With the advent of new style OH&S legislation, there was pressure for a Standard which could be applied to a wider range of occupations, resulting in a broadening of the scope and application of the 1990 and 1992 versions of AS 2299 and some changes in requirements to allow for scientific and fisheries diving practices. The resultant 1992 document has suffered significant criticism for failing to meet satisfactorily requirements of some sectors whilst being overly restrictive upon others. As a result, it was determined that Worksafe Australia and Standards Australia should jointly develop a new Occupational Diving Code of Practice to address these matters and to cover all types of occupational diving.

The Standards Australia development process uses committees made up of representatives of interested parties to develop a consensus document. The Worksafe process involves selection of an “expert working group” and a “reference group”.

For the Code of Practice for Occupational Diving the two groups were selected by both Worksafe and Standards Australia and supported by a joint secretariat. The expert working group consists of sixteen members drawn from a wide variety of backgrounds including myself as a medical representative. In committee the expert group members are supposed to work co-operatively upon solutions to problems.

The reference group members input is to provide written advocacy for the organisations they each represent. Most working group members are drawn from an interest group which results in some individuals having to wear a co-operative, non-partisan “hat” in committee and a interest group advocacy “hat” as a reference group member. My involvement has been as an independent medical member of the working group, not representing any particular body. SPUMS is the only medical organisation on the reference group, represented by Dr John Knight.

As seems all too common in the diving arena, impartiality and consensus have been difficult goals given the broad spectrum of interests that has been brought together. The timetable set has also made the process somewhat hurried.

Nevertheless, a draft document has now been produced in a quite different format from previous Standards, which is hopefully consistent with the required OH&S approach. Lack of awareness of the framework in which the Code is being developed and misunderstandings regarding the working group’s deliberations have probably added to the confusion and concern that has been voiced to date.

However the process now requires review of the Draft Code of Practice by the relevant Standards Australia committee and by Worksafe’s Standards Development Review Committee, followed by a period of public comment. Much time is still available for further review of proposals.

Some readers may find parts of the Draft Code disappointingly general in nature. This has been a result of the need to provide a document that can be applied to all occupational divers from all “industry” sectors. This has been a source of much discussion inside and outside working group meetings, with the proposition often put forward that “industries” be allowed to develop their own codes which would be suitable to their “industry”. There would thus be a “scientific diving” code, a “fisheries diving code” a “construction diving code” and an “occupational divers in the recreational industry code” etc. Unfortunately, it would appear that there are too many potential demarcation disputes between such groups for such an approach to be acceptable to regulatory authorities. Although practices may be varied for different tasks or hazards, subdivision of requirements by “industry” definitions is apparently not to be allowed to form the basis for having a range of different Codes of Practice.

The task of developing hazard / risk based recommendations has been a difficult one, and many will see the result as not serving any group well. Certainly the process has been rushed and it is hoped that the input to come will result in improvements. Many important provisions are included however, and the generic statements of basic responsibilities are a vital element that has been lacking from more technically oriented standards.

Critics of the Expert Working Group and Secretariat should consider the confines within which the document has been produced and hopefully supply useful criticism in context and in the appropriate directions! Readers of the Draft Code should realise that the Code is not intended to be a textbook or a law and that other documents, in particular training and operations manuals, should provide the detail for safe diving practice in any given situation.

The Draft will be available from Worksafe Australia, 92 Paramatta Rd, Camperdown, NSW 2050 after an advertisement in the national press. I am prepared to talk to any SPUMS member who reads the draft and wishes to discuss particular matters. Submissions can also be made directly to Worksafe Australia by individuals or through Dr Knight representing SPUMS.

Dr Ian Millar MB BS, Dip DHM, is a visiting Specialist in Hyperbaric Medicine at the Alfred Hospital, Commercial Road, Prahran, Victoria 3181, Australia.

He is the AMA representative on the Occupational Diving Committee (SF17) of Standards Australia. His address is 53 Coverdale Road, Sale, Victoria 3850. Home phone (051) 44 3813.

SPUMS NOTICES

CONSTITUTIONAL AMENDMENT.

At the 1992 Annual General Meeting it was agreed to change the financial year to January to December.

The Society had been using a Financial year that ended on 30th April. However the Rules of the Society contain the definition *"Financial year" means the year ending 30th June*.

In order to abide within the Rules this definition will have to be changed.

It is proposed to put the following resolution to the 1993 Annual General Meeting.

That the words "30th June" appearing in rule 2 (a) be changed to "31st December".

Darrell Wallner
Secretary of SPUMS

SPUMS ANNUAL SCIENTIFIC MEETING 1993

will be held at
the Palau Pacific Resort
SUNDAY 16th to TUESDAY 25th MAY 1993

The guest speaker will be Professor David Elliott, co-author of The Physiology and Medicine of Diving with Dr Peter Bennett.

The theme of the conference will be
THE LONG TERM EFFECTS OF DIVING
A workshop on
FREE ASCENT TRAINING
will be part of the program

Anyone wishing to attend should contact
Allways Travel
at the address below.

SPUMS ANNUAL SCIENTIFIC MEETING 1994

will be held at
Rabaul, Papua New Guinea
Provisional dates
MAY 14th to 23rd 1994

The guest speaker will be Dr Peter Bennett, co-author with Professor David Elliott of The Physiology and Medicine of Diving.

For further information contact
Allways Travel
168 High Street, Ashburton,
Victoria 3147, Australia.

Telephone

Australia	03 885 63
International	61-3-885 8863
Toll Free (Australia only)	008 338 239

Fax

Australia	03-885 1164
International	61-3-885 1164

SPUMS
DIPLOMA OF DIVING AND HYPERBARIC MEDICINE.

Requirements for candidates

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

1 The candidate must be a financial member of the Society.

2 The candidate must supply documentary evidence of satisfactory completion of examined courses in both Basic and Advanced Hyperbaric and Diving Medicine at an institution approved by the Board of Censors of the Society.

3 The candidate must have completed at least six months full time, or equivalent part time, training in an approved Hyperbaric Medicine Unit.

4 All candidates will be required to advise the Board of Censors of their intended candidacy and to discuss the proposed subject matter of their thesis.

5 Having received prior approval of the subject matter by the Board of Censors, the candidate must submit a thesis, treatise or paper, in a form suitable for publication, for consideration by the Board of Censors.

Candidates are advised that preference will be given to papers reporting original basic or clinical research work. All clinical research material must be accompanied by documentary evidence of approval by an appropriate Ethics Committee.

Case reports may be acceptable provided they are thoroughly documented, the subject is extensively researched and is then discussed in depth. Reports of a single case will be deemed insufficient.

Review articles may be acceptable only if the review is of the world literature, it is thoroughly analysed and discussed and the subject matter has not received a similar review in recent times.

6 All successful thesis material becomes the property of the Society to be published as it deems fit.

7 The Board of Censors reserves the right to modify any of these requirements from time to time.

CHANGE OF ADDRESS

The Council of the Australian and New Zealand College of Anaesthetists (ANZCA) has kindly consented to provide SPUMS with a permanent address.

All correspondence, **addressed to the office holder concerned**, should be sent to

SPUMS, C/o
Australian and New Zealand College of Anaesthetists,
Spring Street, Melbourne
Victoria 3000, Australia.

MINUTES OF SPUMS TELECONFERENCE ON SUNDAY 15TH NOVEMBER 1992 AT 10:00 HRS

Present

Drs Des Gorman (President), Darryl Wallner (Secretary), Sue Paton (Treasurer), John Knight (Editor), David Davies (Education Officer), Tony Slark (Past President), Chris Acott, John Williamson, Guy Williams.

Apologies

None.

1 Minutes of previous meetings

Minutes of the previous meeting were accepted with an alteration to Item 4. The Diving doctors Course run in Perth in 1986 was given by the Australian Sports Medicine Federation.

2 Business arising from the minutes

2.1 PALAU ASM

Guest speaker

Dr Elliott is finalising his presentations. The full texts will be forwarded to John Knight well before the ASM.

FreeAscent Training Workshop

Dr Gorman and Drew Richardson are co-operating on the format for the Workshop. Dr Knight wishes to ensure that a definition of Free Ascent occurs and includes PADI's recommended instructor practice, which contrary to their stated policy, does appear to be Free Ascent.

Dr Williams will be in Palau early and will be available to help organization of the ASM if required.

Duties of the convener

Dr Gorman will formalise these duties in a statement for future reference.

Registration fee

The breakdown of this figure has been received from Allways and will be forwarded to the Secretary. Some re-negotiations occurred with the Hotel to lower some unrealistic charges, particularly the Banquet Dinner which will now be their normal menu for that night.

2.2 PNG ASM

Rabaul is the venue for 1994 ASM in the second week of May. Three hotels have been booked. Pre- and post- conference dive charter boats have also been booked.

Dr Acott will arrange for CIG to supply oxygen cylinders. Nonga Base Hospital is suffering from equipment shortage and would be grateful for any anaesthetic equipment that anaesthetists may be able to send.

David Pennefather, a local expert from Lae, will be invited to give talks on the war history of the wrecks.

SPUMS policy on the funding of visiting speakers was restated: The Society meets the costs of air travel, accommodation, meals, but not alcohol. Dependents of the speaker have their rooms costs funded.

2.3 RED SEA AS ASM VENUE

Dr Gorman reported it as unsuitable. Diving was disappointing due to large number of divers, coral damage, poor visibility and little fish life.

2.4 FUTURE ASMs

Quotes for other venues, nothing further. Dr Paton would like Committee Members to supply her with their own favoured venues. This would provide a framework for quotations from Travel Agents.

Because of delays in surface mail overseas members should be notifie of future ASM by airmail. These members' only source of information is announcements in the Journal, which may arrive far too late.

3 North American Chapter

Has been fully reimbursed and also a $1,400 reserve fund has been established. It was thought reasonable that the North American executive could be included in the teleconferences. However, the cost was to be investigated by Dr Paton.

4 Diving doctors list

This is nearly complete. Dr Davies and Dr Oxer hope to run a course in Perth in January on diving medicine.

5 Treasurer's report

At present we have $5,000 in a working account and $30,000 in an interest bearing account. Expenses each 3 months period is approximately $11,000.

After the first billing there was approximately one third of members require a 2nd account, which will go out shortly.

6 Journal printing quotes

Four quotes are being obtained in Melbourne, only one has been received.

7 Correspondence

Dr Knight will ask ACOM to arrange that mail arriving will be redirected to our new address. The Secretary will inform Consecta Services of this.

7.1 DR OXER'S LETTER

Dr Oxer's letter referring the publication of Dr Mark's thesis. Dr Gorman has replied clarifying some misconceptions.

7.2 DIVING MEDICALS

Dr Thomas' letters was tabled, and the unsatisfactory and inconsistent views of various State Branches of the AMA was noted, regarding properly trained doctors performing diving medicals. Also that doctors performing aviation medicals belonged to a restricted list was noted. It was resolved to publish a condensed version of the AMA's letters in the Journal.

7.3 DIPLOMA OF TROPICAL HEALTH AND HYGIENE

Dr Gordon's letter from Townsville asking for our support to include some underwater medicine units in their Diploma of Tropical Health & Hygiene. The Committee gave unqualified support and will liaise with Dr Gordon about course syllabus and progress.

7.4 HYPERBARIC TECHNICIANS AND NURSES ASSOCIATION

Letters from the Hyperbaric Technicians and Nurses Association were noted.

7.5 NASDS

Letter from NASDS was discussed. The matter of the DCIEM tables and the role of the APSF and its independence from SPUMS was emphasised. Dr Knight will review the letter and revise it regarding inaccuracies of fact and misconceptions and any response will be discussed.

8 Diving emergency insurance

Dr Acott is awaiting certain expert and legal opinion on this package, which unlike certain travel and other insurance available would hopefully cover decompression illness specifically.

9 Controversial medical topics

Dr Davies will produce proposals to hold workshops at ASM's on some of these topics related to underwater medicine.

10 Visiting medical professor

Professor Harijento Mahdi from Surabaya will be visiting Australia, and Dr Williamson will extend an invitation to visit the Hyperbaric Medicine Unit at Royal Adelaide Hospital.

11 Next meeting

Date of next teleconference is 7th February 1993, at 10:00 hrs Daylight Saving Time.

SPUMS ANNUAL SCIENTIFIC MEETING 1993

Annual General Meeting 1830 22nd May 1993

Monday May 17th

Venue Conference Room, Palau Pacific Hotel

1630-1800 SPUMS Executive Meeting

1800-1900 Registration
1900-1930 Conference business and notices *(Gorman and Allways)*

1930 Cocktail Party

Tuesday May 18th

The long term sequelae of diving

Chairman	***Gorman***
1630-1645	Introduction *(Gorman)*
1645-1730	Dysbaric Osteonecrosis *(Elliott)*
1730-1800	Discussion

Open papers

Chairman	***Williamson***
1815-1845	A first-person report on a diving accident *(Cummins)*
1845-1900	Discussion
1900-1945	Risks and procedures for deep, drift and multi-level diving *(Richardson)*
1945-2000	Conference business and notices *(Gorman and Allways)*

Wednesday May 19th

The long term sequelae of diving

Chairman	***Acott***
1630-1715	What are the long-term sequelae of diving ? *(Elliott)*
1715-1730	Dysbaric Osteonecrosis *(Elliott)*
1730-1800	Discussion

Open papers

Chairman	***Davies***
1745-1815	The 1992 PADI survey of diving consumers and diving instructor candidates *(Richardson)*
1815-1830	Discussion
1830-1900	Diabetes mellitus and the scuba environment *(Sullivan)*
1900-1915	Discussion
1915-1945	Factors in underwater escape from an inverted helicopter *(Elliott)*
1945-2000	Discussion

Thursday May 20th

The long term sequelae of diving

Chairman	***Williams***
1630-1700	Studies of outcome after treatment for decompression illness in Australasia *(Gorman)*
1700-1745	Neurological deficits after diving *(Elliott)*
1715-1800	Discussion
1815-1845	The development of diving safety *(Elliott)*
1845-1900	Discussion

Workshop on emergency ascent training: Part 1

Chairman	***Gorman and Richardson***
1900-1945	Current philosophy and practice of emergency ascent training for recreational divers *(Richardson)*
1945-2000	Discussion

Friday May 21st

Workshop on emergency ascent training: Part 2

Chairman ***Gorman and Richardson***

1630-1645	Introduction *(Gorman)*
1645-1715	Diving incidents necessitating an emergency ascent in Australasia *(Acott)*
1715-1745	A training agency perspective of emergency ascent training *(Cummins)*
1800-1845	A medical perspective of emergency ascent training *(Knight and Williams)*
1845-1900	Summary *(Richardson)*
1900-2000	Discussion and formulation of SPUMS policy on emergency ascent training.

Saturday May 22nd

A review of diving and hyperbaric medicine in Australia and New Zealand

Chairman ***Paton***

1600-1630	A progress report on DIMS *(Acott)*
1630-1645	Discussion
1645-1715	A progress report on clinical hyperbaric studies at the Royal Adelaide Hospital *(Williamson)*
1715-1730	Discussion
1730-1800	A progress report on diving medicine studies in the Royal New Zealand Navy *(Gorman)*
1800-1815	Discussion

LETTERS TO THE EDITOR

LAMBADA DANCING ON A TIGHTROPE

NATIONAL ASSOCIATION OF SCUBA DIVING
SCHOOLS-AUSTRALASIA INC.
Unit 7/15 Walters Drive
Osborne Park, W.A. 6017

Dear Editor,

I write in response to Dr Des Gorman's editorial "Lambada Dancing on a Tightrope''[1].

During the preparation of the AS4005.1 NASDS consistently voted in favour of a mandatory medical examination for all candidates for scuba diving instruction. Indeed, Dr John Knight[2] mentioned NASDS' consistent support.

For at least the last 14 years NASDS has maintained a mandatory standard which requires all recreational divers trained by NASDS (FAUI) to have completed a comprehensive medical. The maintenance of this standard has perhaps been to our commercial detriment.

The NASDS medical standard was at first based on the AS2299 diving medical. Subsequently minor variations were made and did not vary in any substantial manner from the SPUMS endorsed medical[3] or the ultimate Australian Standard format published in AS4005.1.

NASDS strongly believes and recommends that all diving medicals should be carried out by physicians trained in diving medicine. Our failure to vote for this as a requirement for AS4005.1 was based on practical issues and not on a divergence of philosophy. Any requirement to make compulsory the conduct of diving medicals by diving doctors was, in our view, unworkable. Even today, there appear to be too few physicians trained in diving medicine. Until such time as more trained physicians are available, which we hope is not too far away, the compromise of providing the general practitioner with solid guidelines to conduct diving medicals is the only realistic choice.

We admit that our funding of DES has been spasmodic. This has been due to tough economic times. In any event we have managed to pay many thousands of dollars to DES. NASDS has always made donations free of any strings and currently NASDS maintains a fifty cent levy on a diver's entry level certification.

At the time of developing the current funding support for DES, NASDS was promised, as were the other agencies, access to data compiled through the Australian Patient Safety Foundation (APSF) Critical Incident Monitoring programme. These are statistics which the agencies need to gauge the effectiveness of their instruction and are generally more useful than reports on accidents (deaths). To date, only one such report has been received[4] by NASDS and that was in January 1990.

Dr Gorman's comments on the sale by NASDS of DCIEM Tables are at best described as his side of this complex issue. Unfortunately there is neither the time or the space in this letter to fully detail all aspects of this matter. Suffice to say that conflict between APSF and NASDS arose when both parties could not achieve a mutually beneficial business arrangement for the sale of the DCIEM tables.

Given NASDS' history of no-strings-attached financial support for DES, our continued endorsement of DES, our consistent commitment to diving safety through the promotion of the DCIEM Tables, and our earlier attempts to reach a commercial compromise with RAH/APSF, Dr Gorman's comments were totally uncalled for.

NASDS has for many years been an associate member of SPUMS and a keen supporter of the Society's goals. Our record of support is probably unmatched by any other certification agency. Our failure to attend annual SPUMS conferences has been due to lack the finance and time. A situation, I'm sure, in which we are not alone.

NASDS believed that we had a close and warm relationship with SPUMS and the medical profession. Dr Gorman's editorial did nothing to contribute to the further development of this relationship. We are disappointed.

Ian Milliner
National Manager, NASDS Australasia Inc.
(Lately Federation of Australian Underwater Instructors)

References

1. Gorman D. Lambada dancing on a tightrope. *SPUMS J* 1992; 22(3) 126-27
2 Knight J. The SPUMS diving medical submission to Standards Australia. *SPUMS J* 1992; 21(4) 231-35
3 *SPUMS Diving Medical*. March 1992.
4 Pilot incident study results. *Divesafe* 1990; No 1 (January): 4-5

MALARIA PROPHYLAXIS

Traveller's Medical and Vaccination Centre
2nd Floor, 393-397 Little Bourke Street
Melbourne, Victoria 3000

Dear Editor,

It was pleasing to read the DES column in the November DIVE LOG Australia Magazine. Some important issues were highlighted concerning diving in areas where chloroquine resistant malaria occurs and they are worth bringing to the attention of SPUMS members.

The first issue is that a range of personal protection measures to avoid mosquito bites is essential and diving medicine practitioners should offer this specific advice to divers at risk.

Secondly, it is reassuring to read the SPUMS statement on the avoidance of mefloquine (Lariam) for malaria prophylaxis for these areas because of its known side effects and adverse reactions. This is consistent with the policy of the Traveller's Medical and Vaccination Centre clinic's throughout Australia, which also supports the use of alternatives to mefloquine for divers. P.N.G., Solomons, Vanuatu, parts of Indonesia and Malaysia and Indo-China all report chloroquine and antifolate drug resistant malaria.

It is worth reminding divers that doxycycline is associated with photosensitivity reactions so a maximum - protection blockout is appropriate for divers using doxycycline.

Lastly, the differential diagnosis of non-specific flu like symptoms of weakness, tiredness, headache; myalgia, vomiting and abdominal pains in diver in tropical areas includes malaria as well as D.C.S. and specific testing for malaria should be performed.

A Gherardin

TRAINING FOR DIVING MEDICALS

Avondale Accident & Medical Clinic
PO Box 19-253, Avondale, Auckland 7
New Zealand

Dear Editor,

As a newcomer to the New Zealand chapter of SPUMS, one who attended its recent annual scientific meeting, I am disappointed that the ANZ diver death series[1] is subject to fallacious interpretation by an apparent majority of Society members.

The study is a retrospective exercise in data collection which is bereft of any mathematics more complex than elementary addition and from which only the most tentative of conclusions can be drawn.

It should not be used to support arguments for compulsory post graduate training of those doctors who wish to conduct recreational diver medicals. Although the authors would have found at least 25% of the (dead) divers medically unfit had they taken a history before the fatal dive, no evidence is presented as to what proportion of a matched population of divers who did not die while diving would have survived such a history taking.

In over half of all divers who died in this series, that event occurred shortly after exhaustion of the air supply (56%), and/or problems with buoyancy (52%), and or/a failure of the buddy system (59%). On this evidence, efforts to prevent deaths in recreational divers should concentrate on reducing the incidence of these precipitating factors by ensuring that all divers receive appropriate training, and that throughout their diving career they continue to dive in accordance with that training.

Rhys Cullen

Reference

1 Edmonds C and Walker D. Scuba diving fatalities in Australia and New Zealand. *SPUMS J* 1989; 19 (3): 94-104.

Reply

1423 Pittwater Road
Narrabeen
New South Wales, 2101

Dear Editor,

I thank Dr. Cullen for showing that there has been at least one person who has read our paper[1] critically. Before dealing with the matter which appears to trouble him most, the requirement that a doctor must acquire some knowledge of diving-related problems before giving an opinion on the subject, I will answer the other matters he details.

First, as he provides no evidence to support this statement that this paper has been "fallaciously interpreted" by the majority of members of this Society. I cannot find a basis for discussion. Indeed, I have no evidence that anyone other than he has given it any thought, let alone been influenced by it.

Second, that the study was retrospective. As there is no way known to to me to monitor a significant number of novice divers during their first year of diving to record their skills, understanding, experience, dive profiles, health, etc. it has been necessary to research the problem from the episodes of morbidity. It is sadly true that the only divers who come to notice have selected themselves by dying or attending for treatment of DCS or CAGE. As there is no data concerning the numbers of divers, their frequency of diving, their age and health profiles or types of dives they perform, it was thought appropriate to provide raw numbers rather than (meaningless but neat) statistics. Indeed it is my view that however small the statistical risk may be, if it can be reduced, it should be. It is unfortunate that neither the majority of SPUMS members nor any of the Instructor organisations have recognised the value of seeking out information and sharing it, and have continued resolutely to ignore all requests that they join the research project known as "Project Stickybeak".

While I doubt whether either of the authors would actually have said "failed" to 25% of these divers if seen in life, nevertheless, rightly or wrongly, the present rules in this area state that asthmatics, epileptics and insulin dependent diabetics (among others) should not be assessed as Fit to Dive. Some such people are passed as Fit to Dive by doctors ignorant of the reasons for such rules, and this could have legal and insurance consequences.

Dr Cullen is under no obligation to undertake Diving Medicals so his claim that he is forced to take post-graduate training needs to be moderated. It seems reasonable to require anyone offering an assessment of another's fitness to know the parameters of the job or activity involved.

I believe that there are three questions which should rightly demand our attention. First, is a Diving Medical necessary (if it is, then surely it should be performed with awareness of what are the medical problems to be considered). Second, who desires this assessment and for what purpose, the Instructor organisations for insurance and/or liability reasons, or the applicant. The degree of potential risk considered acceptable is not a medical but a legal/ insurance decision. Thirdly, my research (soon to be published) shows that about half the scuba-diving related fatalities in Australia over the past 20 years have involved those who were grossly inexperienced, and that the commonest adverse factors were low-air status and failure to ditch weights and/or inflate the buoyancy vest. Cardiac factors only become a significant risk factor in divers aged 40 years and over.

There is a good case for a radical review of the content and diving practice component of present basic courses and of the support made available to novices during their first few dives performed without benefit of supervision by an instructor. The medical factor usually is less critical to survival than the experience level, but all the Instructor organisations are likely to continue to require "a medical" for their own reasons. It is they, not the medical profession, who have the simplistic belief that "medical fitness to dive" is a simple YES/NO decision. Remarkably, in Australia, they do not require that this medical assessment is performed by an appropriately informed doctor.

I thank the Editor for this opportunity to clarify matters.

Douglas Walker

Reference

1 Edmonds C and Walker D. Scuba diving fatalities in Australia and New Zealand. *SPUMS J* 1989; 19 (3): 94-104.

AMA POSITION ON DIVING MEDICALS

Australian Medical Association Limited
42 Macquarie Street
Barton, ACT 2600

Dear Sir,

I am replying on behalf of the AMA and of the President to your letter of 6th January concerning SPUMS' views on medical certification of divers' fitness.

Ethical position

The most recent version of the Association's Code of Ethics (copy enclosed), although focused on clinical rather than preventive aspects of patient care, contains at least four statements, as follows, which bear on any medical practitioner's ability to perform satisfactory examinations for certification of a diver's fitness.

1 "Practise the science and art of medicine to the best of your ability and within the limits of your expertise."
2 "Evaluate your patient completely and thoroughly".
3 "Recommend to your patient that additional opinions and services be obtained when treatment is not within your expertise".
4 "Accept a share of the profession's responsibility to society in matters relating to the health and safety of the public, health education and legislation affecting the health or well being of the community".

As a general principle of the AMA holds that, except in emergencies when there is no reasonable alternative, medical practitioners should not attempt examinations, diagnoses or procedures which are beyond their ability or training. The important thing is for medical practitioners to be aware of their own limitations !

The AMA considers that the overall standard of general practice throughout Australia is very high. Given that many if not most of SPUMS' members are probably general practitioners who have an interest in hyperbaric and diving medicine rather than full time specialists in those arcane pursuits, SPUMS' repeated denigration of general practitioners appear unfortunate and inappropriate.

To an impartial observer, SPUMS protestations might even be construed as a cynical attempt to capture the market in diving medicals for its members. If you find such a suggestion hurtful, I assure you that the AMA considers no less repugnant any suggestion that its motives in opposing early introduction of certification requirement for diving medicals stem from cupidity rather than from ethical and professional concerns.

The AMA is unaware of extant or pending legislation which would require specific training for medical practitioners who perform diving medicals. Does SPUMS contemplate advocacy for such legislation federally and/or in the several states and territories? Alternatively, does SPUMS believe that adoption of some relevant Standard by SAA would ensure early passage of appropriate legislation, or does it consider that the mere existence of such a Standard might be sufficiently persuasive to cause non-qualified examiners to desist? (In the absence of legislation, AMA members, who subscribe to the Code of Ethics, might be disadvantaged by non-members, equally untrained, who continued to perform such examinations.)

SPUMS appears to resist any analogy between aviation and diving medical examinations. Nevertheless, it is a fact that an acutely disabled diver can at worst lose only his own life and perhaps that of several diving companions, while an acutely disabled pilot may crash an aircraft, costing the lives of all on board and perhaps many others besides (e.g. in the case of an accident in a city, as occurred in Holland last year). Presumably for this reason, public authorities have long since required medical examinations for crews and have designated practitioners empowered to undertake them, while this has not yet been deemed necessary in the case of divers. Of course scuba diving is a recreational activity accompanied by considerable risk, but then so are mountaineering, hang gliding, bungee jumping and rug by. To date, no legislative requirement exists for any medical examination prior to those activities, let alone examination and certification by soi disant "experts".

Risk assessment

SPUMS apologists appear ready to make statement such as that at the end of page 203 in the SPUMS Journal you enclosed:

"Some of these people died as a result of this failure to assess them properly."

What is the evidence for such assertions? What does SPUMS consider to be the incidence and total numbers of absolute and relative contraindications to scuba diving which should have been revealed by adequate history and physical examination but are missed by "non expert" examiners? While most clinicians "just know" some things to be so, proving them is very different (as the AMA has found in its attempts to have chiropractors excluded from treating visceral/somatic conditions because of their ministrations for such complaints).

Availability of services

What are SPUMS' estimates of numbers of regular or occasional sports scuba divers throughout Australia? How often does it believe medical examinations for them should be performed? How many medical practitioners does SPUMS believe are now appropriately trained and experienced to undertake the necessary examinations? What is the level of congruence between examiners' and potential examinees' numbers and locations?

Availability of training

The AMA would be grateful to receive form you details of training courses in hyperbaric/diving medicine which SPUMS believes would equip medical practitioners safely to perform diving medicals. Attending longer course is difficult for many AMA members. Attracting a suitable locum tenens requires considerable planning, and course and travelling costs may considerable. You will be aware that numerous general practitioners today earn only quite modest incomes.

Conclusion

The AMA obviously takes most seriously any representations made on behalf of a reputable and expert body such as SPUMS. The purpose of the antecedent material is simply to ensure that SPUMS fully understands that there is another side to this debate. Perhaps you would care to contact the editor of Australian Medicine, the AMA's news magazine, to explore with her the possibility of writing an opinion piece on this matter for the magazine? That would be certain to stimulate discussion of it within the AMA. I should be happy to summarise the countervailing arguments for simultaneous publication.

I shall distribute copies of your letter and of this reply to all AMA Branches and members of Federal Council and invite their further comments on the matters raised. Formal dialogue between SPUMS and the AMA should as least allow both to be more aware of the other's views and the reasons for them.

Yours faithfully,
Dr. P.S. Wilkins
Australian Medical Association Limited

The above has been edited down from a letter, of four A4 pages, typed with single spacing, sent in response to the paper IS THE AMA REALLY INTERESTED IN PREVENTIVE MEDICINE ? (*SPUMS J* 1992; 22 (4):203-206)*. The Editor's preliminary reply appears below.*

Dear Dr Wilkins,

Thank you for your letter of 13/1/93.

I enclose a photocopy of an article in the SPUMS Journal[1] which makes it quite clear that doctors without training in underwater medicine were not living up to your first quote from the AMA code of ethics. They were quite clearly outside their expertise.

This is not suprising as there is no discussion of underwater medicine in the undergraduate curriculum in most medical schools and and insufficient to prepare people to examine candidates for diving (one or two lectures) in the one or two that do include the topic.

SPUMS considers that a sports diver needs a diving medical before using compressed air but sees no need for regular medicals after that. SPUMS has no desire to restrict diving medicals to its members. In fact about half those who have done the necessary courses are not members of SPUMS. The whole exercise is to raise the standard of practice and protect prospective divers.

Unfortunately there **<u>is</u>** evidence from studies of diving deaths that "Some of these people have died as a result of this failure to assess them properly". It will take me some time to find and photocopy the cases and I wish to send this letter today before going to work. I will therefore write again when I have had the time to gather up-to-date information and references to answer your questions.

Most of the information you require is on file with Dr Darrell Wallner, the Secretary of SPUMS, of 114 Vasey Crescent, Campbell, ACT 2601.

I hope that before the end of 1993 we will be able to convince the AMA that SPUMS is only interested in promoting good standards of practice which will offer higher quality and safer service to diving candidates.

Dr John Knight
Editor, SPUMS Journal

Reference

1 Edmonds C. MMM, the Mickey Mouse medical. *SPUMS J* 1986; 16 (10; 3-4

6 Union Street
Newcastle NSW 2300

Dear Editor,

I wish to reply to the comments made in the letter from the Assistant General Secretary, Australian Medical Association which makes reference to the qualifications required to be a Civil Aviation Medical Examiner. As part of his defence of the AMA's position that there is no need for certification of doctors who wish to perform fitness examinations of candidates who wish to undertake scuba diving, he states that a precedent exists where Civil Aviation Medical Examiners require no training to undertake that position. I have held my examinership in that capacity for a number of years now and when I was first appointed the position was as he stated.

However since Dr. Robert Liddell has taken the position of Director of Aviation Medicine, to gain a new appointment as an examiner one must have completed the Aviation Medical Course at Monash University which is of two weeks duration. All those of us who continue to hold our position as Medical Examiner however, are also required to attend a number of Aviation Seminars which are conducted in various centres around Australia and to attend at least one Aviation Medical Society Conference each three years. It has also been stated that it is preferred that we should also complete the Monash Aviation course. A comprehensive manual is provided by the CAA.

P. C. Arnold

53 Coverdale Road
Sale
Victoria 3850

Dear Editor,

I am most concerned about the differences between the AMA and SPUMS that are suggested by published letters and statements. As one of the participants in the Standards Australia committee decision that triggered this situation, I hope that the following personal view may perhaps assist in refocusing the debate in a more positive direction.

Diving medicals

I believe that the bureaucracy of Federal AMA would concur with the desirability (as opposed to the absolute requirement) for suitable training for medical practitioners undertaking diving medicals. I have recently written to Dr Wilkins of the AMA urging him to publicly support this view.

The need for training in underwater medicine arises from the lack of training offered in normal medical education and the peculiarities of the physics and physiology of the diving. Those who believe that an informed diving medical opinion is possible in the absence of such training are presumably themselves misinformed or uninformed about diving medicine and its differences from most other fields of medicine.

However there are some individuals, without formal medical training, who have gained significant, appropriate and useful knowledge of diving medicine through their work.

Occupational health nurses, military medics, non-medical physiologists and technicians are examples of persons who may have the skills necessary to ask the basic questions and perform the mechanics of a standard diving medical examination. By following a strict set of guidelines, most applicants without any deviations from "ideal health" could probably be identified by such persons. It is understandable, therefore, why some GPs without an understanding of diving medicine may feel insulted when it is suggested that they do not have appropriate skills for performing a diving medical.

The argument for trained examiners should centre on the need for counselling of diver candidates and for the judgement, further investigation and interpretation that is necessary when deviations from "ideal health" are detected.

In my experience this seems to apply for 90% or more of divers; nearly everyone has some health factor that at least requires further questioning and consideration. I believe that it was this point of view that resulted in a change of opinion amongst some of the representatives at the Standards Australia committee meeting who had supported questionnaires rather than medicals until Dr Knight and I explained the reasons for our opposition to this.

Two differing views exist as to the "purpose" of diving medicals, with both having been aired in this journal and sometimes confused within the one document.

The traditional view is that diving medicals should result in the examiner deciding upon a verdict of "fit" or "unfit".

The alternative view of diving medicals holds that the examiner is an adviser who assists the diver to make an informed decision whether to accept the risk of diving or not. There is of course a continuum of "degrees of fitness" and wide variation in the amount of risk that different individual divers see as acceptable.

The first view is routinely applied to occupational medicals, the second more commonly to the situation of return to recreational diving after an incident. With regard to entry level recreational diving medicals it would appear that opinion is split amongst doctors, instructors, instructor agencies and potential divers. It should be noted however that the basis for the second alternative is individual risk acceptance which should be of an informed nature. Without an adequate diving medical it is difficult to argue that a diver training candidate can give informed consent to training.

Much of the discussion regarding training for diving medical examiners uses terms such as "requirements". This is very open to misinterpretation when not qualified as to who "requires" the medical or the training for the examiner.

Requirements may be dictated by legislation, Australian Standards, Codes of Practice, professional standards, the speaker's own interpretation of safety standards etc. It should be remembered that recreational diving itself is basically unregulated in most States so there are no "requirements" for a medical examination in a legal sense nor therefore for training of the examiner.

"Requirements" in Australian Standards (clauses containing "shall") are merely guidelines for good practice and evidence for court hearings after an incident unless the Standard is called up by legislation or regulation. There is a valid point of view that suggests that there should not be regulation of recreational activity unless the public good is significantly at risk, and diving has been compared with other unregulated activities which appear to carry equal or higher risk.

I believe that these important underlying matters as to the purpose and place of diving medicals require further debate, as it is differences on these points that I believe underlie many differences of opinion and obscure the desire of all to promote continuing improvements in diver safety.

The Australian Standards Committee Decision

As has been suggested, I personally support the proposal that medical practitioners carrying out recreational diving medicals should have appropriate training. I did have some concerns however about the wording used in the draft Standard that was presented to me when I was asked to join the recreational diving committee. In my postal vote on the draft I stated that I believed that appropriate editing could have resolved these concerns without losing SPUMS intentions. A large number of negative votes were received however, necessitating a further committee meeting to resolve these. In discussing the matter with Dr Wilkins of the AMA before this meeting I understood his opinion to be that formal training of diving medical examiners was highly desirable and possibly inevitable in the longer term. Nevertheless, he was apparently mindful of the position forwarded from some branches and felt that an absolute requirement for course completion should not be supported in the context of the draft's inflexible wording and two year time frame.

As it turned out, it did not prove necessary for me to resolve the differences between my personal position and my understanding of the AMA's during the meeting. The chair chose to separate the question of whether a medical examination was required at all from that regarding the training of the medical practitioners who would perform such medicals. During discussion of the former question, I supported Dr Knight's and SPUMS point of view and, I believe, helped convert the views of some of the diving instructor representatives who appeared to have an "anti-medical" opinion based upon some rather unfortunate misunderstandings.

It became clear however that some of the representatives' preparedness to accept diving medicals at all was conditional upon training for medical examiners being "recommended" rather than "required". This created the situation where my supporting an absolute requirement for SPUMS approved training would have divided the committee in such a way that a degree of consensus allowing publication of the Standard could not have occurred. A pragmatic decision thus seemed appropriate. A vote against the second question was registered by all committee members except Dr Knight and one other, enabling the first question to be carried in the affirmative, allowing the draft Standard to pass on for publication.

It was hardly the AMA alone that was responsible for diving medical training for examining doctors being recommended rather than required! I would have preferred a rewording of the section in question and further debate, however in the context of the situation I was happy that the best achievable outcome had been reached, publication of the Standard with all its other important requirements rather than an indefinite stalling resulting from the probable necessity to re-open the public submission phases of the Standards development process. I hoped, and still hope, that time will see rapid extension of appropriate training for medical practitioners who advise divers and diving trainees, and trust that the AMA will join SPUMS and others in supporting this aim.

Standards Australia committees and the AMA

The appropriateness of the AMA having a representative on a diving committee has been questioned. It is my understanding that the AMA has historically supplied a representative to various Standards Australia committees as a public service, usually at the request of others, in order to assist in public health promotion matters. This has certainly been my understanding in relation to the various diving related committees on which I have served for some years now and most of my input to these committees has been of a general nature, in no way needing to represent the "views of the AMA" in any political or member's advocacy sense. I believe that it has been very useful to have a number of medical representatives on these committees as much that is discussed requires medical opinion.

As such I welcomed Dr John Knight's addition to these committees as SPUMS representative. Input and even attendance from NH&MRC, government and Naval medical representatives has unfortunately been limited and erratic in recent years. Obviously SPUMS is an appropriate body to supply a representative, however it seems worthwhile to spread the burden of supporting travel and accommodation for multiple medical representatives across a number of sponsoring bodies. The matter of training for medical practitioners performing recreational diving medical medical examinations has been the first occasion on which I have been asked to present a specific AMA point of view. I can see few other matters on which the AMA and SPUMS would differ, and would thus hope that such differences would not arise in the future.

I make the plea that both parties leave the past behind by accepting that the present Australian Standard has been published and cannot be altered until its next review. Surely energies could be combined to promote diving safety, including that which would follow from promotion of medicals performed by appropriately trained practitioners. Co-operation is required regarding acquisition of the necessary epidemiological data to answer some of the many questions that can be validly asked about the assumptions underlying many of our present fitness "standards". Debate is required about the purpose, applicability and legal standing of the medicals we perform.

Ian Millar

BOOK REVIEWS

FIELD GUIDE FOR THE DIVE-MEDIC
C Gordon Dougherty
Coastal Aquatics Publications, 8807 Wildridge Drive, Austin Texas, 78759 USA.
Price $US47.50 + $US5.50 for post outside the USA.

This updated (second) edition should prove to be useful not only to its specific constituency of Diver-Medics but also to the many who go on diving expeditions and cruises out of reach of rapid attendance by an appropriately trained medical practitioner. It is written in a concise and clear manner, as is to be expected from an author with extensive experience in advising several of the large employers in the off shore oil industry and involved in the training of diver medics.

Because the target readership has received intensive training in emergency medicine before being given responsibility for the care of others on an oil rig or a drill ship, there is omission of some basic first aid advice, such as the management of limb fractures or a treatment flow chart stating that control of any significant bleeding is a priority. Nevertheless the text gives advice on a wide range of problems which a dive leader out on the Barrier Reef might have to face. There is advice on burns and on abdominal pains in addition to the specifically diving-related problems. Perhaps surprisingly (considering the number of women who are now employed as professional divers) there is is no mention of any gynaecological problems. Possibly this will be included in the next edition. Till then you will have to rely on step by step advice given over the radio to manage an unexpected labour!

Despite the present day shore-based medical support via radio for the lay person with the responsibility for some medical problem, there is still a great similarity with the situation faced by the Master of a sailing ship in days of old. He (there were no female ship's Masters then) was armed with a limited stock of medications, a book of basic medical advice, and awareness of the responsibility devolving on himself.

If you have the responsibility for a group of people, you should plan for medial and other emergency situations. As others have undoubtedly said, "it comes with the territory". This book should make the problems easier to manage. While it does not aspire to be encyclopedic in the range of medical problems it covers, it nevertheless is far more than a book dealing solely with the management of diving emergencies.

Being intended for on the spot use, the book has been made tough by being printed on Kimdura plastic, which looks like paper but has a better resistance to a diver's wet fingers. Its spiral binding ensures that it lies flat open at the chosen page. It is book worthy of a place alongside a simple first aid book, in the medical kit of any diving expedition.

There is a special piece of good advice at the end of the preface to the first edition, reprinted in this edition. "The mature, prudent medic will always get advice when he is in doubt". Marry this to the advice on the cover of "The Hitch Hiker's Guide to the Galaxy", ("Don't panic") and you should be a great comfort to those seeking your care.

Douglas Walker

SPUMS ANNUAL SCIENTIFIC MEETING 1992

MEDICAL PREPARATION FOR DIVING THE GREAT BARRIER REEF

Michael Rooney

Is medical preparation for diving on the Great Barrier Reef (GBR) any different from medical preparation for diving anywhere else? The diving that is done on the GBR falls into two categories.

Scientific diving

Scientific research accounts for approximately 10,000 logged dives per year. The type of diving usually falls within the limits of "sport diving" tables. Most research organizations require their divers to undergo yearly medical examinations to a standard similar to AS 2299.

In June 1992 there was no general consensus as to what standards should apply to which divers. My opinion is that if diving is a work activity for which the scientist is paid then the medical should be current, progressive and as thorough as is practical.

Recreational diving

Approximately 1,000 tourists perform two scuba dives every day of the year on the GBR. This figure is consistent with the fact that commercial diving operators require 800,000 tank-fills per year. Most of these dives are performed by novices under the care of instructors. Most of these divers spend two days on the reef, obtain their open-water certification and then do no further diving.

In 1990 I commenced my own follow-up survey of people whom I had seen for diving medicals. A comprehensive questionnaire regarding the dive course, the medical, and subsequently diving history was sent to them 12 months after I saw them.

The response from around the world was good and it provided some interesting information. In a tourist orientated location such as the GBR less than 5% of the people who had taken dive courses had done any further diving since being certified. Diving on the GBR was just part of their holiday and they regarded it as a tourist activity and not the beginning of a new form of recreation.

Given that the first group consists of experienced divers and the second group are in the care of competent instructors who can usually take good care of their charges, how rigorous does the medical preparation have to be?

The medical

It is not my intention to repeat what is readily available elsewhere. Readers are referred to "The SPUMS Diving Medical" published in March 1992.

It should be stressed that while that document is understood by physicians who have an understanding of the physics and physiology of diving, it does not necessarily have the same significance for clinicians without training in underwater medicine. For example, I have seen a medical certificate given to a novice diver which read "Fit to Dive but not to go too deep". While this proviso is well-intentioned and makes sense to the non-diving doctor and the aspiring diver (who just happened not to be able to equalise his ears under pressure), it is exactly the wrong advice.

Personally, I cannot remember the last time that I certified an applicant as permanently unfit to dive on the result of the medical examination. This is partly due to the fact that the dive schools in my area are aware of my standards and their staff first ask a few relevant questions. But more significantly it is due to the medical history that I take.

Perhaps all the dive shops know which applicants not to send in my direction. I am fortunate to be in an area where the diver training industry is not as large as elsewhere and most of the operators rely on good reputations and word of mouth referrals. I know of only one dive school in this area which specifically directs its customers away from me because, in the operator's own words, I "do the job too well, and that's no good for our business".

Who needs a medical?

Under present Queensland law, anyone who is about to undertake a diving course must have a current medical certificate. Less than 5% of the people whom I see for recreational diving medicals have any intention of taking up scuba diving as a regular pastime. For this small group there is no doubt in my mind that a medical assessment before starting diving is an excellent idea.

But what about the remaining 95%? Most of these are tourists from overseas. Surprisingly, most regard the medical as "a good idea". This opinion however is inconsistent with their other comments ranging from "an inconvenience, a waste of time, an unnecessary extra expense and something which may prevent them from undertaking one particular aspect of their planned around-the-world trip". It is interesting to note that the people who think it is "a good idea" are the ones who least need any medical advice and the strongest objections come from those who most need it.

I personally find it distressing to tell a tearful young lady who has specifically come to North Queensland to learn to dive on the GBR that Ventolin and compressed air are not a healthy combination. What makes it even worse is that she could have learnt to dive back home in England, come here with a C-card and done whatever she wanted to. An even worse situation is where the super-fit triathlete who is going to prove that his asthma is not going to ruin his life storms out of the office with the statement "Well I'll just go to Cairns and not mention asthma on the form". I do not see a solution to this problem while the legal requirements remains as they are. If a tourist intends scuba diving no matter what, then giving false information on a questionnaire is not going to worry him or her.

How do we reconcile the situation where someone undertaking a course has to have a medical while someone who is doing a one-off "resort" dive only has to fill in a questionnaire? The only way I can make sense of this situation is that the resort diver is closely (and usually very competently) under the care and responsibility of an instructor. But as stated before, this also applies to 95% of tourists who undertake a certification open-water course. Does this mean that the medical is unnecessary for the 95% of tourist divers? I can only make the comment that once a diver has a C-card in his possession he is legally entitled to go out and take his own risks without an instructor around to keep him out of trouble.

What is the role of the diving doctor?

Unfortunately, to my mind, the duty of the diving doctor is to put a signature on a legal document which states that a person may/may not undertake a particular activity. While this has some merit in situations where an individual's actions have an effect on other individuals or the general public, I do not see it as the doctor's duty to play policeman where an individual should be taking personal responsibility.

I see the diving doctor as being in a unique position to give the people who consult him for an opinion as to their particular risk status.

Rather than saying that the candidate may or may not go diving it seems more sensible to me to let the people concerned make responsible, informed decisions. Given an appropriate medical opinion, a reputable dive school will not take responsibility for an unnecessarily high risk. The diver training organizations will not support a school which takes unnecessary risks, and finally, the insurance companies will not support a training organization which takes unnecessary risks. Money is always a good persuader.

If a medical is to be performed it should be taken seriously. I frequently see patients for diving related illness who comment on how long they had to wait while I was doing another medical (usually about thirty minutes). When I tell them that this is fairly average for recreational divers they respond with "Gee Doc, mine only took two minutes". Not surprisingly they are not returning to the same doctor to have their problems attended to. My favourite illustration of this situation was a professional musician with severe bilateral middle ear barotrauma who noticed during her three minute medical that her pulse and blood pressure had been recorded without having been taken. Her tympanic membranes had not been inspected and I would have been more than happy to support her in any legal action had she wanted to take any. I believe it is most important to keep an accurate record of the history and examination for the purpose of comparison if the diver has problems later.

The problem with a discourse such as this is that it is preaching to the converted. The message needs to be delivered to the consumers, the 400,000 recreational divers who visit the GBR every year. Unfortunately there will always be consumers who want to "save a buck" where possible, and operators who want to "make a buck" no matter what the risk. Unfortunately some people hold the view that anyone who can pay $350.00 for the dive course is medically fit to dive.

Very rarely do I see diving morbidity which is due solely to a medical problem to start with. The diver who perforates an eardrum while diving with a cold and the diver who gets decompression sickness after five dives in one day demonstrate the two major causes of morbidity. Neither is medical. They are greed and stupidity.

Dr Michael Rooney's address is Townsville Diving Medicine Centre, 2-10 Walker Street, Townsville, Queensland 4810, Australia.

CORAL CUTS AND ABRASIONS

Vic Callanan

Many corals have a sharp edged hard exoskeleton which often cuts or abrades human skin, sometimes after surprisingly little force. Early treatment is often ignored as the injury is deceptively mild, but significant morbidity may result from even slight coral contacts.

The injury

The abrasion or laceration often looks clean initially, however there are many possible contaminants occur including slime and mud, nematocysts, coral polyps, pieces of hard coral and salt-water bacteria.

An early tissue reaction with itching and stinging is often seen within a few hours. This is usually mild and is probably due to inflammation from nematocysts and other contaminating toxins e.g. slime. If no infection occurs and no foreign bodies remain embedded the swelling, tenderness and erythema settle in 3 to 7 days.

If untreated the wound may progress to a significant injury. Continued exposure to the marine environment favours progress of the lesion due to skin maceration and further contamination. Two complications, alone or in combination, often occur, sometimes despite adequate early treatment. Firstly, infection by either skin organisms or marine bacteria and secondly, foreign body reactions from implanted coral fragments.

The lesion becomes very swollen and tender and may show ulcers with a sloughing base. These are often very slow to heal and become chronically infected. Regional lymphadenopathy is usually present. These lesions eventually heal with scarring and may be subject to recurrent breakdown if foreign material remains in the wound.

First aid

Correct early treatment is important for even apparently mild injuries.

1 Stop all bleeding, usually by direct pressure.

2 Remove all coral fragments. Wash and scrub the wound with clean warm water. Do not use sea water as this may introduce more contamination. Use a soft brush e.g. toothbrush. If this is not possible because of the extent of the injury or because the victim is a child then seek early medical advice as local anaesthesia may be necessary.

3 Apply an antiseptic. This is not a substitute for thorough cleaning of the wound.

4 Cover the wound with a dressing and bandage.

5 Inspect the wound daily and seek medical attention if swelling and tenderness increase or persist.

Medical management

Patients may present despite good first aid management.

1 In deep or badly infected wounds radiological examination to exclude a foreign body is indicated.

2 If obviously infected or if cellulitis or lymphangitis are present culture the wound. Inform the laboratory that marine contamination occurred as routine culture media may not grow the marine organisms which are likely pathogens.

3 Clean and debride the wound. Local anaesthesia is often necessary. General anaesthesia may be needed for extensive or deep wounds or children. A scrub with an antiseptic e.g. Betadine may need to be followed by sharp debridement of dead tissue or slough. All foreign bodies must be removed. The wound should not be sutured.

4 Apply a no-stick dressing and bandage.

5 Ensure tetanus prophylaxis is adequate.

6 Administer antibiotics if infection is present. Some marine bacteria may be present. Doxycyline is the antibiotic of choice as it is active against marine vibrios and most skin organisms.

Research needs

Large prospective studies are needed to define the incidence of infection and the organisms responsible so that better antibiotic choices can be made.

Further reading

Edmonds C, Lowry C and Pennefather J. *Diving and subaquatic medicine* - 3rd Edition. Oxford: Butterworth-Heinemann, 1992.

Williamson J. *The marine stinger book* - 3rd Edition. Brisbane: Queensland State Centre, Surf Livesaving Association of Australia, 1985.

Professor Vic Callanan is Director, Department of Anaesthesia and Intensive Care, Townsville General Hospital, Eyre Street, Townsville, Queensland 4810, Australia.

MANAGEMENT OF DIVING RELATED ILLNESSES IN TOWNSVILLE

Tom Fallowfield

Introduction

In addition to its main work of elective hyperbaric oxygen therapy, the compression chamber in Townsville General Hospital (TGH) is the treatment facility for all reported cases of decompression illness, previously known as decompression sickness and arterial gas embolism, arising from diving on the Great Barrier Reef. It also deals with divers from Papua New Guinea, and the islands of the South West Pacific out as far as Fiji and Nauru. So far, all the cases referred have come into the above categories and it must be presumed that other manifestations of barotrauma are dealt with locally.

Presentation

Case management must start on first contact with the patient by the diving doctor. The doctor may then be aboard a diving boat, at any airfield in the collection area, in the Accident and Emergency Department (A&E) or talking to a patient on the telephone at some remote location. Patients arrive at or are retrieved to TGH by the various routes shown in Table 1. About half reach the hospital "under their own steam".

TABLE 1

LOCATIONS OF RETRIEVAL OR ATTENDANCE FOR 235 DIVERS TREATED BY TGH BETWEEN 18.11.77 AND 30.4.91

Airlie Beach	19	Hayman Is.	1
Bamaga	1	Hervey Bay	1
Brisbane	6	Ingham	2
Buderim	1	Innisfail	1
Cairns	67	Lady Elliott Is.	1
Cape York	7	Maroochydore	2
Cooktown	1	Maryborough	1
Cow Bay	1	Mossman	3
Christmas Is.	1	Nauru	1
Darwin	2	PNG	14
Fiji	3	Rockhampton	3
Flinders Cay	1	Solomon Is.	3
Gladstone	1	Thursday Is.	3
Gympie	1	Townsville	91
Hamilton Is.	2	Unrecorded	4

TABLE 2

PRESENTING SYMPTOMS 1991

Neurological	57
Musculoskeletal	12
Pulmonary	3
Total	**72**

Unlike commercial divers, the large majority of recreational divers from the reef treated for decompression illness present with neurological symptoms. These vary from tingling extremities to rapidly increasing loss of power and sensation. The presenting organ systems found in 1991 are show in Table 2.

About half of those treated in 1991 attended late, two to five days after the onset of symptoms, for medical assistance. Most of these patients made their own way to the hospital and mostly had less severe symptoms.

TABLE 3

INTERVALS BETWEEN ONSET OF SYMPTOMS AND REPORTING SICK 1991

Interval	No. of patients
<1 hr	12
1 - 3 hrs	7
3 -12 hrs	13
12 -24 hrs	13
1 - 2 days	9
2 - 3 days	7
3 - 4 days	2
4 - 5 days	6
1 week	2
2 weeks	1
Total	**72**

Initial management

Away from the relative comfort of the hospital it becomes rather difficult to obtain a full history and do a detailed examination of the patient. Retrievals often take place in the middle of the night from an airfield in the rain with all facilities closed. Another scene is the deck of a diving boat rolling at her achorage by the reef, with an impatient helicopter circling overhead.

The necessities are to confirm the diagnosis of decompression illness and to assess the severity of the condition.

The patient is frequently found to be on oxygen, but not so frequently using a system delivering a concentration near 100%. Dextran 40, saline, dexamethasone and diazepam are on hand in our emergency kit for administration at the doctor's discretion after assessment. The next action is to pursue the aim of early recompression.

If the retrieval is by helicopter, the patient is kept horizontal during the winching operation and given oxygen in transit to the compression chamber. The return flight is as fast and low as possible, typically 140 knots at 40 feet. In the instance of a hyperbaric retrieval from a distant airfield, using a portable chamber, the patient is recompressed there and then in the aircraft. This gives the major advantage of early relief, so that while the patient is being transported he is already feeling the benefit of treatment. If the remaining treatment time justifies it, arrival is followed by transfer under pressure into the hospital chamber.

Recompression schedules

At the Hyperbaric Medicine Unit in Townsville, three therapeutic tables are in general use. RN Table 62 is the first choice for the less severe cases of decompression illness and for use in the portable chamber, because of the limitations on the amount of gas that can be carried. More severe cases are treated using the Comex table, CX30 (figure 1), which starts off at 30 m on 50/50 helium and oxygen. If circumstances such as an uncontrolled ascent, indicate that the diver may be suffering from a cerebral arterial gas embolism, compression without delay to 50 m is followed by RN Table 63.

If the response to the first recompression is minimal or unsatisfactory, a second treatment with a CX30 will follow. This is unusual and any residua can usually be removed by short oxygen treatments at 10 m, repeated if necessary. The principle is to continue until complete relief is obtained or, unusually, there is no further improvement.

Further management

On discharge, patients are warned of the need to rest and of the possibility of recurrence of symptoms. In most cases follow-up is impossible, because the patients do not live in our area. However patients are encouraged to telephone later if they feel the need for advice. After complete resolution of decompression illness, they are advised not to dive for at least one month. If there are residual effects, the patient is brought back for review if possible. If not, advice is given to seek review by a diving doctor

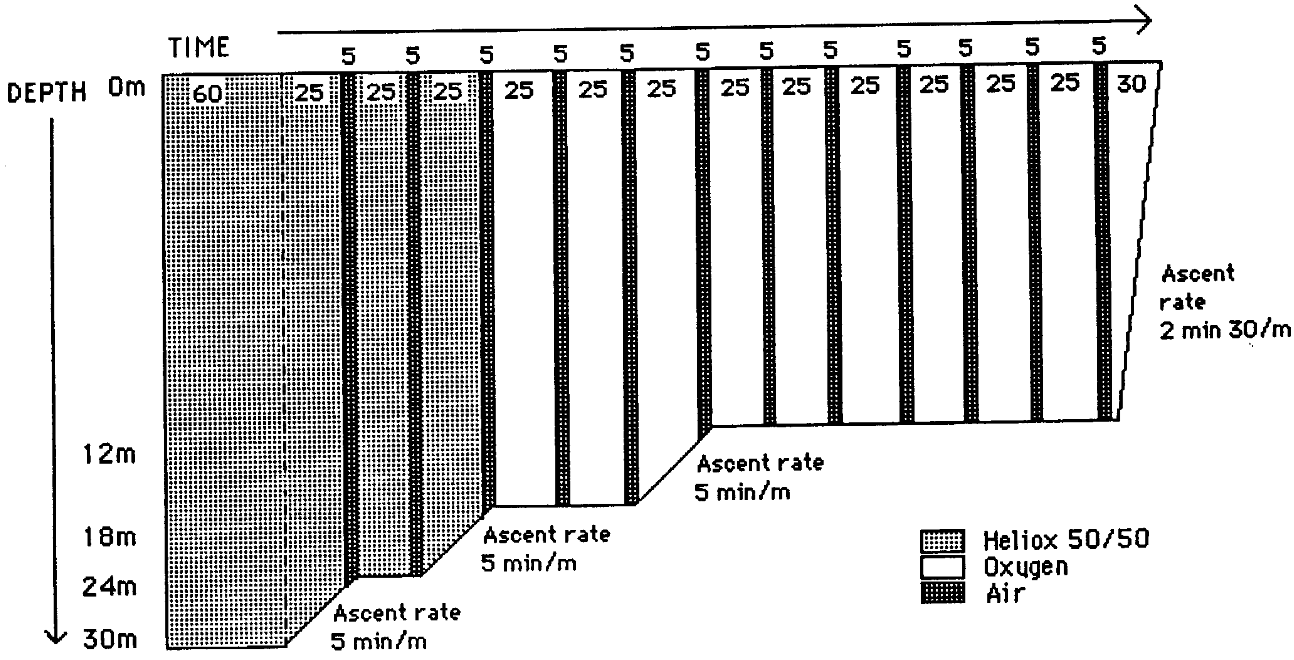

Figure 1. Comex treatment table CX30

elsewhere before contemplating a return to diving. After pulmonary barotrauma, the advice is to give up diving.

As most of the patients are tourists, the question of flying arises early. After complete resolution of the condition, a prohibition is put on flying for 48 hours. Persistent residual symptoms or signs make this question much more difficult. The only answer is a delay until the diving doctor is happy to allow the patient to fly.

Case histories

Case 1
Male, age 45, dived to 140 m, and surfaced following his computer's advice 42 minutes later. After 20 minutes he developed severe vertigo, nausea, vomiting and deafness in the right ear. He was seen at Honiara. There was no aural barotrauma. He had left lateral nystagmus and a positive Romberg test. He was recompressed in the portable chamber, started on an extended RN Table 62 and flown to Townsville.

Next morning, still unsteady, nauseated and vomiting, he was falling to the right with eyes closed and had coarse left lateral nystagmus. He was recompressed on Comex Table CX30 with relief from vertigo and nausea. Next morning he was feeling much better but still unsteady. He swayed with his eyes closed, and had faint nystagmus. Audiometry was normal. He was treated with hyperbaric oxygen, 10/60/30, twice. He was discharged without symptoms or signs.

Case 2
Male, age 29, dived to 36 m for 10 minutes. Shortly afterwards he had pain in his back, legs and groins, followed by numbness in both legs. A hyperbaric retrieval with portable chamber was undertaken. Before recompression he had loss of sensation below the mid chest and 1/5 power in both legs. He was treated with an extended RN Table 62, with transfer under pressure into the hospital chamber.

Next morning he had numbness and tingling in both legs and was walking with assistance. Examination showed 4/5 power in his lower legs, diminished touch and pain sensation below the upper right thigh and left knee, worsening to complete sensory loss in both feet. He was recompressed on Comex Table CX30.

On following morning, he was cheerful and complained only of flitting paraesthesiae. Diminished sensation was present in the lower left leg. The extent of sensory diminution decreased to zero with three hyperbaric oxygen treatments, 10/60/30.

Case 3
Female, age 23, admitted for neurological investigation of sensory loss in the perineum and right thigh. A myelogram was negative. She was referred by the neurologist on finding that she had dived to 30 m two weeks before. She had been seasick and abstained from fluids. She developed extreme and unreasonable fatigue after the dive. She was treated by RN Table 62 with complete relief.

She returned two weeks later with areas of persistent sensory alteration after two transient episodes. On examination, she had partial loss of touch and pin prick sensation over the left shin, right shin and calf. She was given 4 daily hyperbaric oxygen treatments, 10/60/30. Before and after the last treatment she had a small area of sensory diminution on the upper 1/3 of her right shin. This was left to resolve.

Case 4

Female, age 45, dived to 16 m for 37 minutes. Pain, gradually extending from the right ankle to knee and hip, started a few minutes after surfacing. She had tingling in both feet and the right leg. Flown ashore from an island to the local hospital, at 500 ft, her symptoms worsened during the flight. She was given oxygen in hospital with considerable relief. Hyperbaric retrieval ,with RN Table 62 in the portable chamber, was arranged. Treatment continued after transfer under pressure into the hospital chamber with complete relief.

Case 5

Diving instructress, age 26, diving three times a day for the previous five days to about 12 m in spite of being very tired and having right ankle pain for the last two days. On the day after her last dive she developed additional pain in the right wrist and thumb, with palmar itching in both hands. She was transferred by air at sea-level cabin pressure. Two short generalised tonic seizures occurred during transfer. When conscious she complained of a choking sensation and difficulty in breathing.

When seen at TGH she had severe pain in her right arm and a choking sensation. She was dyspnoeic, distressed and unresponsive to questioning. She was recompressed on an extended RN Table 62.

Her residual symptoms next day of slight pain in both wrists and the left side of her chest disappeared after one hyperbaric oxygen treatment, 10/60/30.

Case 6

Male, age 47, referred from A&E with symptoms, increasing in severity, after dive to 30 m four days before. He complained of paraesthesiae of both legs, dizziness and unsteadiness. Findings in A&E were nystagmus, sensory loss on the right side of his face, loss of power and deviation of his tongue to the right with diminished power and sensation in both right limbs.

He complained of claustrophobia and was nervous, sweating with a tremor. He was treated on RN Table 62 with the aid of a small dose of midazolam and improved. Next morning he was still dizzy so was given hyperbaric oxygen, 10/60/30.

During this treatment the patient's lady friend and his mate arrived to tell us that he had not been diving and that he had this problem about inventing such stories! He was told he was cured and given into custody of his friends.

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ARTICLES OF INTEREST REPRINTED FROM OTHER JOURNALS

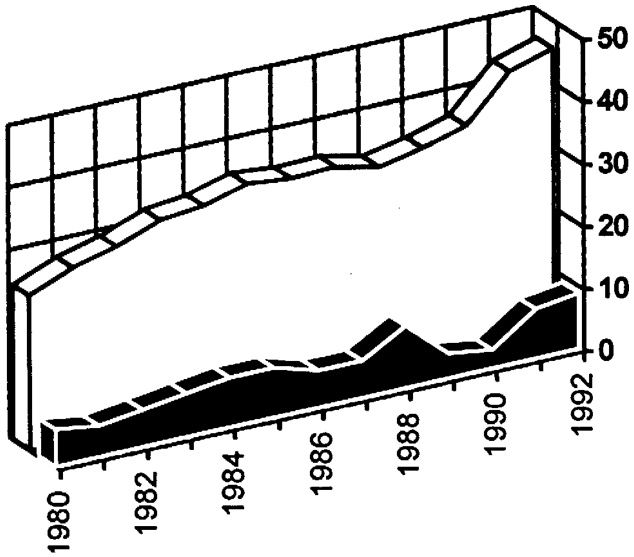
DEEP DIVING DUFFERS DIVERT DOCTORS

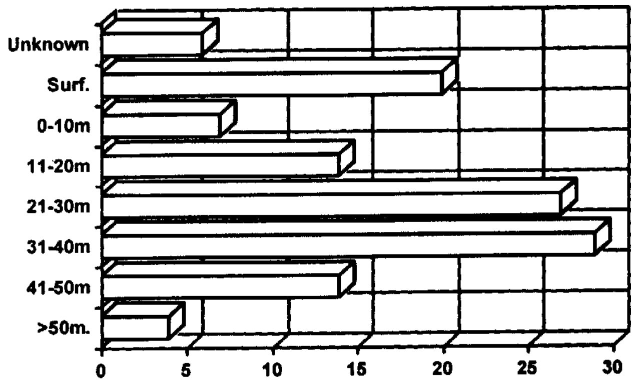
Tim Parish

1992 has been a fairly quiet year for diving incidents when compared to the previous 2 years, particularly when compared to the increase in BS-AC membership and the growth of diving in general, with a reduction in the number of incidents overall. On the basis of our current figures it is estimated that around 1,500,000 "man-dives" were carried out during the 1992 incident year (1st October 1991 to September 1992 inclusive), with a total of 123 incidents being logged (compared with 201 in the preceding year). The dives were carried out by around 70,000 divers, of which 47,000 are BS-AC members.

The number of incidents does not include figures for "unreported" cases of recompression, which normally we obtain via BIGHT and the Institute of Naval Medicine (INM). A computer failure has meant that the INM have, at the time of writing, been unable to provide us with their data for this year. The number of decompression incidents, therefore, should be looked at while bearing in mind that the INM figures usually increase our own data capture figures by 20-30 per cent (probably increasing the number of incidents by about 40).

Considering the number of dives undertaken and the much reduced number of incidents reported overall, it is distressing to note that 17 fatalities have occurred this year (9 BS-AC members, 8 independent), one more than last year's total. However, three of these fatalities were victims





Incidents and depth ranges compared (1992)

of heart attacks, all three of which were not actually caused by diving, but happened to divers while diving or just after a dive. To make matters worse, four fatalities occurred within the space of one month off the Poole/Swanage coast. This led to a large amount of bad publicity for the sport as a whole in the national press and television. In most cases the reports have been inaccurate and very distressing for relatives and friends of the deceased.

It is difficult to spot any specific trend in the fatal incidents that occurred this year, all of them appearing to have different reasons. It is apparent in many of them, however, that basic training and diving skills are being forgotten and the advice given in Safe Diving *Practices* ignored. Sound dive planning and dive practices have got to be followed in order to conduct dives safely, especially if the dive is deep or requires decompression stops. A distinct lack of training has also been a factor in at least two of the incidents this year (not involving BS-AC members). One of the fatal incidents involved an untrained person whose only attempt at gaining proper training was to attend a "Come and try it" evening at a local club. At least one other incident this year ended up as a fatality partly because basic rescue training had not been part of that particular diver's training program.

There have been 43 decompression-related incidents reported this year, although the INM figures will, when received, probably take these up to around 80-85. In this area the one thing that is easier to spot is that there appears to be a continuing trend towards deeper, more adventurous diving, and this is borne out by the types of treatment being carried out by recompression chambers around the country.

There has been a continued increase in the number of treatments given for Type II DCS reported this year from recompression incidents. It is a sobering thought, perhaps, that the INM and other chamber operators are reporting that10-15 pe rcent of of those divers being treated for DCS with neurological symptoms are left with some form of permanent injury or paralysis.

Once again it is apparent that many of these deep dives are being carried out without all the skills and experience necessary to conduct this type of dive in safety. In many cases divers have carried out ascents without a datum line, having been unable to find the shotline, either because of poor visibility or because they have had insufficient air reserves to return to the shot. In both cases this shows a lack of planning and, dare one say it, plain common sense. Any deep dive is a serious undertaking and needs to be planned properly, particularly regarding air consumption, decompression and methods of regaining the shotline to carry out the required stops, such as a bottom line.

A further trend appears to be an over-reliance on a dive computer's ability to return a diver to the surface safely. It is important to remember that a computer is a very sophisticated instrument, but it is really little different from a watch, set of tables and a depth gauge. Dive planning still needs to be carried out properly and allowances made for general health, fitness to dive and the possibility of computer failure during the dive.

Air sharing, from a single second stage, has continued to be a significant factor in a number of incidents. This reinforces the BS-AC's move towards alternative air sources as a piece of your standard equipment, as introduced in the revised training scheme earlier this year (1992). In several cases this year clubs have reported making the decision to ensure that all buddy pairs carry alternative air sources on all club dives, following incidents involving air sharing. Air sharing or buddy breathing is a difficult skill to master in a safe training environment. It becomes even more difficult to master when someone's life may depend upon it. Of course, in most instances, proper planning of air requirements would avoid the situation arising in the first place.

Another factor that comes up time and time again in incident reports is that of diving in a threesome. While this is acceptable during a training session when a pair of divers is being trained or assessed by an instructor, the number of incidents occurring to divers on normal dives indicates the problems that having two buddies to look after can create. Diving as a threesome immediately introduces an extra element of risk and should be avoided whenever possible.

The BS-AC Incidents Reporting Scheme has been established for some 27 years, longer than some diver training organisations. It uses information gathered form a large variety of sources, including the individuals and clubs involved, HM Coastguard, recompression chamber operators, the Institute of Naval Medicine and a press cuttings service. The BS-AC uses this information to identify any trends in diving incidents in order to give its best advice and, if necessary, revise diver training prior to these trends becoming commonplace occurrences.

The reporting of incidents is entirely voluntary and all the information received is treated as strictly confidential, no names or personal details are ever released without permission. It has become apparent over the past few years that some divers and Diving Officers are beginning to ignore this procedure on the basis that although an incident has occurred no injury or serious damage resulted. This attitude shows a lack of understanding of the responsibilities of the position of Diving Officer and a lack of care for the divers under their control An incident can be defined as anything that goes wrong during a dive, whether the problem was resolved successfully or not, and should be reported via BS-AC headquarters. The Incidents Scheme is open to all divers whether members of the BS-AC or not, and the resulting annual analysis and report are available from Headquarters from December each year.

As previously mentioned, many of the incidents that have occurred could have been avoided had the recommendations issued in the BS-AC publication *Safe Diving Practices* been followed. The 1992 revision to *Safe Diving Practices* is now available from BS-AC Headquarters, now printed in A6 format (the same size as the BS-AC Qualification Logbooks and Dive Logs). Once again this booklet is available to all divers and other parties with an interest in sport diving. Please ensure that you make the effort to obtain a copy and take note of its advice and guidance.

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WHY DIVERS GET BENT: DATA FROM DAN

In 1990, 1,044 diving injuries were reported, ranging from decompression sickness to a broken foot caused by a dropped tank.

Of course, the injuries we divers are most concerned with are the bends (DCS) and embolism (Arterial Gas Embolisms, AGE, to be more precise). Of 738 reported DCS cases. The Diver's Alert Network (DAN) analyzed 459.

We have condensed DAN's report, pulling out the most cogent facts to help you to dive safely. We take all responsibility for editing errors or omissions.

Diver inexperience

Lack of experience plays a role in injuries. Of the injured male divers, 23% had been active for only one year compared to 41% of the injured female divers. Most had dived 20 times or less. Roughly 80% were diving within the limits of the repetitive dive tables they were using. Injuries to new divers were often among the more severe.

Illness, exercise and fatigue

Eighty four divers were diving with illnesses such as gastro-intestinal problems, back problems, muscular skeletal problems, asthma, etc. These, however, may be unrelated to getting DCS and there is no specific correlation between any particular illness and the severity of the DCS. However, any illness or injury that limits an individual's ability to perform physical activity, or inhibits gas exchange, may contribute to DCS.

Good physical conditioning does not necessarily prevent DCS. A high percentage of divers felt they were physically fit at the time they had decompression illness; 75% stated they exercised 3-4 times/week.

Exercise to the point of muscle fatigue contributes to decompression illness. More than one third performed strenuous activity, jogging or lifting and carrying numerous tanks, prior to or after their dive. Some conducted an exceptionally strenuous dive.

Fatigue may affect nitrogen off-gassing. Twenty percent of the injured divers began the dive day fatigued or with less than an adequate amount of sleep. Forty percent of those had dived on the previous day. The fatigue could have been a sign of decompression illness from the day before.

Nausea, diarrhea and alcohol consumption contribute directly to diver dehydration and fatigue. Without appropriate rehydration fluids, dehydration may lessen the body's ability to off-gas nitrogen accumulated during scuba diving.

Dive profile

A record number of DCS cases involved repetitive diving to depths 24 m (80 ft) or greater, or multilevel profiles. The deeper depth, longer duration and multi-level diving may reflect the growing use of dive computers. Of the DCS cases, 77% dived to 24 m (80 ft) or more. Rapid ascent contributed in only 22% of the DCS cases.

Equipment

Thirteen percent of the 1,044 accidents involved equipment failure or improper equipment use. Improper buoyancy control and running out of air most generally were associated with AGE. Other problems involved gauges, a leaking mask, leaking octopus hose, failure to turn on computer, and assisting another diver with an equipment problem.

Symptoms

The most common initial symptom was pain. Computer users had almost twice as many pain-only limbs bend (DCS 1) than table users. Because many computer users are more experienced divers, we can assume that they are less likely to run out of air or make a rapid ascent leading to an accident. But, multilevel profiles allow for longer bottom times at shallower depths; this decreases the partial pressure of nitrogen in the faster neural tissues but not necessarily slower peripheral tissue groups which, we believe, is where DCS 1 occurs.

More than 15% of divers with decompression illness continued to dive after developing the first symptom of decompression illness. They either failed to recognize the symptoms, denied them, or were reluctant to mention their symptoms to a group of their peers.

DCS pain can be mistaken for normal aches and pains common to exertion. Some individuals may prefer not to seek evaluation due to remote locations or do not feel their symptoms are serious enough to seek treatment. The delay in seeking assistance may decrease the possibility of immediate and complete resolution.

The cure

Fifty-three percent of all decompression illness cases who received hyperbaric treatment stated there was complete resolution of symptoms. Resolution may have occurred after a single treatment or after multiple hyperbaric exposures.

Post treatment residual symptoms are present in approximately 40% of all injured dives. Divers with neurological symptoms of decompression illness were the most likely to still have symptoms.

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

We reprint below three articles dealing with the way that divers deny the possibility of decompression illness.

DENIAL: THE TRUE NO 1 SYMPTOM OF DCS

R Kelly Hill

Once upon a time, as all good mixed company stories begin, there was a dive trip into the vast and occasionally clear Gulf of Mexico. Among the many seekers of depth were two divers, the well-known Ian Structor and the less well-known Al Sohit, a certified diver and not Ian's student. They boarded their mighty ship, the SS Minnow, and arrived at the fabled diving grounds, The Rigs.

Donning his excellent gear, purchased at his excellent dive store, Ian activated his dive computer and that of his diving partner, Bud Dee. At the same time, Al Sohit and his partner, Buddy Too, were ritually preparing to dive and turned their computers on, as did the rest of the group. All (not to be confused with Al) made an uneventful dive, with some of the intrepid aquanauts taking photos. The dive was to approximately 80' (24 m) and was within the computer's No-stop limits as well as the USN No-stop limits. Assisted back onto the Minnow by first mate Gilligan, all of the divers felt wonderful and regaled one another with tales of sights seen, photos taken and death cheated. Little did they know...

The second verse was the same as the first. A good time was being had by all. They had a couple of hours of surface interval, and then hit the brine again. Sure enough, another wonderful experience in our underwater world. (Narrator's note: though all of them were beyond the Navy No-Stop limits, that isn't the object of this story). As they rewarmed under the almost friendly sun (hopefully wearing sunscreen), Ian noticed that his shoulder was beginning to hurt. "Must have strained it loading tanks. It will feel better when I get back in the cool water." Bud Dee knew nothing of this symptom. Unbeknownest to them, Al Sohit was also having shoulder pain, but in the other shoulder. "Must have strained it carrying my dive bag." he probably mused.

Like lambs to the slaughter they made good entries into a bad situation with another dive. Their shoulders felt better during decent, but the pain returned with a vengeance on ascent and on the deck. Ian Structor thought of using some of the Minnow's oxygen, "just in case", but decided not to partake of this magic elixir. Bud Dee, his partner in life as well as diving, rubbed his sore shoulder, but without relief. AI Sohit moved around the boat, moving his arm in an attempt to get relief ("Nah, it couldn't be the bends"), but neither victim was aware of the other's plight. As the Skipper docked the Minnow, our victims became aware of the other's infirmity. Plans were made to drive home, skipping the excellent hyperbaric facility near the port. They would wait and see what happened.

What happened was that the pain got worse for both of them, finally shattering their denial of the problem. Both ended up in our chamber in the middle of the night. Both had abnormal neuropsychological tests as well as Type I symptoms. Both got to experience not having their symptoms go away on the first part of a Table 5 (a paltry 2 hours), so they got the pleasure of a Table 6, a thrilling 5 hours in the chamber, and since both of them still had some symptoms, earned a Frequent Diver return chamber ride later in the morning.

Unfortunately, they still weren't done. Al Sohit had complete clearance of his symptoms and a return of his neuropsychological tests to normal in a total of four treatments (Table 6 + 3 two-hour repetitive treatments), consuming 2 days. Ian Structor took a total of fifteen treatments to achieve the same clearance, he was with us for a week. At a hospital charge of roughly $350 per treatment, triple that for the Table VI, you can see that Al ran up a $2,100 tab, not including tests, Emergency Room, X-rays, or physician fees (paltry), and ignoring the loss of income from not being at work. Ian had right at $6K worth of treatment under the same conditions. They were very lucky - they got well, not everyone does.

The moral of the story is that every single bent diver I have ever seen treated, denied the possibility that he or she could be bent if conscious enough to speak. I have even seen trained diving medical officers deny that they had DCS. Of all of the symptoms you might find listed somewhere for diving accidents, this one, denial, is not on the list, and yet it is the most common. If you experience a pain consistent with DCS after diving, give yourself the benefit of the doubt and breathe oxygen until you can get recompression treatment.

Just for fun, let's look at the litany of errors of judgment on the part of Ian Structor and Al Sohit.

They experienced symptoms consistent with DCS and denied the possibility.

They didn't let anyone else know. Both divers said that if they had known about the "other" guy, they would have taken the threat more seriously.

They made another dive. This is a big one and they are lucky to be alive. Once bubbles form, additional nitrogen on-loading into the bubble is very easy, so the bubbles can readily grow.

They didn't use the only first aid for diving accidents, oxygen, despite its being available. Why? See first error and foolish pride.

Lemming-like, they drove past the nearest chamber and went home, adding hours to their suffering and doubtless making their treatment more prolonged.

Their profiles may have contributed to their accident, but all bed-time stories involve some limits.

Of note is the fact that of the 20 or so divers involved, diving similar profiles, only two got hit. This is a real-world example of the statistical nature of DCS. If we repeated these dives (wouldn't the lawyer love that!), correcting for Ian's and Al's recent injury risk factor, probably different people or a different number would draw the black bean. Also of note is that both now dive more conservatively and Ian even uses oxygen on the surface after his dive.

So, they all lived ever after, poorer, but wiser. May you just be wiser.

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DEALING WITH DENIAL: GETTING THE BENDS OUT OF THE CLOSET

Bret C Gilliam

Decompression sickness (DCS) or "bends" is a statistical inevitability in diving. It has no conscience and rarely abides by any set rules. Although we can identify certain predisposing factors to DCS in divers it is still impossible to explain the exact mechanisms of physiology that allows one diver to be bent while his partner escapes unscathed. It is best that divers, particularly those in the high-tech community, accept that DCS hits will eventually occur and take steps to deal with treatment responsibly.

What concerns many of us in the business of treating divers is the unfortunate mindset that somehow has developed with the sport diving population that consistently denies the possibility of DCS. Indeed, a certain stigma to reporting symptoms has developed and this trend flies in the face of all common sense and logic. Why would any intelligent adult ignore symptoms with the knowledge that DCS manifestations are progressive and they get worse with time? Further, any delays in reporting symptoms and seeking treatment only contribute to a poorer prognosis for recovery.

Historically, denial of symptoms and treatment delays are the rule in sport diver DCS injuries rather than the exception. The emerging high-tech diver community hopefully will be pivotal in reversing this "head in the sand" mentality. We have to remove the stigma of "blame" so improperly associated with DCS reporting. It is no one's fault that they got bent; a diver can plan everything in his dive plan precisely by the book and still get hit. Likewise, a deliberately high risk dive profile may not produce symptoms. The point here is diving leaders have to stop pointing fingers and using antiquated analogies ("He screwed up and he got bent, the idiot!") or continued reluctance to report symptoms will prevail.

Almost all of us know individuals who have surfaced after a dive and exhibited DCS symptoms but steadfastly refused further evaluation or even basic first aid such as surface oxygen by demand valve/mask. It is not macho to attempt to "tough-out" shoulder pain or progressive numbness. It is just plain stupid.

In the working and commercial diver ranks an entirely different attitude prevails. Divers are trained to report symptoms as soon as possible and the attitude of diving supervisors is one of accident "containment" not accident "crisis" as in many sport diving situations. DCS is regarded as an occupational hazard that will occasionally take place and commercial operators and the more progressive sport diving facilities regard DCS as a manageable scenario. For the best outcome, divers and chamber supervisors work in a partnership of honest reporting of even slight symptoms with prompt evaluation and treatment.

Until recently, there were few operational recompression chambers at remote resort sites and divers who manifested DCS symptoms were faced with expensive medivac transportation and significant delays even in the best of circumstances. Possibly as a result of this, many so-called "experts" were prone to overly broad condemnations of sport divers who got bent and this attitude only contributed to diver denial. Negative peer pressure and professional loss of face proved to be powerful influences on divers to ignore DCS symptoms in the mistaken hope that they would somehow get better without treatment. Rarely was this the case, however.

Most chamber supervisors that I have known in my career feel that if DCS is promptly reported and evaluated with ensuing on-site treatment, then the prognosis for complete resolution is excellent. The attitude of many commercial diver medics and chamber operators is "No matter what the problem, if reported and treated quickly, we can clean the diver up." Type I DCS (mild symptoms, pain only) affords less risk than Type II DCS (serious symptoms, central nervous system involvement) but in either presentation aggressive oxygen therapy and prompt recompression has produced nearly a 98% success record. Many academicians find fault with the commercial operators' confidence in resolution of symptoms but their track record is enviable.

In March of 1991, I was an invited speaker at the joint DAN/AAUS/NOAA Multi-day Repetitive Diving Workshop held at Duke University. For the first time, this conference included representatives from the sport, commercial, scientific and "high tech" diving communities assembled to compare notes on actual DCS incidence rate in the field. Some interesting statistical patterns developed as the workshop unfolded. The overall incidence of DCS for commercial divers was (approximately) 1 in 1,000 dives, for the sport divers it was 1 in 10,000 dives and the scientific diving community rated an extreme low of 1 in 100,000 dives. Sampling from the "high tech" segment was too low to be statistically tallied.

With this rather startling multiplier of 10 between groups, it would be tempting to draw the too obvious conclusion that the scientific diving group is 100 times safer than the commercial diving group. Actually, the incidence rates are interesting for discussion purposes but do not reflect much data to produce true comparisons of relative dive safety vis-a-vis DCS risk. Rather, a clearer pattern of diving "attitude" was defined. Discussion of what an acceptable rate of DCS would be provided the best indication of how several schools of thought can basically approach a complex problem from entirely different angles.

Most scientific diving projects are planned from inception at eliminating as much risk as possible in all phases of the diving operation. This is accomplished by strict supervision and training of divers and a markedly conservative discipline in dive profiling. In short, every possible precaution is taken to reduce the possibility of a DCS occurrence. At the other end of the spectrum, the commercial diving community must deal with a job performance/task completion goal motivated by economics. Therefore, the concept of "acceptable risk" comes into play for both groups but each deals with risk differently.

By extremes of discipline, supervision and training the scientific community hopes to prevent DCS incidence. With the use of highly trained supervisors, diver medical technicians and on-site recompression facilities, the commercial companies aim to effectively manage any accidents that may occur. It is difficult to quantifiably gauge the "end user" effectiveness of either group since DCS still occurs in scientific and commercial divers; the distinction being that if a commercial diver gets hit he is benefited by immediate and state-of-the-art medical treatment which may not be available to a science diver in a remote situation. Per capita DCS rates may or may not reflect the effectiveness of either approach to accident management but the commercial operators are steadfast in their opinion that immediate evaluation and treatment are an acceptable alternative to a lesser statistical incidence rate.

All would agree that no bends hit is a good thing, especially if you are on the receiving end. Terry Overland of Oceaneering International made this point at the conference: "While most sport and scientific dive operations would like to reach a goal of zero per cent DCS incidence in commercial diving this is simply unrealistic. Ideally, we would like to reach a zero rate on Type II hits, but we still feel that Type I hits are essentially manageable. I guess what I am saying is that we accept the fact that if we give a worker a hammer, he will eventually hit his thumb and when he does we will treat it. If we put a diver in the water to work, eventually he will get bent and we will treat that as well. That is the simple facts. We have the technology to handle such hits and we feel that this is a more responsible outlook than attempting to unrealistically eliminate the malady. It is going to happen; we all know that. Let us be prepared to treat it. Importantly, our divers feel that our system works and it is their butts on the firing line, of course."

Further distinctions are sometimes made between "deserved" and "undeserved" DCS hits. Simply put, hits following a dive profile that would suggest a high-risk of DCS exposure, such as clear Table limits violations or deep repetitive or reverse profile dives, can be categorized as "deserved". Hits following dives that were within accepted limits are considered "undeserved". This is not to say that as chamber supervisors we sit back and blithely pass judgement on patients; categorizations of DCS hits using such terms merely allows a perspective on reasons for the presentation.

First and foremost, we have to encourage reporting of symptoms at the earliest observation. Second, the importance of surface oxygen by demand valve/mask cannot be over-emphasized. Dr Jefferson Davis was one of the earliest advocates of aggressive 100% O2 delivery in the field and his pioneering work has resulted in the new accepted practice of oxygen therapy as a first line of treatment en route to the chamber. A significant percentage of symptomatic DCS patients will lose their symptoms following a 30 to 45 minute oxygen breathing period if delivered by demand valve/mask. During a one year period while Vice President of Diving Operations for Ocean Quest International I observed nearly a dozen cases of symptomatic DCS clear completely following demand system O_2 during transit to our chamber on the ship. Free-flow systems are far less effective and are wasteful of the gas.

I ran the Ocean Quest diving program along similar guidelines to a large commercial operation: expect the worst and be prepared to deal with it. We were very successful in encouraging divers to report any symptoms and had a 100% resolution rate on every one of the DCS cases we treated. Our overall incidence rate came out to be approximately 1 case in 12,000 dives; this is significant since we allowed an unlimited diving program with respect to depth and number of repetitive dives daily. In the space of one year we conducted almost 80,000 dives!

Thankfully, we are seeing more and more fully operable field chambers coming into use. Grand Cayman, Cozumel, Roatan and even some live-aboard vessels all feature state-of-the-art treatment facilities that would have been unthinkable only a decade ago. But remember, the chamber is only an effective tool if used (hopefully as soon as the diver notes a problem). It is incumbent on all divers to take responsibility for themselves and report any abnormality that could even be remotely, linked to DCS. Use 100% O_2 at once and seek professional evaluation and a test of pressure if the possibility of DCS is suspected.

All divers should have a complete and detailed contingency plan for DCS management. For higher risk dive profiles, more attention to detail will be required and should include the provision for on-site recompression either in properly staffed and set-up field chamber or through use of an evacuation chamber such as SOS's Hyperlite.

With the advent of affordable medical insurance such as available through DAN, the financial deterrent to admitting DCS and seeking help should be removed. There is nothing "macho" or "cool" about denial of DCS symptoms that could result in lasting injury such as paralysis or worse. It is time divers woke up to the fact that bends is an injury like any other and common sense dictates its treatment. Finally, the encouragement of prompt reporting with no associated peer or professional blame will vastly improve the safety of a sport infamous for symptom denial.

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IT'S OK TO SAY, "I'M BENT"

Ronald J Ryan and Andrew A Pilmanis

Diving accident treatment facilities around the country see cases of air embolism and decompression sickness with fair regularity. The large majority of these cases are treated and resolved with no further difficulty. But it's the cases not seen, reported or treated that are most worrisome. Dr. Albert Behnke, the "Father of Diving Medicine", cautioned:

"The most common error in is the failure to treat doubtful cases. Compression therapy is one of the most innocuous treatments in the medical armamentarium. Mistaken treatment of low back strain in a diver who might have spinal cord decompression sickness will never be criticized. Failure to compress could result in a life of paralysis, impotence and anal incontinence if we were wrong."

Feedback from local divemasters leads us to believe that there probably are an undetermined number of cases of symptomatic decompression sickness on many dive boat trips in Southern California waters. Making a valid estimate of how many unreported cases are out there is nearly impossible. However, with 25-35 Southern California dive boats, each going out 2-5 times a week, we can make a projection using the SWAG (Scientific Wild A** Guess) method, and some "what if" figures. See Chart 1.

SOUTHERN CALIFORNIA "WHAT IF"
UNREPORTED CASES
(50 Weeks/Year)

Dive boat trips/week	**DCI Rates** 0.10	0.25	0.50	0.75	1.00
50	250	625	1250	1875	2500
70	350	875	1750	2625	3500
75	375	938	1875	2813	3900
90	450	1125	2250	3210	4500

The projected numbers of unreported cases shown in this chart are based on a scale ranging from 1 case for every 10 boat trips (10 "best case") to 1 case on every trip (1.0 "worst case"). It may be seen that if unreported cases do occur within this scale range the the annual potential for unreported cases in Southern California alone could be significantly greater than the national average for reported cases compiled by the Divers Alert Network (DAN) each year.

If a scenario involving significant numbers of cases a year in Southern California turned out to be realistic, we could potentially be looking at hundreds of unreported cases a year in the United States.

Our experience at the Catalina Hyperbaric Chamber has found that the average recreational diver is not well versed in the finer points of diving accidents. They just can't recognize a "hit" when they see one. (Correctable by attending one of the Catalina Chamber's 2 or 5 day courses). But even when they think they are "bent", we hear a lot of excuses (second hand) for not reporting it and going untreated. For example:

"Oh, heck. It'll go away in time." (Along with your spinal cord).

"I can't be bent! I run a dive shop and being treated (guess the disease doesn't matter) could hurt my business. And oh, could you please help me into my wheelchair?"

"Hey, I'm macho! It don't hurt, much".

"Gee, can't I just drop by next Tuesday afternoon for a quick treatment? It's not really convenient for me now, besides maybe it'll just go away by then".

"I can't be bent. My buddy was within the tables. But my big toe sure hurts...bad!"

"No, I'm not bent. I'm just too tired to write clearly. And oh, how come you gave me a cup of black hot water instead of the coffee I asked for?"

"Oh, heck, I got bent the day before yesterday. It's no use getting treated now. My dive instructor told me (in 1950 maybe) that if you don't get treated within 24 hours, you might as well forget it."

If you suffer decompression sickness and aren't treated, it may have no long-term effects; or it could lead to dysbaric osteonecrosis[3] (progressive bone death) and/or permanent spinal cord degeneration.[4] You might not even know for sure until you're old and grey. It's not uncommon for decompression sickness (and especially air embolism) symptoms to "magically" disappear in time. But that does not mean that the bubbles have all dissolved. As long as bubbles remain in your system, further tissue damage can continue. It's not know how long bubbles last in the body, but some researchers have suggested as much as 30 days in some tissues. Typically, the longer you wait to get treated, the harder it is to resolve your problems, and the longer it'll take to treat you. Don't take unnecessary chances. If you think you might be "bent" call your local hyperbaric chamber (one that treats diving accidents). Talk to them! If you don't know where your closest chamber is, call DAN at (919) 684-2948 and find out. They can answer your questions, tell you where your nearest chamber is and refer you to a "Diving Doc" in your area as well. Not every physician is well versed in diving accidents and find one who is.

Once "bent" get treated. And don't wait, or try to deny it. There's nothing to be embarrassed about. Think of it like twisting an ankle or a knee while playing Saturday afternoon football. If you dive, sooner or later it may be your turn. You don't necessarily have to do anything wrong to get hurt. For some, it's even considered an acceptable occupational risk.

Don't misunderstand, diving is a very safe sport. It's safety record is a tribute to all of the training agencies. Allowing ourselves to admit we're bent, when we are, will only make diving safer for everyone. So instructors, teach your students that it's okay to say "I'm bent", then practice what you preach.

Further reading

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4 Palmer AC. and Calder IM. "Neuropathological evidence for neurological defects in divers", in *Diagnostic Techniques in Diving Neurology.* London: Medical Research Council Decompression Sickness Panel, 9-24.

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Dr A.A.Pilmanis was the Director of the Catalina Hyperbaric Chamber, University of Southern California. He was the guest speaker at the SPUMS 1986 ASM. His address is USAF/AL/CFTS, Brooks AFB, Texas 78235.

UPDATE ON RECENT CAVE DIVING INCIDENTS JUNE 1991

Peter Horne

During the past 12 months or so, a disturbing number of serious cave diving incidents have occurred around the country involving divers of all levels of experience; incidents which could quickly have turned into fatal accidents if the victims had not been rescued by others or kept their "cool" while sorting out their problems. In these days of more advanced training, techniques and equipment, such stories are indeed cause for concern; it is with the hope that other cave divers will avoid the dangers of such situations that the following summaries are presented.

The most dangerous incidents involved sudden out-of-air (OOA) situations, caused by human error rather than equipment malfunction , and unstable rockpiles or boulders, or a combination of both factors.

Air supply problems - the "terrible twins?"

At our new Cave and Penetration levels, where cave divers cannot reach the surface by simply ascending, they obviously need to be sure that a failure of their main air supply will not endanger their lives. We now have several caves "in the system" which require much greater safety planning and awareness that was required to safely explore the sinkholes known to the Association just five years ago. However, the simple act of donning two scuba cylinders does not automatically mean that a diver is safer; indeed, such divers can feel over confident and may neglect the safety advantages offered by the "buddy system". Because they can penetrate further from the surface, they can also find themselves getting into more serious trouble.

One case involved an experienced diver who had been inactive for a while, was unfamiliar with the gear he was using and had not set up his regulators correctly. Beginning his ascent from considerable depth with his companions, the diver reached the limit on his first tank and proceeded to change regulators...unknowingly initiating a series of simple mistakes which rapidly combined to create a life-threatening situation.

Although the diver knew that his No. 1 regulator's purge button was faulty (in fact, it was completely inoperative), he did not anticipate any problems changing over to his No. 2 regulator (which worked normally), and neglected to take a deep breath before removing his first regulator from his mouth. However, when he then attempted to find his No. 2 regulator, he could not locate it where he thought it would be and he suddenly realized that he had a problem.

Equipped only with his now-flooded first regulator (which could not be purged) and lacking his No. 2 regulator (which, because it was not held in place by a neck-strap or similar tether, had become hooked up behind his tanks), the diver suddenly found himself completely deprived of an air supply!

Struggling to locate his missing regulator, the diver did not attempt to signal his crisis to his dive buddies, and it was only through the attentiveness of his nearest diving companion that his emergency was recognised. This diver instantly rushed to his aid and provided both emergency air and much-needed positive buoyancy, and with the assistance of one of the other divers nearby, they were able to ascend safely.

Other life-threatening OOA emergencies involved very experienced divers who, through becoming distracted while setting up for their dives or using unfamiliar equipment configurations, accidentally turned their air supplies off and then only partially on immediately prior to descending. Even the most experienced cave divers need to concentrate on what they are doing if they want to avoid extra problems.

Failure to know whether a tank has been partly turned on or off is a very common problem which most of us would have experienced. While partially-activated cylinders can usually be readily detected and corrected without too much fuss in open-water or sinkhole environments (where there is a buddy to help or immediate access to the surface), such remedial action is not available while divers are negotiating squeezes or low, one-person passages. Unfortunately, it is precisely during such relatively hazardous activities that OOA emergencies are most likely to occur through accidental bumping of equipment against the ceiling or walls of the cave.

Although snagged and ruptured hoses and connections have been reported previously, impact between divers' exposed (and barely turned-on) taps and rock surfaces has caused the total shut-down of air supplies in recent cases. One diver barely survived after he lost his main air supply in this manner while negotiating a squeeze; recognizing a malfunction by the sudden increase in inhalation effort, he held his breath and reached for his No. 2 regulator only find that, due to it having an overly long neck-strap, it had become tightly jammed between his chest and the boulder! With his buddy oblivious to his distress and disappearing into the distance, the diver had only seconds to play with and pushed forward and to one side, fortunately succeeding in forcing the trapped regulator to slip free for his immediate use.

It is interesting to note that, while it is possible that such accidental ceiling-bumps could conceivably turn any tap, every incident reported to date has involved only DIN valves. Perhaps divers need to take extra care with how they set such units up for cave diving.

Unstable boulders and rockpiles

Near-entrapment involving the unexpected shifting of boulders and rubble in water-filled caves caused extreme anxiety for several divers during the past year. In every case, the divers were pushing areas which had only been cursorily explored previously (if at all!) because of the nature of each site. While open caves in themselves may be considered to be extremely stable features, unstable mounds of introduced rubble are to be found in many of the popular sinkholes (especially under cut ramps and near roadways), and divers need to realize that these unnatural, teetering additions can quickly collapse at the mere presence of an avid diver who attempts to manoeuvre along the base. Several divers learned about such unstable mounds the hard way, but fortunately they were able to extricate themselves from the area before too many rocks fell on them!

Even some of the well-known, frequently visited caves contain natural regions of instability in their more restrictive regions, and it only takes a single accidental push on the wrong object to suddenly cause a seemingly-stable slab to suddenly slide and settle, perhaps cutting off a cave-diver's only escape route.

One of the most potentially-serious incidents of this nature recently occurred just after a diver had exited from a very small entry pool, ahead of his companion who was still underwater a few metres behind him. A huge boulder, more than a metre long, suddenly slid down from just above the water-level and fell into the narrow underwater passage, completely silting-out the exit tunnel for the second diver and blocking his way! Feeling that his exit was obscured, he realized that his only hope was to try to slide the boulder further down under his body, a desperate ploy which fortunately worked, thanks to the boulder's shape, size, underwater weight, angle of fall, the fact that the (experienced) diver managed to keep calm and no doubt, a lot of sheer good luck!

Discussion

It is the author's belief that the number of "close calls" reported recently (or heard about through discrete sources due to victims' unwillingness to come forward themselves) involving the use of twin scuba cylinders, in anything more than a simple "pony bottle" setup, indicates that many divers fail to appreciate that the use of such systems, like all facets of diving, requires training and a good appreciation of the special problems inherent in their use.

Independent twin tanks provide both a reliable source of additional air for more lengthy penetration and another management headache if things are not set up correctly. It is strongly recommended that divers always perform a final check before they enter the water (is the air really on or almost off? Is that old J-valve lever still taped in the "on" positioned, etc?), and to detect other regulator faults and the like, divers should always perform underwater regulator check on each of their units immediately before commencing their descents. These checks will quickly show up leaky exhaust valves and (usually) partially-turned on tanks, among other things (e.g. foreign objects such as lumps of clay or algae inside the mouthpiece).

The reports of rock movement (and other less-serious instances of falling blocks etc, which are by no means rare, and this danger has to be appreciated by cave divers who, after all, are entering the subterranean world; there are no guarantees of safety once you leave the comfortable sunlit surface of our planet. While some may feel the need to criticize divers who wish to push the less inviting regions of our underwater realm, it would be wise to remember that was only through such determined diving practices that many of the recent major discoveries (e.g. Engelbrechts, Three Sisters, Tank Cave) were made. Such exploratory diving should never be attempted by all but the most experienced cave divers who have had the benefit of many years of slowly-gained experience to guide them in their risk assessment and decision-making.

The author would like to thank those divers who, despite their fear of ridicule about their mistakes or techniques by their peers, were brave enough to report their rather hair-raising experiences for the benefit of their fellow members. Such responsible action is very much appreciated and it is hoped that other cave divers will likewise be willing to discuss such instances to enhance the safety of cave divers should they occur. Members are invited to forward any information regarding their cave diving problems to the author at 12 Addison Road, Hove, S.A. 5048, or to the director of "Project Stickybeak" (Australia's diving accident reporting organisation), Dr Douglas Walker, PO Box 120, Narrabeen, NSW 2101.

Peter Horne is a cave diver of great experience and the author of SOUTH AUSTRALIAN DIVING FATALITIES 1950-1985. It was reviews in the SPUMS Journal (1988; 18 (3): 113).

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REDUNDANCY, OR WHY ONE BC IS NOT ENOUGH

Tony Curtis

You hit the water right on time. Looking down into the "Gin Clear" expanse below it was obvious this was going to be a dive to remember. Equipment check over, with a quiet sigh the final air escaped your BC and you submerged.

The dive went well. Slowly descend to the rockpile at 50 m then off to the side of the cave and commence circuiting round the walls, often the floor vanishing into the inky blackness over 60 m down. At this depth, with your wetsuit compressed to 1/4 of what is was at the surface you inject more air into your BC, hearing the overpressure valve open, allowing excess air to escape. Continuing on and down, another squirt into the BC and then the problems started.

The overpressure valve stuck open. All your precious buoyancy going fast. Your BC now empty, you plummet towards the bottom whilst wildly flashing you torch at your buddy. When he finally sees you, you are at 55 m and falling fast. When he reaches you, you are at 65 m - and panic almost taking control of things. With a fully inflated BC your buddy is still having trouble stopping the wild descent. The twin steel tanks and large torch housings adding to your troubles. The air was seeming very hard to get at, you are feeling dizzy with the effects of narcosis and, shit, what a spot you are in.

The above scenario is fictitious - this time. Although a distinct possibility for those of us who explore the fresh water sinkholes or "cenotes" that abound in the Mount Gambier region. Redundancy is something that is drilled into us right through our cave diving training. Hey, we use 3 or more torches, twin tanks, two regs, some also use two masks and two knives. But almost EVERYONE only uses one BC.

Considering all the other paraphernalia we cave divers use, heavy torch housings, twin steel tanks, etc, it's no wonder the old BC gets a thorough workout. You would be surprised just how negative you really are carrying all this stuff. Add the compression factor of your wetsuit at depth and without a BC you are looking like a Polaris Missile in reverse. Most of us still use a jacket style BC and it is very easily adapted to taking a set of BC wings as well. Simply slip them on your tank bands before bolting on your usual BC and you're away.

I know what you must be saying right about now. "These guys never give up. We may as well now tow a full set of gear behind us for that problem that may never arise." Well, considering the environment we choose to dive in, mostly steep sided sinkholes, how else are you going to get out if your BC should fail? If you do manage to crawl up the sides you'll probably run out of air half way or get bent doing it. Great choice, huh?

A dual BC system makes very good sense for deep diving anywhere, not just cave diving, and you won't know it is there, until you need it. Some have started using twin BCs. I'm not saying I advocate it for everyone, but it does seem to make sense, doesn't it? After all, what's your life worth?

Guidelines Editor's note. The opinions expressed in this article are those of the author only, and should not be taken as those of the CDAA.

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THE 1991 SSAC INCIDENT SURVEY

Adam Curtis

The 1991 survey was the sixth survey carried out by the Scottish Sub-Aqua Club (SSAC). Twenty-eight men and eight women replied to the questionnaire. This is a rather lower figure than previous surveys, see Table 1, but some clear conclusions can be drawn from the survey. As before, the latest results are reported and compared with previous surveys.

The 1991 survey reports on a total of 9,761 dives (8,134 by men, 1,627 by women) covering 5,501 hours underwater over a total diving experience of 242.45 years. The 1991 sample had a rather higher frequency of dives than seen in earlier surveys.

together with those that were no more than incorrect diving or only potentially injurious, and called incidents. But their data is not based on our attempt to get some divers to report all their mishaps. The accident rate in the SSAC, where injury or death occurred, is very much lower. Slight scarring of your reputation to yourself (or others) is not that serious but much may be learnt from it, both by the individual to whom it happened and by people, e.g. the NDC members, reviewing the general statistics. Table 2 shows details of the incident rate over the last five surveys.

The 1977 survey gave results very similar to those reported from the 1979 survey. There seems to have been a marked reduction in incidents between 1979 and 1986 and the low rate of incident achieved by 1986 has been maintained in most categories since then. It is dismaying, however, that shared ascent and free ascent (SEAA) incidents have increased recently. Comments on some of the forms and the high incidence of direct feed failures (surveyed for the first time in this survey) suggest that loss of buoyancy control may be responsible for the increase in SEAA ascents. The increase in shared ascents is unexplained. The data on SEAA and shared ascent deliberately exclude any such ascents carried out as part of training. The high rate of direct feed failures (usually of the type in which the direct feed cannot be turned off) is worrying and at least one accident has occurred in SSAC because of this.

TABLE 1

SURVEYING THE SURVEYS

Survey	1987	1979	1981	1986	1989	1991
Number of divers	44	65	40	105	39	36
Number of dives	6,606	8,298	7,001	17,099	9,917	9,761
Years of diving	217	309	161	465	208	242

The number of dives per year and the total number of years of diving are shown in Table 1. The survey covers both divers who only started recently as well as a number of divers who have had many years of experience, as in earlier surveys divers with four or less years experience form half the group surveyed.

What does the surveyed diver look like?

He or she is likely to be using a dry-suit. For exactly 75% are now using one regularly. Just over 50% use a decompression computer. They have been diving for an average (mean) of 6.7 years, though the most frequent number of years of diving in the sample was four, and carry out an average of 40 dives per year.

Details of incident rate

Incidents are events that should not have occurred, e.g. free ascents, air failure, hypothermia, shared ascents, rescues etc. Incidents in SSAC definition are events that should not have happened, not those that necessarily led to injury let alone death. This definition is not that used by the BS-AC, where events that led to injury and death are lumped

The perfect diver

Eight of the men and two women reported that they had never been involved in an accident. This incident-free group, the ‘perfect divers’ were not inexperienced for they had a total of 1,241 dives amongst them spread over 618 hours underwater over 39 years. Can there really be such ‘good’ or is it ‘careful’ divers? Perhaps that is a fairer and more interesting question to ask rather than ‘Are there accident prone divers?’ If these incident-free divers were like the total group they should have had 29 incidents on the basis of numbers, or, after a correction for their rather lower rate of diving, 13 incidents. So a statistical test (see note) can

TABLE 2

DIVES PER INCIDENT

Survey	1979	1983	1986	1989	1991
Air supply failure	252	291	854	620	650
Shared ascent	286	975	551	1,903	390
SEAA 237	558	1,315	1,239	443	
Rescue from UW	237	304	854	826	813
Hypothermia	422	368	854	826	1,084
Illness during a dive	ND	ND	ND	1,239	1,084
Direct feed defect	ND	ND	ND	ND	305

ND means no data was collected. SEAA stands for Swimming Exhaling Air Ascent ie, "Free Ascent".

be applied and this tells us that such a difference could only have a very small probability of being anything but real. In this comparison I ignored direct feed misaction but since these marvellous divers had only one instance of direct feed failure between them they must be nearly perfect in that area too! Are there going to be more of these marvellous divers in the next survey? It would also be interesting to survey a larger group of divers just asking them yearly over a three or four year period what incidents if any they had in the past twelve months.

First two years

When I first started these surveys it became obvious that the majority of incidents experienced by divers were in the first two years of their diving and that thereafter their incident rate dropped. This even included the incidents that really happened to their buddies though involving them in a secondary way. In the present survey 26 of the 36 divers surveyed were involved in 38 incidents in their first two years of diving. This was in a total of 51 years of diving (not 52 because some divers had done less than two years of diving). Twenty-five divers of the survey had 39 incidents in 143 years of diving after their first two years.

Thus the incident rate per year per diver fell from 0.021 to 0.01. (This data excludes direct feed defects.) This result is probably to be explained by the fact that they became more experienced and skilful and were able to take precautions which prevented incidents in their later dives and in their buddies' dives. Did this mean that they dived in their first two years with persons less experienced than they themselves became? Well, there is some reason for thinking that this may be so because the overall incident rate has been falling from survey to survey so that the newer comers to diving re being better trained that their instructors were or/ and their equipment is less likely to let them down. How very pleasing!

Dive frequency and incident rate

In the earlier surveys clear evidence emerged that the more frequently you dive the relatively less likely you are to have an incident in any give dive. What exactly does that mean?

It means that though the number of incidents the average diver experiences, increases as the total number of dives per year rises, it does not rise as rapidly as you would expect if dive experience did nothing for safer diving. In this survey the same effect was found, divers with a high frequency of dives have a lower frequency of incidents for a given number of dives, say in a year, than less frequent divers who take four years to do the same number of dives.

Conclusions

In the main the conclusions remain the same as in the last two surveys, namely that the incident rate is reasonably low, that the first two years of diving are the most incident-prone, and that there is a group of divers who are appreciably different from the rest as regards incident rate, the "perfect divers". The survey gives no indication that incident rates are continuing to drop and this in turn might make you wonder as to whether changes in training have contributed to safer diving or are we close to the irreducible minimum of incidents? Direct feed malfunctions are the most frequent cause of incident and manufacturers should give attention to redesign of this type of equipment.

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2 Curtis A. What really happens. The veil on diving incidents begins to lift. *Scottish Diver* 1978; 17: 2-5

3 Curtis A. Diving incidents. *Scottish Diver* 1982; 81-85.
4 Curtis A. Diving incidents - the fourth survey. *Scottish Diver* 1987; 28: 94-97.

Note on statistics

Two by two contingency test used for comparisons incident rates in paired groups, e.g. “perfect divers” versus the “the rest”, “first two years” against “subsequent years”. Linear regression analysis used to test drive frequency against incident rate. Results only accepted as significant if there is less than a 1% chance that the result could have been obtained by chance.

Photocopies of the five incident surveys published in Scottish Diver are available as a set for £1.4 (including postage within UK), £1.70 within the rest of Europe and £3 airmail in other countries. Cheques or bank drafts on UK banks should be sent to A. Curtis, 2 Kirklee Circus, Glasgow G12 0TW Scotland, UK.

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GLEANINGS FROM MEDICAL JOURNALS

The following articles have come to the notice of the editorial staff and these notes are printed to bring them to the attention of members of SPUMS. They are listed under various headings of interest to divers. Any reader who comes across an interesting article is requested to forward the reference to the Journal for inclusion in this column.

FITNESS TO DIVE

Compressed air diving and respiratory disease. A discussion document of the Thoracic Society of Australia and New Zealand.

Jenkins C, Anderson SD, Wong R and Veale A. *Med J Aust* 1993; 158: 275-279

Abstract

Objective: To review the pathophysiology and respiratory complications of compressed air diving, and to formulate guidelines for assessing respiratory fitness to dive so that diving candidates can be advised of the risks associated with respiratory disease, in particular asthma.

Data sources: Specialist medical journals in the area of respiratory medicine, physiology and diving medicine. Morbidity and mortality statistics were obtained from international diving bodies, diving medicine scientific meetings, and papers.

Synthesis: The major complications of underwater diving in subjects with compromised respiratory function are drowning, pulmonary barotrauma and arterial gas embolism. Diving candidates with a history of asthma, pneumothorax, obstructive or restrictive lung disease, lung cysts or thoracic trauma should be advised not to dive in view of these risk factors.

Conclusions: Several respiratory diseases carry an increased risk of morbidity and mortality from compressed air diving. An accurate history and measurement of lung function are an essential part of assessing fitness to dive, both to advise potential divers appropriately and to reduce risks associated with this increasingly popular recreational activity.

MARINE ENVENOMATION

Current challenges in marine envenomation: an overview.

Williamson J. *Wilderness Med* 1992; 3: 422-431.

Marine envenomation is a common, frequently serious, and sometimes neglected medical event. Studies in marine envenomation are now on a firm scientific basis, but remain unfledged in many respects. Present ignorance includes the taxomony of the Cubozoan and *Physalia* ‘jellyfish’, the world distribution and life cycle related to Irukandji and ciguatoxic fishes, and the true incidence of human fatalities from envenomations by stonefish, sea snakes, chirodropids, *Carybdea* organisms, and sting rays. Toxinologic study of marine venoms indicates that Irukandji and *Chironex* venoms are of particular significance. Little is known about stingray or Crown-of-thorns starfish venom chemistry. Venom retrieval, purification, fractionation, lability, and immunology (including antibody cloning) are current research challenges. International appreciation of the value of the Australian first-aid technique of compression/immobilization bandaging in selected envenomation situations, and the availability of safe and specific antivenoms for marine envenomations are future goals. Although the International Consortium for Jellyfish Stings is active, world-wide collaboration is still fragmentary. Crucial to advances in this subject is the exchange of multi-disciplinary information between epidemiologists, chemists, biologists, immunologists, medical clinicians, and divers working in the field.

Key words: envenomation, marine, first-aid, venom, allergy, immunology.

F*rom the Hyperbaric Medicine Unit, Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital, North Terrace, Adelaide, South Australia 5000, Australia.*

WRITING TO BE UNDERSTOOD.

How readable are practice leaflets ?
Albert T and Chadwick S. *BMJ* 1992; 305: 1266-8

A review of practice leaflets and how understandable they were. The authors found that many were difficult to understand because they used long words and long sentences.

They advise that authors should use a simple index of readability (fog test) to test for clarity. This is printed below.

THE FOG TEST

1 Choose a passage of about 100 words, which must end in a full stop.

2 Find the average sentence length by dividing 100 by the number of sentences.

3 Find the number of long words, defined as those of three syllables or more, excluding
(a) proper nouns;
(b) combinations of easy words, like photocopy;
(c) verbs that become three syllables when "-es", "-ing", and "-ed" are added;
(d) jargon that the reader will know.

4 Add the average sentence length to the number of long words.

5 Multiply by 0.4 to get the "reading score".

As a general rule the lower the score the easier the passage is to read.

SELECTED ABSTRACTS

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UNDERSEA AND HYPERBARIC MEDICAL SOCIETY
ANNUAL SCIENTIFIC MEETING
23rd-27th June 1992

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

CARBON MONOXIDE POISONING

Delayed neuropsychiatric sequelae following CO poisoning and the role of treatment with 100% O_2 or hyperbaric oxygen - a prospective, randomized, clinical study.
Thom SR, Taber RL, Mendiguren I, Clark JM and Fisher AB. *Undersea Biomed Res* 1992; 19 (Supp): 47

This is a preliminary report of an on-going study. Patients with a history of CO exposure and symptoms such as nausea, vomiting, headache, dizziness, near syncope, ataxia, lethargy and/or blurred vision, were evaluated, and treatment begun, within 6 hours of removal from a CO-contaminated environment. Informed consent was obtained and following treatment (determined randomly) quantitative evaluation of neurological function was achieved with a psychometric test.[1]

Treatment consisted of 100% O_2 by non-rebreather mask until asymptomatic (duration of tx. 2-8 hours), or hyperbaric O_2 (2.8 ATA x 1/2 hr, 2.0 ATA x 1 1/2 hr). Patients were evaluated, as a minimum, at 1 week (telephone), and formal psychometric testing at 3 to 4 weeks. If abnormalities occurred, follow-up was continued until patients were asymptomatic, and test scores normalized (defined as first test score).

To date, 27 patients have been entered, and 2 lost to follow-up, in each treatment arm. The groups are closely matched according to age, symptoms, and COHb levels (8-40%). Following 100% O_2 treatment, 5 patients have developed symptoms/signs, and 4 of these 5, deteriorations in psychometric tests scores, from 3 to 14 days later. Changes are consistent with the diagnosis of delayed neurological sequelae. Following hyperbaric O_2 treatment, no patients have suffered deteriorations ($p<0.005$, x^2, two-tail test).

Reference
1 *Am J Emerg Med* 1983; 2: 226

From the Institute for Environmental Medicine, University of Pennsylvania, Philadelphia, Pennsylvania, USA.

Carbon monoxide off-gassing of patients poisoned by CO and treated with 2.8 ATA hyperbaric pressure: a prospective clinical series.

Langston PG, Ramsay R, Frye JNR, Williamson JA and Russell WJ. *Undersea Biomed Res* 1992; 19(Supp): 49

Carbon monoxide (CO) poisoning remains a common form of death. Although hyperbaric oxygen (HBO) is widely used as the definitive treatment, limited information is available about the efficacy oxygen under hyperbaric pressure for this condition. In a pilot study presented to this Society in 1985, Willms, Scott and Norman[1] claimed a greater expired concentration of CO with HBO (pressure unspecified) than with normobaric oxygen (NBO) in 9 patients. However, quantitative data were not given in the abstract. We are studying the elimination of CO by monitoring the quantity of CO exhaled before, during and after HBO treatment. Patient expired gas from the built in breathing system was measured at 1 ATA for the concentration of carbon monoxide by a Drager PAC II CO monitor. The minute volume of the patient was simultaneously measured and the total elimination in ml (1 ATA) per minute calculated. Blood carboxyhaemoglobin (COHb) was measured directly on arrival, immediately before and after the HBO treatment.

Preliminary data indicate that the elimination of CO is a simple single exponential function during 2.8 ATA HBO. The half life of the elimination is about 20-30 minutes. Air breaks are given every 15 minutes and during these breaks the CO elimination fell sharply, and rose again when HBO was recommended.

The data are consistent with elimination from mainly the well and moderately perfused compartments of the body and may reflect the elimination from the muscles. If the single compartment model proves reliable, it may give a more accurate method of quantifying the total CO load than COHb.

Reference

1 Willms SJ, Scott AA and Norman PN. Carbon monoxide off gasing during hyperbaric and normobaric oxygen therapy of CO poisoned patients: A prospective clinical series. *Undersea Biomed Res* 1985; 12 (1) Suppl: 56

From the Hyperbaric Medicine Unit, Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital, North Terrace, Adelaide, South Australia 5000, Australia.

The role of neuropsychological testing in the hyperbaric management of the carbon monoxide patient.

Schiltz KL, Millington JT, Wilmeth JB and Label LS. *Undersea Biomed Res* 1992; 19(Supp): 48

Three case studies are presented that demonstrate the necessity of hyperbaric intervention in severe cases of chronic carbon monoxide poisoning. The case histories demonstrate the difficulty in identifying carbon monoxide poisoning as the causative agent due to the nonspecificity of symptoms and physical findings. Aggressive hyperbaric treatment was instituted following the appropriate laboratory testing despite the significant delay in diagnosis. Comprehensive neuropsychological testing was instituted prior to the initial hyperbaric exposure treatment with serial testings performed across hyperbaric treatments. In these case studies, we present neuropsychological test data demonstrating the progressive recovery of selective cognitive domains along with the continuation of selective cognitive residuals across the serial treatments. The relevance of comprehensive neuropsychological testing as another measurement tool in the hyperbaric care of the patient will be discussed.

From the Los Robles Regional Medical Center, Baromedical Unit, Thousand Oaks, California 91360, USA.

Evaluation of neuropsychiatric dysfunction after carbon monoxide poisoning.

Davis PH, Shelton DL, Piantadosi CA, Moon RE and Logue PE. *Undersea Biomed Res* 1992; 19 (Supp): 68

Patients presenting with acute carbon monoxide poisoning may have subtle neuropyschiatric abnormalities not detected by routine history and physical exam. There is also a problem of accurately documenting readily apparent neuropsychiatric abnormalities in quantitative terms. In addition to these problems there is a need for an instrument to evaluate the effectiveness of treatment as well as standardized long term follow up. Our center has utilized the Neurobehavioral Cognitive Status Examination (NCSE) (The Northern California Neurobehavioral Group, Inc) as an instrument to address the above concerns. The NCSE provides form-referenced scores of orientation, attention, memory, language, calculation, constructional paraxis and higher-level reasoning. We chose the NCSE because it is brief, valid, reproducible, sensitive, specific and well tolerated. Patients are evaluated at the time of the initial clinical examination prior to their first hyperbaric oxygen treatment, immediately post-treatment and at a variable interval. All but one had follow up testing at least 2 weeks post treatment. Twelve patients have been evaluated using NCSE. Four patients received pre-HBO evaluation, post-HBO evaluation and follow up testing. Eight patients received pre-HBO and post-HBO evaluations. Three patients were given 2 HBO treatments. The carboxyhemoglobin level found ranged from 7.1 to 42.7 and 5 of 12 patients experienced loss of consciousness. Eleven of 12 patients had abnormal NCSE at presentation. Nine of 11 showed significant improvement in one or two measurement levels after HBO treatments. Of these, 7 patients improved into the normal range in all parameters. A third examination administered when the post treatment evaluation was abnormal showed continued improvement in 3 of 4 patients without additional HBO. There was variable correlation between the levels of measured carboxyhemoglobin and measured pyschometric scores. The NCSE appears to be an effective instrument to evaluate and quantitate subtle as well as apparent neuropsychiatric abnormalities after carbon monoxide poisoning. It is also effective in quantitatively establishing the condition of patients after a significant interval post treatment.

From the F.G. Hall Hyperbaric Center and Departments of Anesthesiology, Medicine and Psychiatry, Duke University Medical Center, Durham, N.C., USA.

Carbon monoxide poisoning - an account of a mass gassing.

Pirone C. *Undersea Biomed Res* 1992; 19 (Supp): 22

Forty nine patients presented to city hospitals with suspected carbon monoxide (CO) poisoning following an evacuation from a fish factory. Fork-lift trucks had been operating in a closed work, space and employees were reported to have collapsed while working. All patients were referred to the Hyperbaric Medicine Unit. Of the 49 patients reviewed, 33 could not speak or understand English and 31 patients required hyperbaric oxygen treatment. Over several days to total of 85 HBO treatments were given for 31 patients with a range of 1-8 and an average of 2.57 treatments per patient. There was a 35% incidence of varying degrees of aural barotrauma but no other side effect of the treatment. The influences of culture, language, and group response upon the management of a mass gassing will be highlighted as well as recommendations for a hyperbaric mass casualty plan.

From the Hyperbaric Medicine Unit, Royal Adelaide Hospital, North Terrace, Adelaide, South Australia.

NEUROLOGICAL SEQUELAE IN DIVERS

Predictors of long term neurological sequelae in recreational divers.

Dear GdeL, Corson K, Dovenbarger J, Moon RE and Bennett PB. Undersea Biomed Res 1992; 19 (Supp): 19

The Diver Alert Network (DAN) database contains the details of 1384 cases of decompression illness in recreational divers from 1987-1900. Mean age was 35.3 years (range 15-71 years). Analysis revealed 396 divers who had neurological sequelae (NLS) post treatment, 128 for more than 3 months. symptoms are defined as; mild (severity code[1] 1-3), severe (severity code 4-6). NLS were counted as present at the end of recompression treatment (NLS End HBO) and ≥90 days (NLS 3 months).

	No NLS n=988	NLS end of HBO n=396	NLS 3 months n=128
Mean Severity Code	3.71	4.28***	4.5***
Mean delay to treatment(hr)	22 (1-1440)	21 (1-2376)	17 (1-2376)
USN TT6 use %	58.7	58.5	58.6
Male divers %	77.3	68.6	58.6
Oxygen before HBO %	29.3	29.3	31.3
Progressive symptoms%	68.1	68.6	70.3
Age >40 %	20.3	30.6**	31.9**
Symptom onset <10 min %	39.8	47.5*	55.5***

Compared with no LNS: * $p \le 0.05$, ** $p \le 0.01$, *** $p \le 0.001$

There was no significant relationship between the following and NLS: delay from onset to recompression, use of USN TT6, gender, use of O_2, temporal progression of symptoms and history of previous decompression illness.

Severity of symptoms, age over 40 years and short latency of onset were risk factors for NLS. Age and latency were still significant when corrected for severity.

Reference

1 Severity Code in Appendix to 1989 Report on diving Accidents and Fatalities, Divers Alert Network 1991.

From the Hyperbaric Center, Department of Anesthesiology, Duke University Medical Center, Durham, North Carolina, U.S.A.

DECOMPRESSION TABLES

The average sport diver's inability to calculate repetitive dives.

Schinazi E. *Undersea Biomed Res* 1992; 19 (Supp): 63-64

Proper calculations of repetitive dives using standard dive tables is a skill required for certification as a basic Open Water scuba diver. Previous surveys have suggested that many divers lose this ability after completion of their course. A survey was designed to test the ability of trained divers to calculate residual nitrogen and repetitive dive designation groups utilizing examples similar to those taught during scuba training. Subjects were allowed to use any dive table configuration taught in training. Of those approached during a national meeting, only 10% (284 divers) agreed to participate in this survey. Surveyed divers ranged in certification from basic open water to instructor level and from 1 month to 20 years experience. Overall, 65% (186) had difficulty in determining the repetitive group and residual nitrogen times for a straightforward multiple dive profile. A score of 100% was considered "passing", which is equivalent to certification requirements. Subjects with one to three years experience accounted for the highest number of incorrect surveys. Those with more experience performed slightly better. Interestingly, 23 of the 72 instructors who took the survey were unable to complete it. Since participation was voluntary, it may be assumed, individuals who agreed to be tested were more likely to do well than those who refused and the results were skewed to the positive. We conclude that more than half of certified divers are unable to utilize dive tables correctly. This has great implications for diving safety of which training agencies and dive tour groups should be aware.

From the Hermann Center for Hyperbaric Medicine, Hermann Hospital, 6411 Fannin, Houston, Texas. 77030 and Department of Anesthesiology, University of Texas Medical School, 6431 Fannin, Houston, Texas 77030, U.S.A.

The use of a pig model to evaluate decompression tables.
Brubakk AO, Reinertsen RE, Eftedal O, Flook V[1] and James P.[2] *Undersea Biomed Res* 1992; 19 (Supp): 76

Decompression tables have mainly been evaluated by using human divers and decompression sickness as the endpoint. However, since even mild decompression sickness and exposure to decompression stress can lead to changes in the central nervous system and the lungs, there is a need for methods that, during development, allow tables to be tested without using humans. The amount of intravascular gas bubbles has been used as an index of risk. Documentation of identical gas bubble formation in experimental animals and humans would make it possible to perform inititial testing of decompression tables without exposing humans. We have developed an experimental pig model where gas bubbles in the venous return is monitored with an ultrasonic scanner and evaluated semi-quantitatively by computer post-processing. The model has been evaluated by comparing gas formation in pigs with gas formation in humans performing air dives with heliox decompression following the same profiles. The results show good agreement between the number of bubbles in humans and pigs being tested on the same decompression profiles following an air dive. Thus, the pig model provides a useful method for evaluating decompression tables. Furthermore, through measurements of circulatory and ventilatory parameters, such a model makes it possible to study how gas bubbles affect the organism.

From the Department of Biomedical Engineering, University of Trondheim and SINTEF UNIMED, Section for Extreme Work Environment, Medical Technical Centre, N-7005 Trondheim, Norway, [1]Department of Physiology, Aberdeen University, Aberdeen, and 2Wolfson Institute, University of Dundee, Dundee, United Kingdom

Doppler analysis of sport diver profiles: a second look.
Dunford RG, Wacholz C, Huggins K and Bennett PB. U*ndersea Biomed Res* 1992; 19 (Supp): 70

In an initial series (S1) we reported (UBR Supp 1991 #95) that multiday, repetitive warm-water sport dives produced detectable Doppler bubbles (DDBs) with a mean Kisman-Masurel code (KMC) of 1- in 42% of the divers and 18% of their profiles. In the present study (S2) of 5 additional trips from 1989-1991, we added subclavian sites, replaced a 5 MHz Doppler with a 2.5 MHz system and upgraded technician skills. In S2 93% of 57 divers and 73% of 260 profiles produced DDBs with a mean KMC of 1+. In comparing dive depth, age and dive time, each were greater in S2 vs S1 (85.0 vs 68.3 fsw, 44.4 vs 39.5 years and 44.2 vs 39.1 min.). However, a comparison of each parameter at 10 unit intervals showed that the % of dives with DDBs was 2+ fold greater in S2, indicating that protocol changes had a significant effect on the observed increases in DDBs. In a separate comparison of S2 scores, post trip laboratory analysis of magnetic tape records increased the % of dives with DDBs from 44% to 73% and increased mean KMC from 1 to 1+ when compared to on-site, real-time data analysis. We conclude that 1) subclavian monitoring, Doppler system type, and training have significant effects on DDBs scores 2) real-time Doppler scores from field data may be unreliable and 3) probability of venous gas bubble production in sport divers during multi-day, repetitive dives of similar nature may approach 100%.

From the Hyperbaric Department, Virginia Mason Medical Center, Seattle, Washington 90101 and Divers Alert Network, Duke University Medical Center, Durham, North Carolina 27710, USA.

Combined use of ultrasound and a mathematical model to evaluate decompression stress.
Flook V and Brubakk AO. *Undersea Biomed Res* 1992; 19 (Supp): 69

We have modified and extended a simple model of gas transport in the body, which is based on verifiable physiological parameter values.[1] This has been combined with a semi-quantitative model of bubble growth and used for the simulation of a series of decompression profiles, including some with an air to heliox gas switch. The profiles have been evaluated both in pigs and man with measurement of pulmonary artery bubbles using ultrasonic scanning. Based upon the bubble count, some profiles were considered more severe than others. By using the model, the critical tissues for the different profiles could be identified. Tissue gas tensions and supersaturations in these tissues indicated why some profiles would produce more bubbles than others and permit a ranking of the profiles in terms of different decompression stress. The model has also demonstrated how small changes in the deep stops following the gas switch, can significantly influence the amount of bubbles recorded. The initial results indicate that this method could be used to compare decompression profiles of different severity.

Reference
1 Mapleson 1963; 18: 197-204

From the Department of Biomedical Engineering, University of Trondheim and SINTEF-UNIMED, Section for Extreme Work Environments, Medical Technical Centre, 7005 Trondheim, Trondheim, Norway and Department of Physiology, University of Aberdeen, Aberdeen, UK.

Competition between tissue and bubble for gas when there are many bubbles per volume of tissue.

Van Liew HD and Burkard ME. *Undersea Biomed Res* 1992; 19 (Supp): 74

Growth and decay of gas bubbles in tissue can be simulated by numerical solutions of equations which account for many of the pertinent variables.[1] This communication focuses on the number of bubble formation sites within a given volume of tissue. When there are many bubbles in a tissue unit after a decompression, the growing bubbles deplete the excess dissolved gas in the tissue. Consequences: a) The many individual bubbles do not become as large as they would if there were fewer of them competing for gas. b) More gas is evolved when there are many sites per unit of tissue, but the bubbles are absorbed sooner than the bigger bubbles which grow when there are few sites. c) Transfer of gas into the many bubbles causes partial pressure of N2 in the tissue to fall immediately to a low level, rather than washing out in exponential fashion. d) During the lifetime of the many bubbles, dissolved N_2 which is washed out of the tissue by blood is replenished by diffusion of N_2 from the bubbles, so N_2 in the tissue and the exiting blood remain “clamped” to the low level reached by the initial fall of PN_2 in the bubble. e) The long-term washout of the total system (tissue plus bubbles) is linear, not exponential, as long as the many bubbles persist. Our simulations indicate that the number of bubble formation sites per unit of tissue is an important variable in the determining the behavior and persistence of decompression bubbles.

Reference
1 Van Liew, *Undersea Biomed Res* 1991; 18: 333-345

From the Department of Physiology, University at Buffalo, Buffalo, New York 14214, USA.

COMMERCIAL DIVING EMERGENCIES

A diving medical emergency service experience of 211 cases arising during commercial diving in the UK.

Gunnyeon WJ, McLeod TNN, Rhodes PM, Ross JAS and Watt SJ. *Undersea Biomed Res* 1992; 19 (Supp): 21

Requests for medical advice from diving supervisors for incidents arising during commercial oil related diving in the years 1985-90 were analyzed. Incidents were classified according to type of medical disorder, type of diving, body system or anatomical region affected and whether a doctor attended the dive site. Dysbaric illness was less common than expected .51 incidents (24%) of decompression sickness included 36 during air diving (16 Type 2) and 15 during heliox diving (6 Type 2). Barotrauma accounted for 7 incidents (5 ear/sinus, 1 teeth and 1 AGE). The most common incidents were infective (76 cases, 36%) .69 of these occurred during heliox sat dives and included 23 ear, 15 respiratory tract, 7 gastro-intestinal and 25 superficial skin infections. Trauma accounted for 31 cases (15%), toxicity arising from gas or other chemical agents for 12 (6%) and miscellaneous causes such as psychosis, pancreatitis, and porphyria as well as omitted decompression for 23 (11%) cases. The 21 cases attended by a physician included dysbaric problems, infections and major trauma. The most complex medical management problems were associated with major trauma such as amputations, compound fractures and suction or blast injury. The detailed analysis of these incidents and the associated management problems has resulted in recommendations from improvement of emergency services and facilities at commercial dive sites.

From OMS Ltd., Aberdeen, and Department of Environmental and Occupational Medicine, University of Aberdeen, Scotland, UK.

DIVING FATALITIES

A six year review of scuba diving fatalities in San Diego County.

Powers AT, Bass B, Stewart J, Flahan M and Neuman TS. *Undersea Biomed Res* 1992; 19 (Supp): 20

A panel of 4 members, knowledgeable in various aspects of scuba diving, appointed by the Medical Examiner, investigates each scuba diving fatality in San Diego County, California. Areas of inquiry by the panel include autopsy findings, equipment status, water conditions, and training or safety issues. The review board examined 19 scuba diving fatalities, 17 men and 2 women, from 1985 to 1991. Their diving experience was judged to be fair to good for 13 of the casualties, five were novices (one of whom was not certified as a diver), and one had an unknown diving background.

Drowning was the cause of death in 7 victims. Myocardial infarction with subsequent drowning occurred in one instance. Drowning secondary to gas embolism (AGE) was diagnosed in 7 decedents, and another 4 presumed AGE victims were resuscitated, but died several days after the accident. In these latter 4 victims only 1 had AGE as a final diagnosis. The other 3 victims had AGE by history and clinical presentation; however, the cause of death was officially listed as hypoxic encephalopathy. Investigation into each diving accident revealed multiple contributing behavioural and/or environmental factors leading to the deaths. These included panic (11), poor air management (9), buddy system failure (8), entanglement in kelp or line (7), improper use of/or lack of equipment (4), difficult water conditions (3), drug or alcohol ingestion (2), pre-existing medical condition (1), and possibly one equipment malfunction.

By reviewing the scuba fatalities as a group in this particular region of the country, certain trends were discerned. Panic reactions, lack of air, buddy system failure, and entanglement were repeated factors that contributed to scuba diving deaths in San Diego County. More than half of the diving deaths were due to gas embolism.

From the University of California San Diego, San Diego City Lifeguard Service, Scripps Institution of Oceanography and San Diego State University, San Diego, California 92103-8676, U.S.A.

Brain pathology in divers - a review of recent findings.
Palmer AC and Calder IM. *Undersea Biomed Res* 1992; 19 (Supp): 75

In continuation of our studies on the neuropathology of the brain in divers[1,2] we have re-assessed our original 25 cases (12 amateur and 13 professional) and added a further 10 (5 amateur and 5 professional). Control brain material was obtained from 15 male airmen who died as a result of flying accidents. In the divers, microscopically, grossly dilated empty vessels were present in a total of 17 brains. This finding is probably related to the presence of intravascular gas bubbles from accidental rapid decompression. Lacunar spaces around vessels were observed in 10 brains and hyaline degeneration of small arteries in cerebral white matter in 12. Small foci of necrosis in cerebral grey matter occurred in 8 brains and evidence of patchy white matter changes in 10. These abnormalities probably arose from periodic arterial obstruction by intravascular bubbles.

References

1 Palmer et al. Proc EUBS, 1990, 137
2 Palmer et al 1992, *Neuropath appl Neurobiol* 18, in press.

From the Wellcome Laboratory for Comparative Neurology, School of Veterinary Medicine, University of Cambridge, Cambridge, CB3 OES, England.

Does diving really damage the spinal cord? A neuropathological study of 20 professional and amateur divers.
Mork SJ[1], Morild I[2], Eidsvik S[4], Nyland H[3], Brubakk A[5] and Giertsen J.[2] *Undersea Biomed Res* 1992; 19 (Supp): 111

The unnerving presence of clinically silent spinal cord myelin lesions in divers[1] initiated us to perform an extensive study of the human central nervous system (CNS) in amateur and professional divers. Of the 10 professional divers (age range 29 to 52, median 38 years), 7 were experienced saturation divers, including two with a maximum exposure to 300 and 500 msw (31 and 51 bar). The experience of the recreational divers varied from a few dives to many years of active diving. The age of the amateur divers ranged from 17 to 51, with a median of 29 years. To our knowledge, none of the divers had a history of CNS decompression sickness. The spinal cords were examined grossly after adequate fixation, transversely cut in suitably sized tissue blocks and routinely processed for microscopy. Adjacent sections from every block were stained for myelin with luxol fast blue, and for axons with the Bodian method. Immunocytochemical staining was performed using monoclonal antibodies against glial fibrillary acidic protein (GFAP), to reveal reactive changes (CNS "scarring"), against microglia/macrophage marker (CD68), monocyte/macrophage marker (MAC387), and T cell marker (CD43). Astrocytes react unspecifically to any damage of the CNS, and microglia/monouclear cells take part in disease and "repair" of CNS tissue breakdown. A total of up to 200 sections was studied in each diver. The microscopic examination did not reveal signs of nervous tissue lesions or reactive changes in any of the spinal cord sections from the 20 divers. Of particular interest is the fact that this also applied to the spinal cords of the saturation divers. The extensive sampling and the various histochemical and immunocytochemical methods applied, underscores the significance of our results. Our findings establish the spinal cord as a tissue of great resistance to the strains associated with the hyperbaric environment. In conclusion, previous uncomplicated diving activity, notably saturation diving, and even exposure to extreme depths, do not in itself lead to degeneration or lesions in the human spinal cord.

Reference

1 Palmer, Calder and Hughes, *Lancet* 1987; ii (8572): 1365-6

From [1]The Gade Institute, Department of Pathology; [2] Section for forensic medicine; [3] Department of Neurology, Haukeland Hospital, University of Bergen; [4] The Royal Norwegian Navy, Haakonsvern; [5] Department of Biomedical Engineering, University of Trondheim, Norway.

HYPERBARIC OXYGEN

Transcutaneous oxygen measurements in non-healing wounds.

Atlas G, Josfesen L, Rickets L and Camporesi EM. *Undersea Biomed Res* 1992; 19 (Supp): 58

Transcutaneous oxygen (tcO_2) measurements were obtained from a chart review of 20 patients undergoing a total of 70 hyperbaric oxygen treatments for non-healing wounds or graft preparation. To assess if the initial and/or final tcO2 levels would predict the outcome of the non-healing wound, two extremes of the tcO_2 distribution were compared and the measurements categorized into two groups: While breathing air at 1 ATM abs group I had tcO_2 values of ≤ 4 mm Hg, whereas group II had tcO_2 values of ≥ 40 mm Hg. Measurements were obtained by placement of the tcO_2 probe near the wound or graft site. Values were acquired using room made using the Wilcoxon rank sum test. Wounds were followed and healing was then evaluated as either satisfactory or unsatisfactory. Treatments associated with initial tcO_2 values ≤4 mm Hg were noted t reach significantly lower final tcO_2 values, at pressure, than those with an initial tcO_2 ≥40 mm Hg ($P < .001$, see Table).

Occurrence of one or more low initial tcO_2 values, taken while breathing air at 1 ATM abs pressure, did not appear predictive of wound outcome. The data suggest that hyperbaric oxygen therapy, for non-breathing wounds or for graft preparation, may be beneficial despite low wound tcO_2 values observed during normobaric room air conditions.

From the Department of Anesthesiology and Hyperbaric Unit, SUNY Health Science Center, Syracuse, New York 13210, USA.

Hyperbaric chamber mishap study.

Brown GA, Dart TS and Workman WT. *Undersea Biomed Res* 1992; 19 (Supp): 120

The objective of this project was to collect, analyze, and report hyperbaric chamber mishaps and fires, allowing comparison of mishap causes and recommendations for accident prevention. Key interest areas were determination of mishap trends, major factors causing mishaps, the chamber subsystems involved, and the role of the human element in the mishap. Letters requesting information about incidents and accidents were sent to all United States and international hyperbaric facilities listed with the Undersea and Hyperbaric Medical Society. Thirty (30) fire and 57 non-fire incidents were reported or found in the literature with 63 occurrences inside and 24 occurrences outside the chamber. Non-fire mishaps were attributed to human error (31), equipment failure (29), design flaws (9), and high pressure, greater than 450 psi (5). Some mishaps involve more than one factor. fire data included hypobaric environments using 100% oxygen (Apollo 204, for example) as well as hyperbaric chambers. Fires inside the chamber (20) were caused by electrical/electrostatic (14), adiabatic compression (1), welding equipment (1), heating element (1), imploding light bulb (1), microwave-heated material (1), and undetermined cause (1). Fires outside the chamber (10) were caused by adiabatic compression (6), electrical/electrostatic (1), welding equipment (1), or unlisted cause (1). Fire caused 28 deaths; improper ascent caused 5 deaths due to air embolism (Hanover incident) and 1 death due to Type II DCS. The reported majority of non-fatal injuries were also fire-related, caused by mainly burns from ruptured high pressure oxygen systems which had undergone adiabatic heating. Final results will be compiled into a single document for publication as an Air Force Technical Report.

From the Armstrong Laboratory, AL/AOH, Brooks AFB, Texas 78235-5000, U.S.A.

TABLE 1

INITIAL TCO_2 AND WOUND OUTCOME

Initial tcO_2 (mmHg) room air at 1atm abs	Number of tcO_2 measurements	Average final tcO_2 (mmHg)* 100% O_2 at 2 atm abs	Wound outcome
≤ 4	9	546	2 failed, 6 successful
≥40	11	1,118	0 failed, 11 successful

*** P < 0.001**

MEETINGS AND COURSES

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Workshops on heart and lungs, casualty simulation, protected EAR, advanced cardiac life support and special rescue techniques for victims in water, will be held on Thursday April 29th 1993.

FIRST ANNUAL SCIENTIFIC MEETING OF DIVING AND HYPERBARIC MEDICINE

will be held in Darwin, Northern Territory, Australia on July 29th and 30th 1993.

The meeting is sponsored by the
Hyperbaric Technicians and Nurses Association (HTNA)
and the
Australian and New Zealand Hyperbaric Medicine Group (ANZHMG).
Non-members are welcome to attend.

The AGMs of both associations will be held on July 31st.

The main topics will include, but are not limited to, wound healing, decompression illnesses, hyperbaric treatment profiles, recreational nitrox diving, new technical developments and current hyperbaric research.

For further information contact
Ms Jodie Perris
Royal Darwin Hospital Hyperbaric Unit,
Rocklands Drive, Tiwi,
Northern Territory 0810, Australia.
Telephone
Australia 089-22 8563
Overseas 61-89-22 8563

BIOMEDICAL SEMINARS

UNDERWATER MEDICINE AND PHYSIOLOGY
27th November - 3rd December, 1993
and
THE MANAGEMENT OF
MEDICAL EMERGENCIES IN DIVING
4th - 11th December, 1993

Two inter-linked five day courses for medical practitioners are being planned. Each is being submitted for 20 hours of Postgraduate Education Allowance (PGEA) in the United Kingdom and for CME Accreditation in the United States.

They will be held on the Caribbean island of Cayman Brac and are intended for all physicians who may have divers among their patients.

The initial course “Underwater Medicine and Physiology” is introductory and will be on the fundamental principles and the prevention of diving accidents. This first week is offered as an additional option only to those registering for the second week. The second week “The Management of Medical Emergencies In Diving” will address the practical aspects of diving accident management. It can be combined with the first week, or taken on its own.

The directors of these two seminars will be Prof. David Elliott of the Robens Institute of Health & Safety, University of Surrey and Dr. Nick McIver of the North Sea Medical Centre, Great Yarmouth.

Unlimited diving will be available but does not form part of the course and non-divers are welcome.

Travel from Europe, North America and elsewhere can be arranged by our ABTA travel agent to meet individual requests, and accommodation will be at the Divi Tiara Beach Hotel, Cayman Brac.

Course Fee: £700 for two weeks or £375 for those attending the 2nd week only. Cheques should be made payable to Biomedical Seminars. (Payment by credit card is not accepted). The course fee is fully refundable until 1st July, 1993.

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Fax: 081 786 7036

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