SPUMS JOURNAL
ISSN 0813 - 1988
South Pacific Underwater Medicine Society
VOL. 16 1986 No. 1 JANUARY - MARCH

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Registered by Australia Post
Publication Number VBH 3527

PRINTED BY: KD COPY CENTRE
354 Canterbury Road
SURREY HILLS VIC 3127

EDITORIAL

The Journal starts the new year with a fresh blue jacket. To forestall a flood of letters of anguish from those who have come to expect their monthly fix to arrive in a raiment of white it must be revealed that a change was suggested to the Editorial Staff as a way in which to stand out visually on the shelves in addition to being outstanding in our contents, thereby to catch the eye of idle browsers to their advantage, and ours. It used to be proclaimed that Good Wine Needs No Bush, but in these degenerate times the favoured cliche is It Pays To Advertise.

Medical involvement in diving safety has three main areas of activity, the first being to dissuade those with medical conditions which may be potentially dangerous in the diving environment from proceeding to become divers. The other areas are those of "Diving Medicine" (from spreading information to divers to actual case management) and the specialised area of Diving/Hyperbaric Research. It is the first area of involvement which is the main subject of this issue. There is much hearsay reporting of what Carl Edmonds calls "Mickey Mouse" medicals, what modern Australian vernacular now might call "Claytons" medicals, those you have when you do not want a DIVING medical. Fortunately many diving instructors, from a keen desire to do the right thing by their customers, and a fear of what the Insurance people would say if they allowed an asthmatic to die in one of their classes, vet the medical curriculum vitae of their prospective pupils and require an "informed" medical before accepting such persons even though they be armed with certificates. The list published in the Journal contains the names of SPUMS members who have at least a degree of knowledge of Diving Medicine. It DOES NOT imply all are experts or that those not included are ignorant. It is presented as an interim or stop gap measure until some independent body takes on the task of the maintenance of a list of Approved Doctors who alone will be permitted to assess medical fitness to dive. The Laws of the Medes and Persians got a poor press in later ages because of their notorious inflexibility and lists of medical conditions have until recently had a similar rigidity of approach. Time will show what degree of discretion is allowable for those with some disability factor(s). Which is just one more reason to collect information of all kinds which relates to divers as people and not merely to them as examples of clinical conditions.

In considering the approach to take when the medical examination has revealed some deviation from the normal one should consider what might be the effect of the condition in a worst-case situation. The paper by John Hayman on Sudden Death in the Water may clarify thoughts and aid the reaching of a defendable decision on "fitness ", while the resume of the University of Rhode Island's report on American diving fatalities is a reminder that lack of training, inexperience, and failure to follow the generally accepted rules for safe diving are frequently the most critical factors in fatalities. A report on the New Zealand fatalities of 1983-1984, held over to the next issue of the Journal, reinforces the point. Such factors are usually highly significant even where adverse medical conditions are present and influence the outcome.

In accordance with a belief that diving problems have much in common around the world, we are pleased to include papers from the World Underwater Federation, CMAS, a European input which is welcome. It is important to remember that backache and ENT problems are important, though less dramatic than Air Embolism.

The setting up of a data bank of diving information with access made available to researchers in general is thought to be the first trial of such an idea anywhere in the world. Its success will depend on the level of understanding and support it can generate among those with information to offer. Although its "endowment" is data on fatalities, the hope is to obtain information on non-fatal incidents, the ultimate goal being to collect details of events managed so successfully that no "incident" ever developed. Such will be invaluable to increase our understanding of the critical training, interactions between equipment, health, and environment which determine the outcome of every dive. A correctly designed programme will make it possible to recognise at an early stage the emergence of a new problem or the chance in frequency or severity of a known problem. Attention can then more rapidly be given to the reasons for such changes.

The recent increased interest in and ownership of personal computers, or of access to such equipment, and the development of modems to allow communication between computers, has made it a practical proposition to share information. CONFIDENTIALITY can easily be maintained through a simple strategem, ie. by keeping such details separately in the rather old fashioned way on file cards. What is not "entered" cannot later be extracted.

ORIGINAL PAPERS

MMM

THE MICKEY MOUSE MEDICAL

Carl Edmonds

Over the last twenty years I have taken some pride in my contributions to the education of divers and diving physicians. The founding of the South Pacific Underwater Medicine Society and the Diving Medical Centres; the introduction of diving medical courses in Australia (both Navy and civilian); presenting scientific meetings; lectures to diving groups and instructors; writing a number of diving texts, some of which have been "best sellers" by Australian standards. Indeed, I felt an inner glow. There was no reason to be modest about these achievements.

Two unrelated happenings have forced me to reassess this situation. The first is the number of phone calls I receive from clinicians asking whether a certain candidate whom they are examining, is medically fit to dive. The second was a survey performed in our most famous diving State of Australia, Queensland. Queensland encompasses the Great Barrier Reef.

The enquiries from doctors, usually referring to only one aspect of the diving medical, often becomes irrelevant to any genuine assessment of diving fitness, once one carefully questions the examiner. This usually reveals a grossly inadequate knowledge of the medical examination requirements.

For example, the enquirer may wish to know whether beta blockers interfere with diving. What usually eventuates from the questioning is that the candidate, who could be old, deaf, obese, and suffer a variety of respiratory tract disorders, is likely to be passed fit without qualification or advice and in the absence of a base line audiogram or spirometry.

Thus, instead of making a comment about the more abstruse implications of beta blockers with diving, I am usually faced with informing the enquirer as diplomatically as possible, that he is unfit to perform a diving medical examination.

These calls come in at about five or so a week. It is very rarely that I am phoned up by the same physician more than once.

The survey unfortunately supported my observations. Queensland has better undergraduate diving medical training than any other Australian state. Most of its physicians will be involved in diving if they work there. In New South Wales, where I work, diving medicine has only been included in the undergraduate curriculum for the last two years, and then for only one hour in six years of training. No examination of competence is set on this subject.

The survey was performed by a young diving physician, Mark Marshall. It was carried out under the patronage of my old colleague and diving buddy, Dr Bob Thomas. It was performed as a project for the Social and Preventative Medicine Department of the University of Queensland, and a number of diving medical clinicians did give advice to ensure that the questionnaire was appropriate and relevant. The aim throughout was to "keep it simple", so that there could be no misunderstanding of either the questionnaire or its results.

One thousand doctors were obtained from the telephone directories in Queensland. Only those doctors who responded and were involved in the assessment, advice or treatment of divers were assessed.

Of the 364 respondents who were involved in medical administering to divers, 62.4% indicated they had received no training in diving medicine, and 52.5% no training in marine animal injuries. Training in this context included anything from a lecture at medical school to reading a book or an article.

The official Australian diving medical examination format (or an equivalent), including both history and examination was used by only 10.7% of the doctors. 69.2% used a form from the instructor, and 17.4% did not complete any form at all.

The specialised diving medical centres, who have examined many thousands of amateur diving candidates, have a failure rate of 10% with another 10-15% needing restrictions to their diving. Of the doctors in the survey, 41% always passed divers as fit and 35% failed less than 10%.

The extraordinary finding from this survey is that, based on the doctor's own claims, 87% did not perform an audiogram, 61% did not request chest x-rays and 56% did not do spirometry, 42% did not test the urine, 37% did not check middle ear auto-inflation, 13% did not do any respiratory examination, 8% did not do a cardiovascular examination, and 4% did not examine the ears, nose or throat.

As would have been expected the doctors who were also divers seemed to perform better, as did the younger doctors, with most of their examinations and advice, eg. in ear clearing techniques. They also had more training.

A great deal of information was also supplied regarding the advice given to the divers, about medical problems. 6.3% advised the use of ear plugs, 40.7% advised the use of decongestants, 25% advised pregnant women to continue diving, 16.5% advised women to stop diving during their menstruation.

Of the 26.9% who allowed asthmatics to dive, 85% specified a limitation in the diving depth! Similar figures were obtained for other causes of chronic airways disease. Only 7.7% felt that diving was permissible with epilepsy, but over 50% allowed people with a resting diastolic blood pressure in excess of 100 mm Hg to continue diving. About the same number do not regard beta blockers as any impairment to diving,

Correct treatment? No sophistication here. They were asked to match each of eight common diving accidents with its major treatment, eg.

> decompression sickness - recompression;
> air embolism - recompression;
> venomous marine animal - medical or surgical;
> pneumothorax - surgical or 100% oxygen.

It may not come as a great surprise to find that the likelihood of being given the correct treatment modality (to say nothing of the finer details), hovered around the 50% mark. One shudders to think of what forms of "surgical treatment" were being contemplated for decompression sickness, air embolism, nitrogen narcosis or contaminated air poisoning!

The only part of the survey which gave me some glimmer of hope was the finding that 78.3% considered that more training in diving medicine was needed.

For years I have been making excuses for my MM colleagues, when talking to diving instructors. I stress that they are very busy people, that diving medicine is a negligible part of their training and that it is unfair to expect more expertise.

Well, no longer. By condoning MM medicals, I am not doing a service to my conscientious medical colleagues, to my fellow diving instructors, or to the innocents who undertake diver training with a trust in the professionalism of their advisers.

I am an aviation medical examiner and the skill I need in that capacity is infinitesimal compared to a diving medical examination. Yet, for aviation medicals I have to be a qualified aviation medical examiner. That means I must have some form of training, or at least have demonstrated a knowledge in that field.

Why should an untrained and unqualified physician (untrained and unqualified in this speciality) be permitted to do diving medicals when he has no concept of the physics or physiology of the diving environment or of the demands of this environment, or the equipment the candidate must use to sustain life? Why do they presume such knowledge? I would not be so presumptuous to advise on a gynaecological condition, or do a dermal biopsy, even if I did need the money.

In Australia there is adequate training available. We have a four week course at the Navy base especially designed to introduce physicians to diving medicine. Yet many physicians will reject this training, but perform the medical examinations. There must be a reason. The obvious ones are as follows:-

1. Financial reward.
2. The examiner does not recognise his limitations.
3. Lack of knowledge.

The phone calls that I receive suggests a combination of all three, and the results of the survey lend support to this proposition.

The commercial factor could certainly be significant in Australia. Our Department of Health, although it does not admit to this, allows general medical practitioners to claim a rebate for the medicals performed on divers. It does not permit this practice among specialists in this field, thereby encouraging a minimal and inadequate standard of medical examination.

I think there is a conspiracy between the MM medico and the MM dive instructor (and me until very recently) to pretend that the diving candidate is being well served. I feel that the dive instructors are often more hypocritical than the physicians. At least in many cases, the physicians really do not have the knowledge to start with. Most diving instructors are trained and knowledgeable, and are aware of the problems and complications associated with many of the medical diseases.

Some of the instructor organisations have produced their own MM medical forms which allow any doctor to pretend a knowledge, simply by ticking a few boxes. Perusal of these forms usually reveals that they would be barely adequate even for snorkellers, let alone scuba divers.

In my opinion a good and conscientious instructor will not-only advise the candidate to have a comprehensive diving medical, but he will insist upon it. The easier option is to let any doctor tick the form and thereby exonerate him legally for training unfit divers.

The chances of a candidate being failed on a MM medical or having any diving restrictions imposed, is minimal. Thus, more profit and less hassle to the instructor.

I am certainly not blameless. I have known of this practice for many years. Perhaps I was not prepared to look at it squarely until I read the results of the Queensland survey. Nevertheless, the information was there, with almost every phone call from a prospective diving medical examiner.

I do not know what is going to happen in other countries, but in Australia it is about time we put our house in order.

I do not think this article will endear me to many of my colleagues, either dive instructors or doctors. Nevertheless, it had to be said, and perhaps even a few of the young kids coming through may benefit from the mud that flies afterwards.

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Readers can find the names and addresses of those members of SPUMS who have done at least the introductory course at the RAN School of Underwater Medicine, or an equivalent course elsewhere, on pages 33 and 34 of this issue.

IMMERSION HYPOXIA

PULMONARY AND CEREBRAL CHANGES IN THE SUBMERGED VICTIM

John Pearn

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Underwater accidents can happen at any time, but with the appropriate training and skills possessed by the experienced diver, fatalities should be rare. Management of the near-drowned demands a mix of two themes, the adherence to a rescue and resuscitation drill, and an appreciation that no two incidents will be the same. In the latter instance, the variables of water temperature, degree of hypothermia, hypoxic time, age, and background health status all differ in a particular patient in a particular accident.

Management of the near-drowned is optimal if the medical attendant is familiar with the pathophysiology of drowning,[1] and with the possible events in the lungs and brain of the near-drowned[2] during cardiopulmonary resuscitation (CPR).

Inhaled Water

In "wet" drownings (perhaps 90 per cent of fatalities) death results from inhalation of water into the alveoli.

Water is a mixture of inorganic substances, gases, dissolved organic matter, and particulate matter, including bacteria, fungi, diatoms, zooplankton, and phytoplankton.

Sea water contains a mixture of salts, of which total concentration varies from place to place but of which proportions remain constant. Salinity is defined as the total mass of solids (in grams) in solution in one kilogram of water and is expressed as parts per thousand (ppt) or gm/kg. In oceanic sea water, a typical salt-ion profile is as follows: sodium 10.5 gm/kg; magnesium 1.3 gm/kg; calcium 0.4 gm/kg; chloride 18.9 gm/kg; and sulfate 2.6 gm/kg. Oceanic sea water thus typically contains 34.48 gm/kg of dissolved salts, of which 29.54 gm/kg is sodium chloride. Sea water contains 2.9 per cent sodium chloride compared with 0.87 per cent sodium chloride for human plasma.

Fresh water contains variable amounts of organic material, dissolved salts, and free and nascent gases. Fresh water in the lungs causes much greater loss of pulmonary surfactant than occurs with salt water near-drowning. In experimental studies using dogs, the test subjects survive total immersion marginally longer if the drowning medium is salt water (or even normal saline) than if it is fresh water, but the reasons are unclear.

One of the complications of drowning is that there are several pathways which may lead to brain death, which is the potential end result. The first link in the chain leading to death may be cerebral hypoxia, carbon dioxide narcosis, laryngeal spasm, vagal cardiac inhibition, or ventricular fibrillation. In a pedantic sense, some investigators define "true drowning" as death due to the aspiration of fluid into the air passages; and death due to laryngeal spasm or vagal cardiac effects might be more correctly termed "death from submersion" rather than drowning.

Irrespective of the osmolality of the inhaled water, it is now known that relatively large volumes of water (either salt, or fresh) pass across the alveolar-capillary interface. The Dutch scientist, den Otter showed that the pulmonary vein runs almost water-clear in the few minutes after water is inhaled into the lungs of experimental mammals.[3]

In diving accidents, it may be that only small amounts of water inhaled, which set up major problems in the lungs, initiating a chain of events which lead on to potential disaster. As little as 1 ml/kg of fresh water instilled into the trachea causes gross physiologic responses in the lungs. In studies using a simulated aspiration of 11 ml/kg of fresh water or less, gross lung changes result. However, the resulting increase in blood volume is not greater than the capacity of the heart and kidney to compensate for this potential fluid overload. The heart compensates by using the basic reflexes described by Starling's law, the Bainbridge reflex and the Anrep effect.

Although CPR drills are the same, in "dry drowning" (perhaps 10-20 per cent of cases) the lungs are probably more elastic (less reduction of compliance), at least in the first minutes of a successful rescue. There is now good experimental evidence (from the Canadian wildlife authorities) to support the concept of "dry drowning".[4] In experimental drowning of minks, muskrats and beavers, it was shown that not all animals that are trapped fully submerged and "drown" actually inhale significant volumes of water. When dry drowning occurs, it appears that when a small amount of water enters the larynx or trachea, immediate laryngeal spasm (as a vagal reflex) occurs. An immediate out-pouring of thick mucus occurs, foam and froth develop and physically obstruct the airway.

Diving Reflex

The facility with which diving birds and cetaceans can dive for long periods has intrigued physiologists for over 100 years.[5] Dr Brett Gooden (of Adelaide) an acknowledged authority on the diving reflex, notes that the Weddell seal is capable of swimming under ice for periods of one hour on a single breath of air. The protective diving reflex is triggered centrally, and by immersing the face in water (even wetting the face in some cases), the subject in effect becomes a transient "heart-brain preparation".[5] In childhood near-drownings, the diving reflex still operates, and its effects can be demonstrated in human adult volunteers. The submerged body manifests bradycardia and shunting of blood from the cutaneous and splanchnic vascular beds to the cerebral and coronary circulation. Blood pressure starts to rise immediately. These reflexes are independent of baroreceptor and chemoreceptor input, but depend on both sensory afferents in the trigeminal nerve and reflexive voluntary inhibition of the medullary respiratory centres. Water temperatures above 20°C (the most common temperature in the case of real-life drownings) do not influence the brain-protecting diving reflex, but progressively lower temperatures augment it. The hypothermic brain-sparing effects of near-drowning in cold water may be mediated through an augmented diving reflex as much as through physical chilling of the body core.

Lung Changes

Two Australians, Colebatch and Halmagyi, have done much to clarify the lung changes in near-drowning.[8] After water enters the lungs, rapid changes occur. A series of reflexes are triggered which cause practical consequences for the resuscitation and the intensive care expert (and of course no less for the victim). Vagal efferents cause obstruction to peripheral airways. Aspiration of even very small amounts of fresh water (1 ml/kg in experimental animals) is followed by pulmonary vasoconstriction with the immediate development of pulmonary hypertension due to a parasympathetic reflex. This latter phenomenon is seen particularly following aspiration of fresh water into the mammalian lung and, to a lesser extent, in the case of sea-water aspiration but does not occur with aspiration of amniotic fluid.

Sea water, and water containing sodium chloride concentrations that are approximately iso-osmolar with plasma do not denature pulmonary surfactant but may dilute it or wash it out. Fresh water or significantly hypo-osmolar fluid aspiration causes marked change in surfactant activity.

With the aspiration of larger volumes of water (eg. 2.5 ml/kg), intrapulmonary reflexes cause shunting of blood through non-ventilated areas. This shunt (vagus-mediated), combined with surfactant loss or inactivation and with alveolar collapse, causes a significant reduction in mechanical compliance, a phenomenon that further compounds and adds to the effective right-to-left shunt. A mechanical blockage of the bronchial tree is caused by a combination of bronchial spasm, changes in the elastic properties of lung tissue, and increases in the non-elastic resistance due to physical blockage of the airways by fluid and foam.

The intrapulmonary shunt (ie. percentage of cardiac output that passes through perfused but unventilated lungs and is therefore unoxygenated) increases dramatically after the aspiration of water. It increases from the normal range of 5 to 18 per cent to levels approaching 75 per cent within minutes of fresh-water inhalation. Clinical studies in humans have shown that the shunt takes at least several days to revert fully to pre-accident levels, even although the victim appears normal.

The water flux occurs across the alveolar epithelium, through a basement membrane and finally through the endothelial capillary lining into the capillary lumen where hemodilution occurs. This flux causes rapid and severe distortion of pulmonary ultrastructure. Histologic studies show that cells which produce surfactant are damaged. If the victim is successfully resuscitated, this loss (or denaturation) of surfactant can lead to "secondary drowning".[7]

There is no question that the phenomenon of "secondary drowning" is one of the most feared complications which can occur. It always seems terribly unfair when this complication develops in a rescued victim who appears to be doing so well for the first few hours after rescue . The condition is potentially fatal unless anticipated and treated. Symptoms vary considerably. In the conscious patient the development of tachypnoea, the inability to take a deep breath, a burning retrosternal pain, pleuritic pain with a hoarse rasping cough, and expectoration of increasing amounts of frothy, pink sputum, herald the presence of this condition. Cyanosis may develop if it is not already present, and respiratory failure may approach rapidly. The single most important sign, and one of the very serious prognostic concern indeed, is the return of coma in a near-drowned patient who has had a lucid period. Before the full implications of secondary drowning were realised, this complication had a uniformly fatal outcome.

Brain Hypoxia

Obviously, the most important link in the drowning chain,[8] is that of brain death. Brain death may occur either before or after cardiac asystole. There are four links in the final sequence of brain death in immersion accidents:

1. State of Decreased Neuronal Metabolism
   After consciousness is lost a short period of reversibility of the altered neuronal metabolism occurs, before intracellular hypoxia and acidosis cause permanent damage. Not all neurones are equally vulnerable, and those associated with more subtle forms of intellectual activity are affected first. The electroencephalogram (EEG) becomes flat during this stage but this condition is reversible. Oxygen depletion arrests neuronal activity, and it is probable that the depletion of oxygen stores progresses more rapidly and is more responsible for these early changes than the effect of the accumulation of potentially lethal quantities of hydrogen ion. It is also probable that the order of deleterious influence is hypoxia, acidosis, and hypercarbia.

2. Vasogenic Stage
   This stage is a short period during which extravasation of large molecules from cerebral vessels occurs. The blood-brain barrier breaks down, with both fluid and macromolecules passing into the parenchyma.

3. Stage of Oedema
   Dissolution of vascular and cell wall integrity (functional if not anatomical) leads to both intracellular and intercellular increases in osmotic pressure. If the patient survives, oedema develops. It is thought that cerebral oedema caused by ischaemia is harmful only in that it may cause sufficient hemispheric swelling to result in mass effect and herniation. There is no evidence to date to indicate that oedema, per se, increases the extent of neuronal death. In survivors, the speed with which significant cerebral oedema develops remains uncertain, and in several recent studies this phenomenon has been reported as not being a real problem in the first 24 hours after rescue.

4. Stage of Permanent Cerebral Death
   This condition occurs either within minutes of submersion, and the victim is taken to the mortuary rather than the emergency room of the hospital, or is an iatrogenic clinical state created by therapeutic technology. It is important to appreciate that early (up to several hours) post-rescue signs of apparent brain death (flat EEG, fixed and dilated pupils, no vital signs except the ECG trace) are not fully interpretable with our current knowledge. Some 30 to 50 per cent will still survive, and of these a significant number will not suffer major brain damage.

Post-Rescue Care

A near-drowned victim will have some or all of the above changes in lungs and brain. Triage after rescue is popularly grouped into the Modell-Conn Classification of "A" (awake); "B" (obtunded or "blunted" consciousness); and "C" (comatose). Respiratory support with positive end-expiratory pressure (PEEP) in those not breathing spontaneously (a constant positive airways pressure, "CPAP", is used for the conscious patient), and intensive care monitoring are universally used. At this stage of knowledge, induced hypothermia, barbiturate rescue and invasive monitoring of intra-cranial pressure are controversial,[10] and results from different series can be scientifically interpreted. Management should be directed at watchful expectancy for arterial hypoxia, secondary drowning, hyperthermia, seizures, raised intra-cranial pressure, septicaemia (often with exotic marine organisms) and gastrointestinal bleeding, all of which can be anticipated on the pathophysiological grounds enumerated above, and treated aggressively.

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SUDDEN DEATH IN THE WATER

John Hayman

INTRODUCTION

This review outlines conditions which may result in sudden death in the water. Frequently several factors may be involved in such a fatality, and in assessing a death, the contribution of each of these factors should be evaluated. "Sudden death in the water" includes deaths in divers, swimmers, bathers rather than swimmers, and deaths in those who inadvertently entered water.

The term "sudden death" has been variously defined. The most commonly accepted definition is death occurring in a previously apparently healthy person within 24 hours.1 However sudden death is more frequently thought of as death occurring within minutes. The term "instantaneous or immediate death" refers to death occurring within seconds; such deaths are nearly always cardiac or traumatic in origin.

In considering the causes of sudden death in the water, it is helpful to group the deaths in one of three categories:

A. Deaths occurring in the water, often associated with exertion or stress, but where the water itself was not a major contributing factor.

B. Deaths occurring in water where the presence of water was a major contributing factor.

C. Deaths occurring in water where the water was the essential factor.

These groupings are not absolute, but are intended to emphasise the variable role of the aqueous environment in sudden death.

CAUSES OF DEATH IN THE WATER

A. Deaths associated with exertion or stress

These deaths are mostly cardiac in origin, but in some cases this may be difficult to confirm at autopsy. Swimming either at the surface or at depth requires a deceptive amount of exertion,[2] and the professional diver working at depth expends even greater energy. Such exertion may induce a fatal arrhythmia in a previously asymptomatic individual with ischaemic heart disease, particularly in a person with a low level of habitual activity.[3] The fatal event may well have occurred during exertion in another area, and in these cases death in the water may be simply fortuitous. However, additional factors such as anxiety or panic associated with the initial pain or breathlessness, hypoxia resulting from water inhalation, or malfunction of diving apparatus, and hypothermia may also contribute to the development of a fatal arrhythmia.[4]

Cardiac lesions other than ischaemic heart disease may cause sudden death in the water. Valvular heart disease, including Barlow's syndrome and Marfan's syndrome,[5],6,[7] together with various types of cardiomyopathy, including alcoholic cardiomyopathy, myocarditis including sarcoidosis, and various conduction defects such as the Wolff-Parkinson-White syndrome,8,9,10 may all be responsible for a sudden cardiac death in the water.

Cerebral lesions, such as a cyst of the third ventricle may infrequently produce instantaneous death,[11] but most cerebral or vascular catastrophes result in loss of consciousness, with death occurring from drowning as a secondary event.

The following case reports illustrate this group of deaths.

Case 1

A schoolboy aged 12 was found lying in 1.5 m of water in a public swimming pool during his school's swimming sports. He was immediately brought to the surface where expert attempts to revive him were unsuccessful. He was not seen to be in difficulty and had been beneath the water for no more than one or two minutes.

Case 2

One year later, his younger brother, then the same age, swimming in the same sports, was seen to collapse during a race. Immediate attempts were made to revive him, but these were unsuccessful. Although never proven, it would seem probable that both deaths were due to arrhythmia associated with a conduction defect. Both hearts were examined in detail, and conditions such as myocarditis, cardiomyopathy, valvular heart disease, and anomalous origin of coronary arteries were excluded.

Case 3

A professional diver, aged 42, was working in 30 m of water when his companion found him to be unresponsive. He was brought to the surface and placed in a decompression chamber, where attempts to resuscitate him proved unsuccessful. At post-mortem, there was an area of fibrosis in the inferior wall of the left ventricle associated with atheromatous occlusion of the circumflex branch of the left coronary artery and right main coronary artery. The body showed widespread intravascular and soft tissue bubble formation with explosive disruption of both cerebral hemispheres. Death was due to ischaemic heart disease, and the bubbles would not have been present when the diver died at 30 m, illustrating that bubble formation is a physical rather than a physiological event. With occlusion of two major coronary vessels, this diver could have died at any time, but the exertion and stress of working at depth were held to be precipitating causes.

TABLE 1

SUDDEN DEATH IN THE WATER

Lethal Occurrence; water environment incidental	Non-lethal Occurrence; lethal because of water environment	Lethal Occurrence; caused by the water environment
Cardiac Disease Cerebrovascular Disease Trauma	Epilepsy Cerebrovascular Disease Trauma Head Injury Cardiac Arrhythmia Diabetes Mellitus (hypoglycaemia) Asthma Alcoholism Effects N, CO, CO_2, O_2 Narcotic Drugs Impaired consciousness from other causes Post hyperventilation blackout	Drowning Acute Hypothermia Pulmonary Barotrauma Cerebral Arterial Gas Embolism (CAGE)
Death due to primary event	Death usually due to drowning, secondary to primary event	Death due to primary event

B. Deaths where the presence of water was a major contributing factor

A person may drown following an accident or other event which in itself may not have been fatal. Some medical conditions result in temporary or transient unconsciousness, and if this event occurs even in shallow water, death from drowning may result. In every case of drowning it is important to seek out any such underlying or contributing condition. Epilepsy is commonly considered to be one such disorder[12] although estimates as to its contribution to drowning deaths are variable. One such case is reported in the New Zealand Diving Related Deaths 1983.[13] Hypoglycaemia following insulin, exertion, and lack of dietary carbohydrate is another possible cause. Transient ischaemic attacks associated with cerebral atherosclerosis, and even vaso-vagal episodes due to exertion and changes in external temperature[14] may also result in unconsciousness followed by drowning. Acute vertigo, produced by cold, may result in complete disorientation and drowning.[15] Head injury, spinal injury, cerebral thrombosis, cerebral and sub-arachnoid haemorrhage may also result in unconsciousness followed by death in the water.

Alcohol is commonly associated with drowning in adults, and must be regarded as a contributing cause in all such cases. Low levels may act simply by causing the victim to have lost a certain degree of caution and to swim further from land. Moderate levels may impair co-ordination and help to produce fatal hypothermia. High levels may be responsible for the victim falling into water and being unable to extricate himself. In these cases, alcohol may be considered the prime cause of death, and the water is only a major contributing factor.

Drowning is a frequent means of suicide, and may be chosen by the deceased when there is a desire to conceal the act of self-destruction. Suicide should always be suspected in any unexplained drowning, particularly if a non-swimmer or poor swimmer has been found inexplicably in deep water.

The following cases illustrate the group of deaths where water is a major contributing factor, and the difficulty that may occur in determining the contribution of each factor where there are several factors involved.

Case 4

A male, aged 18 was found floating face downwards in 1 m of water, 50 m from the shore. He was a known asthmatic, and at post-mortem there was histological evidence of active asthma with mucus plugging of small bronchioles and eosinophils in bronchial walls, together with signs of water inhalation. Death was attributed to drowning associated with acute bronchial asthma.

Case 5

The body of a 60 year old man, a known depressive, was recovered from a lake 2 days after his boat was found run aground. When the boat was examined by police, it was discovered that the wheel was fixed so that is would travel directly forward. It seemed that the deceased deliberately left the boat in the centre of the lake, having first arranged motor and steering so that the boat would travel away from him, perhaps intending that his suicide should appear as an accident.

Case 6

A man in his late sixties fell overboard from a boat travelling across a lake late at night. He and his companions on board had been drinking for some hours. His cries of distress were heard in the darkness for about three minutes, but by the time the boat had changed course and circled back, he was lost. The water temperature was 15° C. At post mortem there was severe coronary-artery disease, evidence of drowning, and a post-mortem blood alcohol of 150 mg%. The alcohol, potential hypothermia, and the coronary artery disease may all have contributed to the death from drowning, and it is difficult to assess the relative contribution of each of these factors.

C. Deaths due to water

Here, it is the deceased's presence in the water which is the essential cause of his death. Most of these deaths are due to drowning, with other factors contributing to a variable extent. Thus alcohol ingestion, hypothermia, and exhaustion may be significant contributing factors either in isolation or in combination. In divers, nitrogen narcosis, carbon monoxide poisoning and carbon dioxide retention may all contribute to death by drowning. In breath-hold divers, hyperventilation prior to the dive may lead to anoxia, unconsciousness and subsequent drowning.[17]

The mechanisms of drowning have been investigated clinically[18,19] and experimentally.20 A small amount of aspirated water may lead to pulmonary vascular spasm, pulmonary hypertension, pulmonary venous bypass and anoxia. These physiological reactions may have a more profound effect on consciousness than the actual presence of fluid in the lung. A small amount of fluid, particularly fresh, may be absorbed so that at post-mortem it would appear that no water has entered the lung. After apparently successful resuscitation attempts there may be progressive dyspnoea, reduced lung compliance, anoxia, and death from a progressive form of adult respiratory distress syndrome.21

In the aqueous environment, heat may be rapidly lost from the body,22 the rate of loss depending on the temperature of the water, the amount of insulation due to clothing and body fat, and the amount of movement in the water. In very cold water, hypothermia with fatal cardiac arrhythmia may occur within minutes. Sudden, particularly sudden unexpected entry into very cold water may result in immediate death due to cardiac arrest, cardiac arrhythmia, or to uncontrolled respiration and inhalation of water. In these cases, death has occurred before there has been significant cooling of the body; death is due to cold exposure rather than true hypothermia.

In divers, pulmonary barotrauma with air embolism may be a cause of sudden death and may occur following an uncontrolled ascent from relatively shallow depths.23 Air embolism may in itself be fatal, or may lead to convulsions, loss of consciousness, and drowning. Air embolism may occur where there is partial obstruction of one bronchus,24 leading to over inflation of one or more lung segments despite apparent adequate exhalation on ascent. Decompression sickness may occur acutely,25 but this is unusual and symptoms do not usually appear before surfacing from depth.

In both swimmers and divers, death may occur from trauma, stings and bites from marine animals, shark and crocodile attack. The passing speedboat and the companion's speargun are obvious and not infrequent causes of death or serious injury.

INVESTIGATION OF SUDDEN DEATH IN THE WATER

The investigation of a sudden death in the water requires more than a finical post-mortem examination. All the circumstances of the deceased's entering the water should be determined, including the time since the last meal, alcohol ingestion, and the taking of medication. The water conditions, including temperature, currents, wave heights and time spent in the water must be known. The interval of time during which the deceased was missing, and the nature of rescue and resuscitation attempts should be recorded. If a diver, all details of training, experience and equipment should be known, together with the state of function of this equipment.

The autopsy procedure for a diver has been described in detail.21 If a cardiac death is suspected, the coronary arteries and heart valves should be examined in detail, and tissue blocks for histological study should be taken from each of the four quadrants of the left ventricular wall. If necessary multiple blocks are taken through the sino-atrio nodes and atrio-ventricular nodes and conducting bundles. Other arteries, including the common carotids and carotid bifurcations should be inspected. Material for histological examination should also be obtained from lungs, and all abdominal and endocrine organs. Samples should be taken of lung, liver, kidney and bone marrow for diatom analysis.[27]

The complete investigation of a fatal diving accident involves more than a pathologist carrying out a post-mortem examination and producing a report in isolation. In reaching a conclusion, the findings of the autopsy should be considered together with all the known circumstances of the accident. The complete and correct evaluation of these circumstances is important in understanding such fatalities and preventing future occurrences.

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THE IDEAS BEHIND THE NEW USN TABLES

John Knight

The USN air decompression tables are used by sports divers around the world. No one really knows how good they are because no one knows how many dives are made to what schedule every year and how many cases of decompression sickness (DCS) result. These figures are not even reliable for the USN inspite of the requirement to record every dive and forward the figures to the Navy Safety Center. These are many cases of people getting bent using the USN no-decompression tables as they are written. That is straight to depth and staying there for the full bottom time and returning to the surface. Some will have ascended faster than 60 feet (18 metres) a minute, but others have kept to that limit. Looking at the testing that was done for these tables[1] there were 27 bends in 568 dives, with an average of 6 dives a schedule, covering 88 schedules. This gives a 4.75% incidence of DCS. So one could perhaps expect about 5% bends using the USN tables as they are written. Two thirds of the schedules were never tested!

Repetitive dives were even less thoroughly tested and later experience is much less than for single dives.

Dembert et al[2] published the 1981 USN statistics. There were 35 cases of DCS in 92,484 dives, approximately 0.038%, which is 100 times safer than the acceptance trials and various other series where the USN no-decompression tables have been used. How can one explain the difference. Much of the air diving is shallow, and well within the no-decompression limits. For decompression dives USN divers seldom dive the dive in the book, they often add either a depth increment or a time increment, or both, to the dive and decompress for this fictitious dive. If they get close to the no-decompression limits they often decompress for the first decompression dive in the table.

In an effort to find out the incidence of decompression sickness the USN did a study of decompression dives, as being more likely to be recorded than no-decompression dives, and the incidence of DCS.[3] The results, covering the years between 1 October 1971 and 30 November 1978 were published in January 1980. The overall incidence of DCS was 1.25%. The average incidence was 1.1% for the 43 schedules that were dived more than 100 times. Four schedules produced a statistically significant increased incidence, ranging from 3.1 to 4.8%. The conclusions were that there were a very limited number of schedules that were being used frequently, and that the incidence of DCS was very low (at 1.25%). There was a trend to an increase in DCS incidence with longer dives.

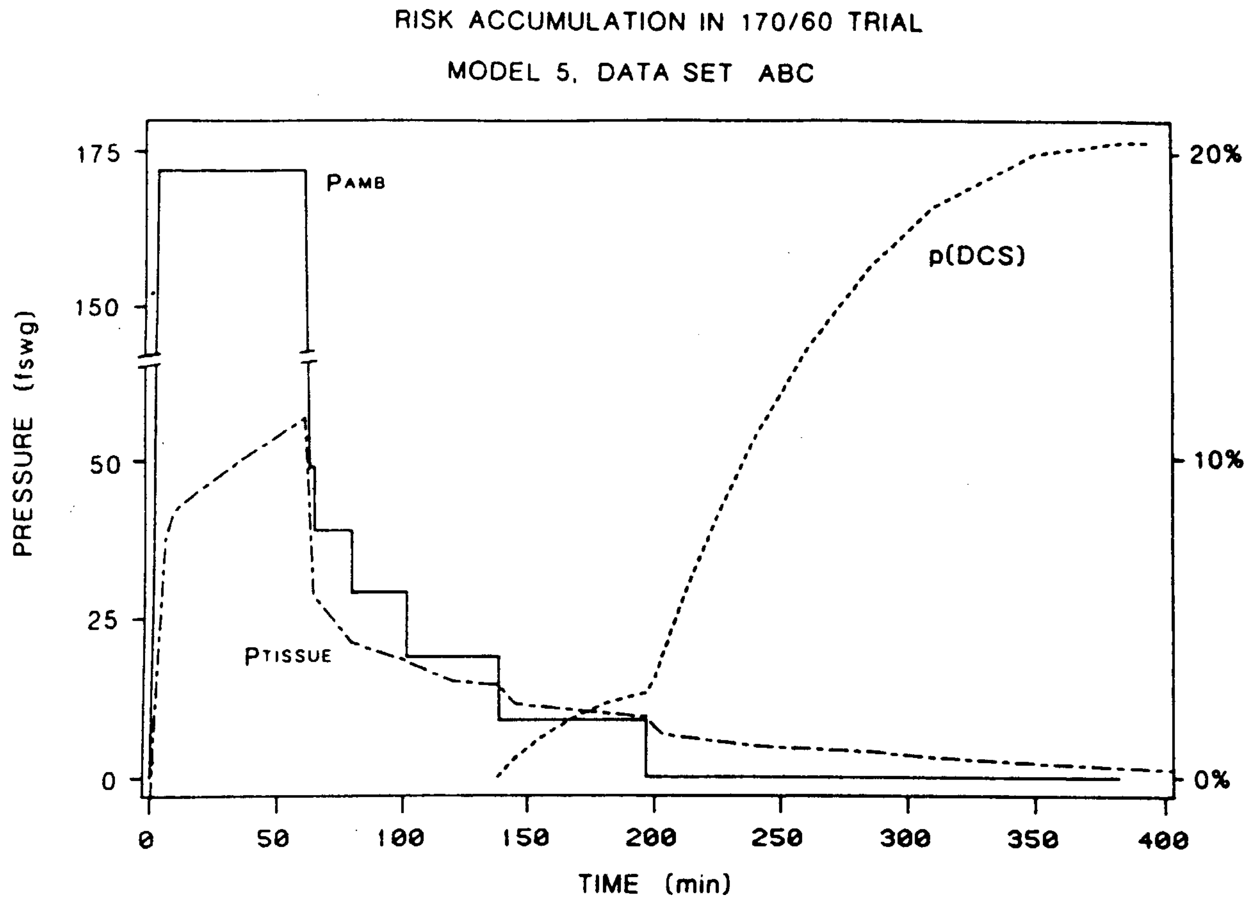
Weathersby et all have published a review of a large number of sets of experimental dives, including: A: the original testing of the current USN Table 1, B: the original testing of the exceptional exposure tables, C: Royal Navy submarine escape trials,[6] D: dives at the Defence and Civil Institute of Environmental Medicine, Ontario, Canada,[7] E: sea trials of a proposed Royal Navy decompression table,[8] F: trials to see whether exercise during decompression affected the incidence of DCS,[9] G: testing of surface decompression using oxygen,[10] and H: a very conservative Royal Navy table which was not accepted for fleet use.[11]

They predicted, using a relatively simple mathematical model, the probability of DCS in these dives of known profile and known DCS incidence. This allowed them to alter the values in the model to get best fits to the data. Their method of integrating risk over the course of an entire decompression differs fundamentally from the usual practice of trying to avoid a specific point, a given supersaturation ratio in the current USN tables and any supersaturation in Brian Hills' theories, all through the decompression. They assumed that a given decompression stress is more likely to produce symptoms of DCS the longer it lasts. This also means that a large number of different decompressions from the same dive may result, after integration, in the same probability of DCS. They did not invoke specific mechanisms of bubble formation, number, or growth. They assumed that when the computed inert gas partial pressure was less than ambient pressure there was no risk of DCS.

They used 6 models to examine their data. The first had one well mixed compartment for calculating the tissue partial pressure of inert gas. The second had a threshold of supersaturation, that had to be exceeded for symptoms, added. The third had two tissue compartments, which meant that the probability of no DCS was the joint probability of no DCS in both tissues. The Fourth was the third with a threshold added. The fifth was a two compartment model with three kinetic parameters rather than a single exponential for each compartment. The sixth was the same as the fifth with a threshold added.

FIGURE 1

Reprinted from reference 4



They calculated the tissue nitrogen partial pressure for the dive and sufficiently long afterwards for it to fall below 1 ATA as the time of onset of symptoms was not usually known. When the tissue nitrogen pressure exceeded ambient the risk of DCS started and increased for as long as tissue inert gas pressure exceeded ambient. Once they were the same the risk remained constant. Figure 1 shows the risk accumulation in a 170 feet for 60 minute dive using model 5 and the combined data from sets A, B and C. In this case the greatest risk accrued after surfacing.

Applying the various models to the different data sets showed that a single tissue model was adequate for prediction using set A, the acceptance trials of the present USN tables. In other words adding another tissue did not improve the fit. Set B, long dives, was also well predicted by a single tissue, and the time constant was close to that for set A. Set C, the submarine escape data, was also well predicted by the single tissue model but the time constants were shorter. So the three sets of data could not be combined and treated with a one compartment model.

The fit can be shown by a bar graph. Figure 2 compares the predicted and observed incidence of DCS using model 1 and data set A. The results were grouped into four categories depending on the prediction, 0-2%, 2-5%, 5-10% and >10%. The figures over the columns show to the right of the bar the number of dives predicted to be in that group. The figures to the left of the bar are the number of cases that actually occurred. The bar is plotted at the predicted incidence and extends to the height of the actual percentage incidence. In the 2-5% group the model predicted 65 cases with an average incidence of 3.3%. In fact there were 3 cases of DCS which is 4.6% of 65. So the bar is at 3.3 on the predicted scale and rises to 4.7 on the observed scale. The thin vertical lines are the 95% confidence limits for the observed incidence. The dotted line is where the bar tops should be if observed and predicted were the same. The nearer the top of the bar is to the line the better the prediction.

The combined data needed a two compartment model with the two time constants similar to those found when the three sets were examined separately. When these models were applied to the Canadian dives the time constants, though similar to those using the combined data, were not quite so short nor quite so long, which is to be expected as the dives did not include the deep short ones or the long ones of sets C and B.

Then they examined the four sets combined. The result was not quite as good as with sets A and B. The results were much the same as for the four sets. So they decided to take the results from the data sets A, B, C and D and use them as their best summary of air diving risk.

FIGURE 2

Reprinted from reference 4

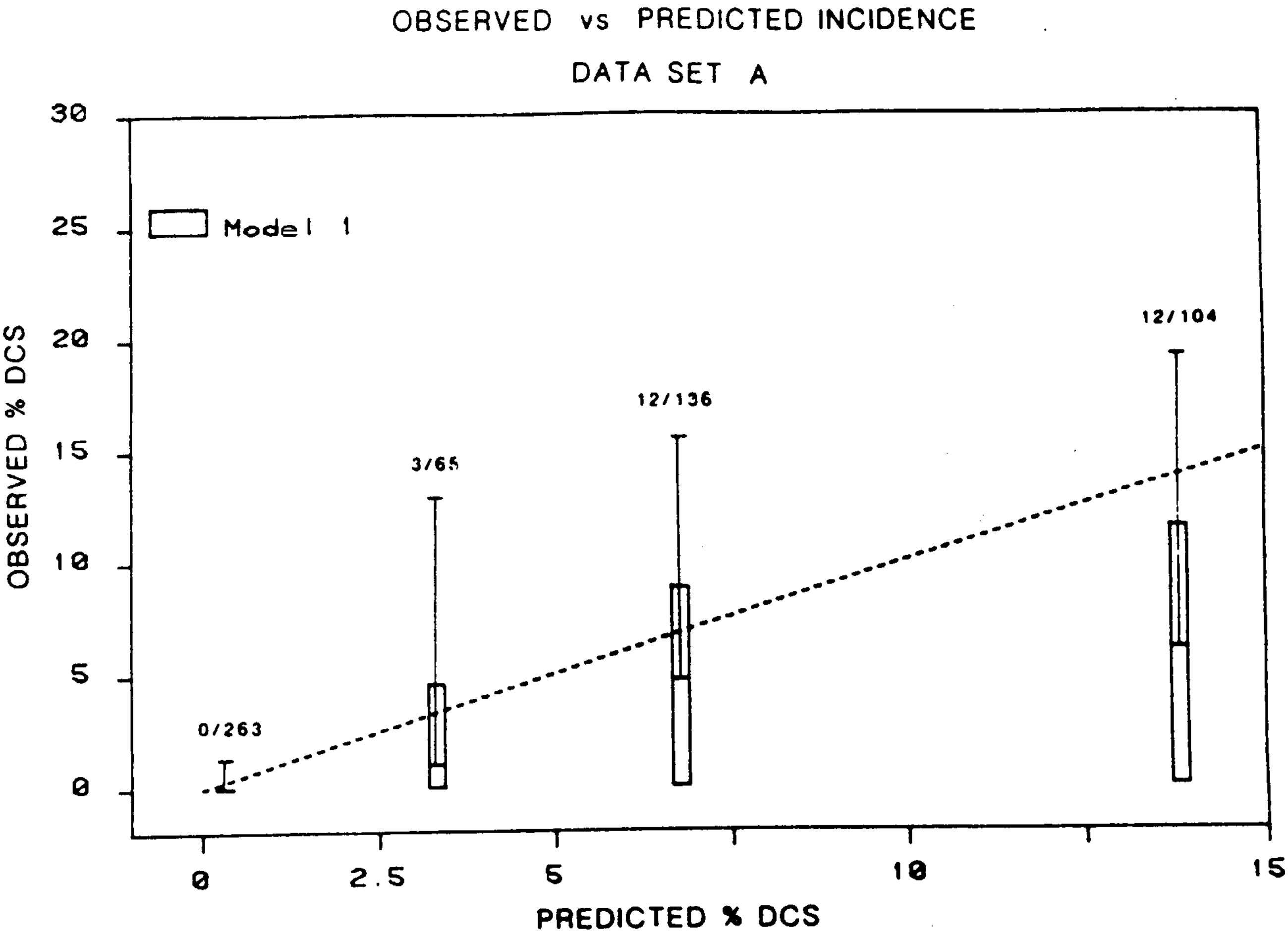


TABLE 1
PROJECTION OF RISK IN ADDITIONAL DATA

			Cases Predicted by Model/Data				
Data Set	Dives	DCS Cases	1/AB	3/ABC	5/ABC	4/D	3/ABCD
E	50	9	0.8	0.8	0.7	1.8	0.8
F	141	42	3.9	3.6	4.3	7.3	3.4
G	143	9	0.9	1.1	1.3	7.5	1.7
H	192	1	3.2	3.7	3.9	5.5	3.8

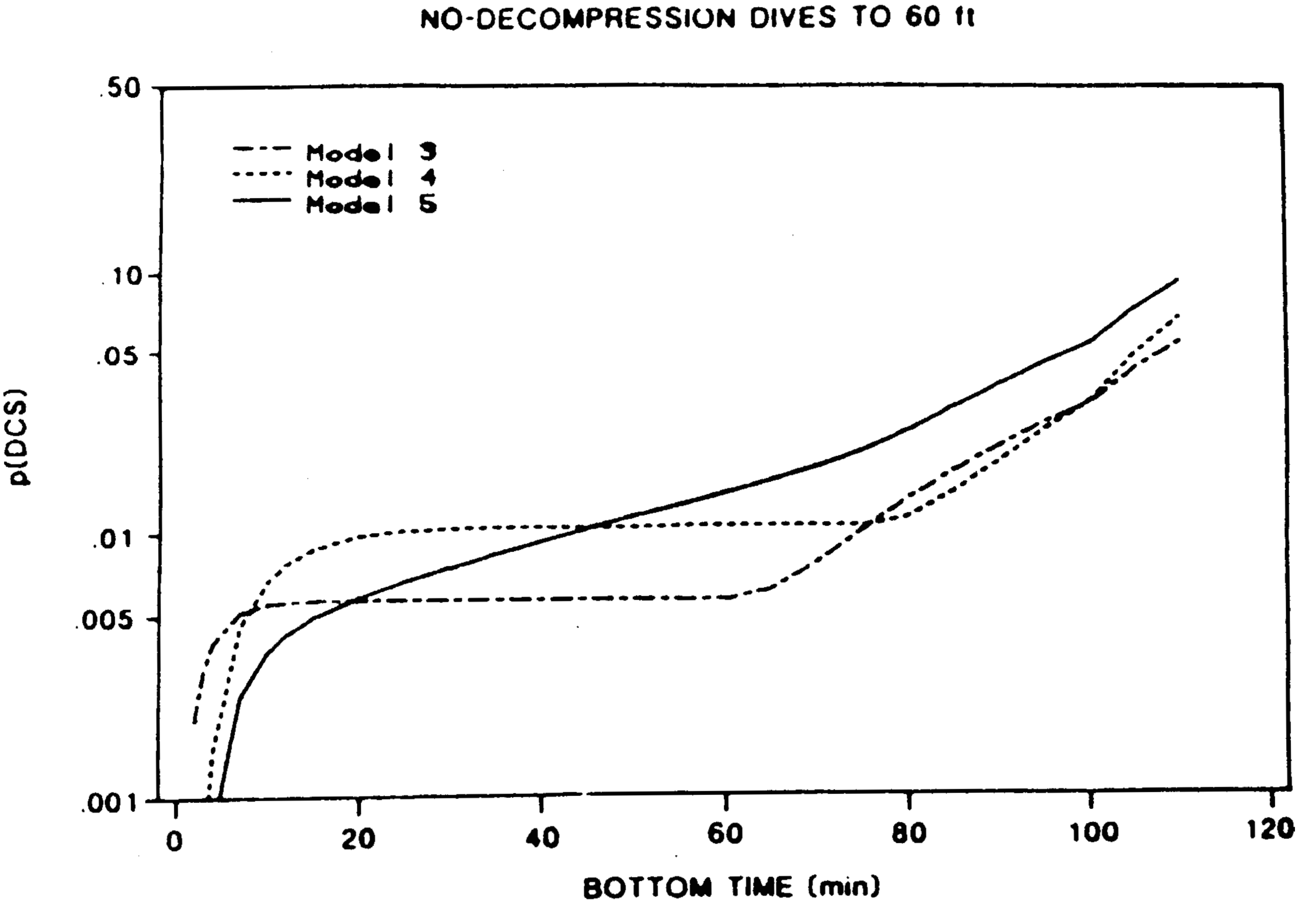
Reprinted from reference 4

Table 1 shows the predictions for data sets E: 1957 Royal Navy trials with shorter decompressions than US tables for the same depth, F: exercise during decompression which were intended to produce a 50% bends rate, G: surface decompression and H: a conservative Royal Navy table, both of which had depths, bottom times and decompressions in the range of those in A and D. It is not surprising that the predictions fit these two sets better than they do than they do E and F, although none of predictions is close to the results.

The predictions were applied to the current USN tables using the same models and data sets used in Table 1. Depending on the model and data set, the USN no-decompression limits, which are what interest sports divers, have predicted risks of 0 to 12% for model 1/AB, 0.3 to 12% for model 3/ABC, 0.4 to 12% for model 5/ABC, 1 to 8% for 4/D and 1 to 9% for 4/ABCD. The highest risk is for 310 minutes at 35 feet. Weathersby et al[4] consider that air dives shallower than 150 feet and shorter than 40 minutes are quite safe, with a risk of DCS less than 0.5%, which depends

FIGURE 3

Reprinted from reference 12



Probability of DCS after dives to 60 ft for various bottom times followed by direct ascent to the surface. Results are plotted for three different models and parameters from Data Set ABCD.

on the model used as 4/D gives risks of 2 to 3% in this range. Dives lasting longer than 2 hours down to 80 feet, longer than 1.5 hours between 90 and 120 feet and longer than 40 to 60 minutes deeper than 120 feet should produce bends at least 10% of the time. Dives that are both deep and long should produce bends more often than not.

The companion report[12] gives the equal risk air diving decompression schedules. To calculate the no-decompression limits a time and depth profile is run through the various models. Models 3, 4 and 5 agree within a factor of two on the level of safety. The "two tissue" models (3 and 4) both produce a plateau where safety does not change with time for a while. These correspond to decompression after the first tissue (time constant) has reached its maximum effect but before the second has raised its PN2 above 1 atmosphere. Model 5, with different kinetics, gives a smoother curve. Two sets of these curves are shown in Figures 3 and 4. Depending on which model is used the risk of 1% bends after a no-decompression dive to 60 feet starts at 20, 45 or 75 minutes. With the dive to 120 feet the 1% risk is reached at 4, 5 and 7 minutes. It is of interest that the models are not consistently fast or slow at the two depths. This depends on the time constants for the models; 3 and 4 have a short time constant which requires deeper stops, but they are brief.

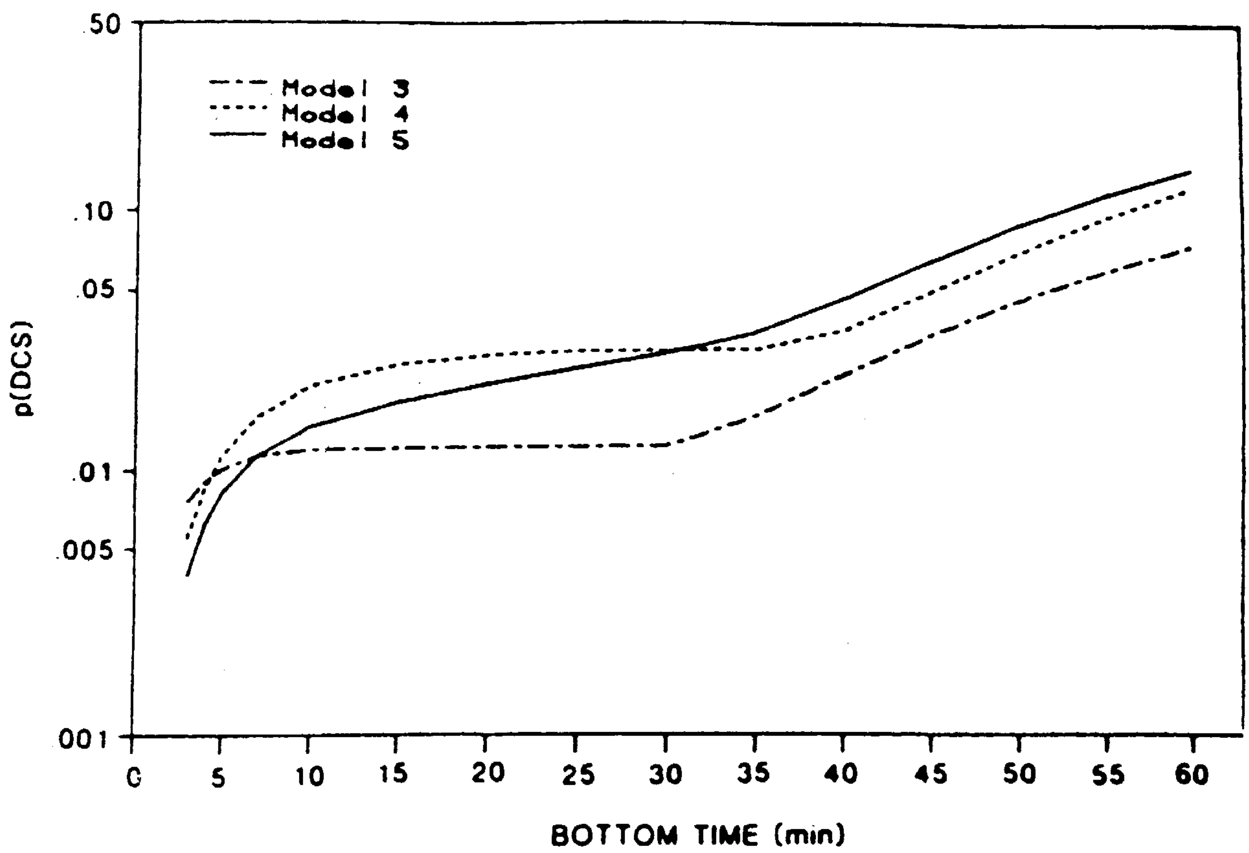
Model 5 was chosen for the tables as it gives a smoother curve for the no-decompression predictions and because it is a kinetic model. The tables have most of the decompression at 10 feet which is quite different to Brian Hills' thermodynamic theory decompression requirements.

The no-decompression limits calculated by three (3, 4 and 5) are set out in Table 2. The current USN no-decompression limits are in the more than 1% risk area in all three models at all depths except for 50, 60, 70, 80 and 90 feet, where only two models are over 1%. For 35 and 40 feet the current USN no-decompression limits are in the more than 5% risk area. The Bassett modification to the USN no-decompression limits is in a slightly better position. None of its limits are in the 5% risk area. At 40 and 50 feet only one model puts it in the over 1% range. At 30, 60, 70, 80 and 90 feet two models put it in the over 1% range. At 35, 100, 110, 120, 130 and 140 feet all three models put its times in the over 1% range which is true of the USN tables as well for these depths. Neither table has any time for any depth in the predicted 0.5% risk zone. In other words the least one can expect is to have a two to one risk of developing DCS after one dive in every hundred using the USN tables, if the models are reliable. (However those who use the Bassett tables with their slower ascent rate are allowing some extra decompression time during surface ascent, so although

FIGURE 4

Reprinted from reference 12

NO-DECOMPRESSION DIVES TO 120 It



Probability of DCS after dives to 120 ft for various bottom times followed by direct ascent to the surface. Results are plotted for three different models and parameters from Data Set ABCD.

the bottom times, with a 60 foot a minute ascent rate would put the diver at the risks mentioned, the slower ascent reduces the risk as does the safety stop on all dives below 10m (30 feet).)

Various people in Australia have told me that the new USN tables will give longer bottom times for less decompression. From these reports[4,12] this is not entirely true. Certainly the "5% incidence of DCS" table times are, deeper than 40 feet, 20 minutes longer than current USN times down to 180 feet where they are 15 minutes longer. But who really wants to get bent every twentieth dive?

The "1% incidence of DCS" table halves the no-stop times at 35 and 40 feet, knocks 30 minutes off at 50, 20 minutes come off at 60, 25 minutes of at 70 and 80, 20 minutes off at 90, 17 minutes off at 100, 13 minutes off at 110, 10 minutes off at 120, 5 minutes off at 130, 5 minutes off at 140, 1 minute comes off at 150 feet and below that depth there are only decompression dives. The limits for these two tables, the current USN tables and the Bassett tables are set out in Table 3.

These tables are untested. The history of testing tables is that in almost every instance the tables have to be modified to reduce the bends rate to an "acceptable" incidence. Chamber dives usually produce fewer cases of DCS than sea dives[8] again leading to table modification. So what the final, tested, tables will be is anyone's guess. But it is pretty certain that they will not be identical with the first proposal.

The idea of decompression tables which allow you to pick the likely chance of DCS is a good one. What is doubtful is whether the equations used to predict the incidence are actually valid under all circumstances. Some of the data sets had to be excluded because the predictions did not fit the results at all well. A reliable prediction model should fit all the data. Weathersby et al12 draw attention to this and to the unreliability of some of the data. They are troubled by the short decompression requirements for very deep but short dives. The USN had a nearly 10% incidence of DCS with short dives to 285 feet with longer decompressions than are suggested in the new tables. Another worry is whether the sudden decompression to shallow stops will cause problems. Only testing will give the answer.

TABLE 2

CALCULATED NO-DECOMPRESSION LIMITS
Reprinted, in part, from reference 12.

PROBABILITY OF DECOMPRESSION SICKNESS (%) WITH THREE MODELS
(CURRENT USN TIMES FOR COMPARISON)

DEPTH	MODEL 3			MODEL 4			MODEL 5			USN
(FSW)	0.5	1.0	5.0	0.5	1.0	5.0	0.5	1.0	5.0	
30	160	180	290	200	220	320	120	170	270	
35	130	140	230	160	170	240	85	130	200	310
40	110	120	190	130	140	190	60	100	170	200
50	80	90	140	10	100	140	30	65	120	100
60	7	75	110	7	25	110	15	40	95	60
70	4	60	95	5	10	90	7	25	80	50
80	3	50	80	4	7	75	5	15	65	40
90	2	40	70	4	5	65	5	10	55	30
100	2	15	60	3	5	55	4	8	50	25
110	2	5	55	3	5	50	3	7	45	20
120	-	4	50		4	45	3	5	40	15
130	-	4	45		4	40	3	5	35	10
140	-	3	40		3	35	-	4	30	10
150	-	3	35		3	30	-	4	30	5
160	-	3	35	3	30	-	3	25	5	
170	-	-	32	-	25	-	3	25	5	
180	-	-	31	-	25	-	3	23	5	
190	-	-	29	-	21	-	3	21	5	
200	-	-	27	-	18	-	-	20	-	

Time is in minutes. Descent rate of 75 ft/min. Ascent rate of 60 ft/min. Descent time counts as part of bottom time.

TABLE 3

NO STOP BOTTOM TIMES
Reprinted in part from reference 12

Depth in FSW	Predicted 5% DCS	Predicted 1% DCS	Current USN	Bassett times
30	240	170	310	220
40	170	100	200	120
50	120	70	100	70*
60	80	40	60	50*
70	80	25	50	40*
80	60	15	40	30*
90	50	10	30	25*
100	50	8	25	20*
110	40	7	20	15*
120	40	5	15	12*
130	30	5	10	10*
140	30	4	10	5*
150	30	4	5	-
160	25	-	5	-
170	25	-	5	-
180	20	-	5	-
190	20	-	5	-
200	20	-	-	-

Both predictions are made using Model 5 with data sets A,B,C and D.

*The Bassett tables require a 3 to 5 minute safety stop at 3 to 5 m on these dives.

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RECOGNISING THE DISTRESSED DIVER

"There is no such thing as an accident. What we are seeing is an effect-from a cause which we do not see." (at the time)

Voltaire

This list has been sent to us by Wayne Williams and Dr John Williamson. It was compiled by a group of experienced Townsville instructors who had observed these problems over the years, with apprehensive pupils.

WARNING SIGNS OF IMPENDING TROUBLE IN NOVICE DIVERS

BEFORE THE DIVE

Vague symptoms to "cop out"
Stalling tactics
Super-quiet

KITTING UP

Errors of simple technique

ENTRY

Grasping boat lines high above the waterline
Inefficient finning
Wide eyed
Inappropriate concern about diving conditions
Reluctant to give up regulator for snorkel
Not following instructions

DESCENT

Equalisation problems -
where no previous problems existed
Buoyancy problems -
where no previous problems existed

THE DIVE

Buoyancy problems
Will not go to the bottom
Keeps off the bottom
Wide eyed
Poor observation of surroundings
Fails to obey pre-dive instructions
Works much harder than other divers
Rapid air consumption (sometimes)

THE 'UP' SYNDROME

A mental attitude where the solution to any problem is rushing to the surface

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Dr J Knight's address is 80 Wellington Parade, East Melbourne VIC 3002, Australia.

DIVING SAFETY WILL COMPUTE

THE NATIONAL SAFETY COUNCIL DIVING DATA BANK

Douglas Walker

The justification for setting up a Diving Data Bank is a belief, based on an examination of the critical paths in the development of both fatal and non-fatal diving problems, that there is still inadequate understanding of the problems which are affecting all types of divers. It is also very apparent that many who are diving endanger themselves by acting as if they were not convinced that the generally accepted rules for safe diving are relevant to them and act as if they believed they had special dispensation from the necessity to remain within the limits of their skills. They fail to attempt an honest pre-dive assessment of the possible and probable dive problems before they, and their companions, enter the water. Such divers range in experience from novice to instructor. While a data bank cannot make such divers learn, it will at least make it possible to identify the consequences of their mistakes for the better instruction of others. The third area of value of a data bank will be the opportunity which it presents for the early recognition of new problems or of some change in the frequency or severity of a known problem. Such changes are commonly a consequence of some alteration in diving patterns (eg. increased commercial weekend dive trips or deep repetitive dives) or of the marketing of new diving technology (eg. dry suits, larger capacity air tanks, new diving tables, better rescue service backup and greater resuscitation expertise). Reports will also enable an improved understanding of how symptoms and signs are perceived by those immediately involved, as such are rarely as clear cut and definitive as the text book description or edited clinical notes will seek to show. It is unfortunate that text books and lectures lead the majority of divers to believe that the only areas where research is required are the "growing points" where physiologists employed by the major diving companies experiment with exotic gas mixtures, great depths, and saturation techniques. The remarkable progress made in enabling almost anyone to dive using compressed air, which has spawned a large service industry has obscured the fact that the information base of many sincerely held opinions is extremely slight. The classic example of this is the debate which continues concerning the value, or perhaps danger, of including a practice of out-of air ascent in the initial training of sport divers. Few if any such discussions analyse the information now available about the critical factors in diving fatalities or provide the needed input of reports of instances where such training has been shown of value. The general excellence and reliability of most diving equipment has dulled the awareness of many people to the critical fact that mankind has not evolved in an underwater environment so must at all times adjust to the new "house rules" and forget any pretensions to acting like the Lords of Creation. Monitoring of the experiences of those who venture underwater is a vital first step in the recognition and avoidance of dangers.

At the present time there are a few reports published which include adequate details about the diver and his/her companions, or give a full report on the circumstances and management of the diving and of the index problem itself. Doctors involved frequently confine their questioning and records to the presenting problem and its management without considering the preventative medicine role they can so usefully play. Only a very small proportion of events will ever be reported formally, and these will be presented shorn of all details not directly significant to the purpose of the paper, and few authors are willing to share their original material with others, so a wealth of information is unused, locked away from the eyes of other than the original doctor or instructor diver, or most often never sought in the first place. This is ultimately to the detriment of all divers, as knowledge is the basis of safety.

When only details of immediate perceived relevance are recorded, a probability exists that at a later stage some other data will be desired, either in relation to the initial investigation or for a spin-off, a new line of investigation. Such information need not burden medical files if data bank storage is utilised. Sharing is of benefit to all. Clues to reducing the occurrence of decompression sickness may lie in the victim's pre-dive fatigue, fitness, the pattern of previous alcohol consumption, accuracy of depth and time measurement, thickness of wet suit, post dive activity, his confidence or stress, or many other factors in the post dive period including willingness by the victim, his companions and medical personnel to consider the diagnosis. In the case of cerebral arterial gas embolism (CAGE) the doctor in charge should inquire into the training and experience of not only the victim but also his companions, and record all the details available concerning the dive itself to assist some later consideration of the chain of events which culminated in critical pulmonary overpressure. The information may reveal common diving practices or problems having a potential to compromise the safety of divers. Naturally, reports from those who recognise and then successfully manage some problem have a special value and it is hoped that divers will recognise the value of a data bank which can, with full confidentiality, make their experiences available to increase the safety of others.

Once it is suspected that some problem exists, or may exist, and an investigation is proposed, there will be two major problems to be faced. The first one is that of convincing others that a problem exists, is significant and can be usefully tackled by the proposed methodology. The second arises at a later stage, after the project has generated masses of information. Some of the information may be of interest but not strictly relevant to the narrowly defined parameters of the study. This is most likely to occur where input is through reports written by others rather than from experiments directly under the control of the investigator(s). There will be limits on the time available for the work, deadlines for writing a report, and demands of other tasks, which will operate and strongly inhibit any tendencies to follow up side issues. As a consequence there will be a very real risk that "irrelevant" information will be either discarded or set aside to await that "sometime" in the future "when there will be an opportunity to look through all the old material at leisure". Few will ever find the time, and if they do the mountains of collected paperwork will be daunting to even the most dedicated investigator.

The answer to the first problem is by presenting the results of a pilot study for critical assessment before progressing to a more ambitious stage. In this respect "Project Stickybeak" reports and the clinical reports given at SPUMS meetings and printed in the SPUMS Journal are offered as indicating the value of the collection and publication of reports which contain uncertainties and are not an edited version of the events, bowdlerised to fit them to the textbook descriptions of clearly differentiated conditions. It is only through the comparison of the predicted with the observed that an opportunity may arise to improve our understanding of events.

Until recently, the only way to manage information storage was by way of some form of card index system. Initially straightforward, the systems soon become complicated as data stubbornly refuses to fit the clearly defined categories set out by the investigators. All living reactions are the resultant of a multitude of factors, many still unknown or barely suspected. Fortunately, computers have now become more available and make possible the storage, retrieval and cross referencing of vast amounts of data, subject only to having a sufficiently flexible programme written initially. Another virtue of a pilot study is that the information and problems it reveals are invaluable to "dry run" a programme before it is finalised.

By a fortunate chance the Victorian Branch of the National Safety Council of Australia has recently obtained a VAX 780 computer. It has a capacity which is in excess of that required by its primary programme and some of its remaining capacity has been very kindly made available for diving-related-data storage. Also provided has been the services of a computer programmer, a vital element if the computer is to be used to best advantage.

The purpose of this communication is to alert everyone who has an interest in increasing knowledge and understanding of diving and hyperbaric problems of this new data source, and to introduce them to the notion that they can assist by providing input. Without an adequate input there can be little progress in the maintaining and improvement of present levels of diving safety or of early awareness of new problems resulting from changes in diving practices.

To be effective the programme must ask the right questions, possibly ones not usually asked. All readers are invited to present their lists of matters which they think should be better researched and suggestions concerning the information which should be collected in anticipation of possible future retrospective investigations. Some important areas will undoubtedly relate to the problems that are observed during training, equipment reliability, boat related and sea conditions related problems, and information concerning diving related problems, particularly those so successfully resolved that no "incident" developed.

One vital aspect of this data store will be the CONFIDENTIALITY guarantee. ALL reports will be treated as MEDICALLY CONFIDENTIAL and no identification of persons involved will be entered on the computer records, a matter made more complete when large numbers of reports are entered from a wide range of localities. As fatality reports are already in the Public Domain (Inquest reports) it may not be possible to obliterate all clues to the actual cases.

The project will work or fail in proportion to the support it can obtain. All divers, present and future, stand to gain both in the immediate and longer term from the information collected. Please give your support. Every report has value. Access to the Data Bank will be allowed to anyone with a research interest, but no details of those supplying reports or involved will be on the records.

Those wishing to correspond concerning this project, particularly those with information they are willing to make available, should write in the first instance to:-

Diving Data Bank Project
PO Box 120,
Narrabeen NSW 2101

BOOK REVIEW

THE MARINE STINGER BOOK
The Surf Life Saving Association of Australia
Queensland State Centre Inc.
3rd Edition, 1985 (page 85)

To describe this excellently written and illustrated booklet as a "first aid handbook" would convey a completely inadequate impression of its value. Although directed primarily towards a lay readership of SLSA members, it is of interest and value to a much wider public. Indeed, both doctors and divers will find it of great help when faced with a person who has become a victim of one of the large number of creatures which can make themselves known after skin contact, penetration by a spine, or following ingestion. Only the shark escapes study and in truth his contribution to marine enjoyment is rare, and a matter for the application of general principles of trauma management. The text and pictures are so good that one can read and later still think favourably of an invitation to enter the water.

The booklet has a useful bibliography, an effective index, a resume of First Aid management principles, and a copy of the Australian Resuscitation Council's Basic Life Support Flow Chart. It is of interest to note two additional details, the availability of a slide set and a videotape to supplement the booklet, and the information that an investigation is being undertaken to increase our knowledge of marine stingers. For those interested in contributing reports the contacts are either the "Marine Stinger" telephone (008) 015160 (24 hours) for more urgent needs, or write to:

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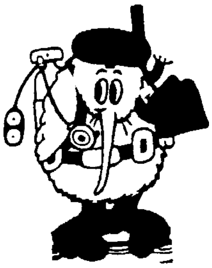


DIVING KIWIS

PAPERS AND ABSTRACTS FROM THE NEW ZEALAND CHAPTER OF SPUMS MEETING 7TH TO 9TH NOVEMBER 1985 KAIKOURA ISLAND, GREAT BARRIER ISLAND

DIVING MEDICALS

Allan Adair and Allan Sutherland

A diving medical is an essential part of a scuba training programme. With this the basic conditions which are incompatible with diving are sorted out and those which may, with some restrictions or medical modifications, allow a person to dive are clarified.

Diving is essentially a physically demanding sport, in an environment which is not basically friendly to the human species.

The interaction between the gas laws and human physiology is extremely complex and is far from fully understood but a knowledge of those gas laws, and the applied physiology is essential for the assessment of the fitness of divers to dive.

Commercial divers are subjected to extremely exacting medical requirements for their diving may be conducted in arduous conditions for prolonged periods and the maximum in physical condition is required for these circumstances.

Amateur divers do not require such exacting standards, but because many different types of people with differing degrees of fitness, physically medically and psychologically, may wish to dive, it is important that a medical examination be conducted to give them the maximum protection during their participation in that sport. Note is made here that in New Zealand it is compulsory (NZ Underwater Association and PADI courses) to have an initial medical, but unless the diver decides to take higher qualifications, there is no compulsion to ever be medically examined again. Obviously, a person's medical fitness may change in time.

Diving medicine and physiology is not taught as an undergraduate subject, but frequently practitioners are required to perform medicals on candidates as part of their everyday work. Difficulties can arise if the significance of a particular condition in relation to diving is not appreciated.

A very important part of a diving medical is the past history of the candidate. From this a wide range of conditions can be recognised which are either totally or partially incompatible with the sport.

Allan Adair has prepared the following suggestions for upgrading the NZUA diving medical form, and in conjunction with Allan Sutherland this is put forward for discussion at this SPUMS (NZ) meeting. We emphasize that these are only suggestions which are available for modification prior to forwarding to the NZUA.

GUIDE FOR EXAMINER

1. Scuba diving is potentially hazardous, and even momentary impairment of consciousness underwater may result in death.

2. The body air spaces must equalise pressure readily, therefore the medical practitioner should give special attention to ensure that the tympanic membrane moves during auto-inflation (eg. Valsalva Manoeuvre), and there is no air trapping from obstructive lung disease, such as asthma.

3. Diving is a physically demanding sport and a moderate degree of physical fitness is essential. Heavy equipment may need to be carried.

4. The following is a list of <u>absolute contraindications</u>:

   a. Epilepsy.
   b. Diabetes.
   c. Chronic lung disease: Asthma, chronic bronchitis or emphysema, TB or lung cysts, spontaneous pneumothorax, penetrating chest injury or surgery.
   d. Ischaemic or valvular heart disease.
   e. Alcohol or drug abuse.
   f. Psychiatric disorders.
   g. Pregnancy.
   h. Previous Bend or Air Embolus with Neurological Sequelae.

5. Some medical conditions can be classified as relative contra-indications and require special consideration:

   Poor physical condition and obesity, hypertension, ENT disease, visual or hearing defect heavy smoking, allergy, drug treatment, physical deformities, severe motion sickness, migraine and impaired respiratory function FEV 1/Vital Capacity ratio less than 75% or Peak Flow less that 75% of predicted for size.

6. For candidates over 40 years an ECG is recommended, and consideration should be given to regular follow-up medicals at 5 yearly intervals.

7. Should there be any doubt as to the suitability of a diving applicant to undertake sport diving it is recommended the Doctor contact the NZUA Medical Adviser for further advise.

SPORT DIVING MEDICAL

A. QUESTIONNAIRE

Name: Date:

Address:

Occupation:

Date of Birth:

1. Rheumatic fever.
2. Chest pains or discomfort.
3. Abnormal shortness of breath.
4. Abnormal blood pressure.
5. Heart disease.
6. Bronchitis, pneumonia, emphysema, pneumothorax, TB
7. Coughing up of blood, chest injuries.
8. Asthma or wheeze.
9. Smoking.
10. Nose, sinus or throat trouble.
11. Allergy of any kind (please state).
12. Ear discharge, impaired hearing.
13. Ruptured ear drum.
14. Fainting, blackouts or giddiness.
15. Fits, epilepsy, convulsions.
16. Diabetes.
17. Blood disease.
18. Head injury, concussion, migraine.
19. Back ache, spinal injury.
20. Any drug treatment.
21. Motion sickness.
22. Pregnancy.
23. Any medical or surgical condition not stated above. Please list:

B. EXAMINATION

General: Age:
Height:
Weight:
Sex:

CVS:
1. Heart rate.
2. Blood pressure.
3. Heart sounds.
4. Exercise tolerance.
5. ECG (if indicated, or over 40 years).

Respiratory System:
1. Chest expansion.
2. Chest examination.
3. Wheeze or dyspnoea.
4. Peak expiratory flow (or FEV 1, or FVC).
5. Chest x-ray. Date, (Insp + Exp Film preferable).

ENT:
1. Ear canals.
2. Ear drums.
3. Middle ear disease.
4. Eustachian tube patency (drums must be mobile on auto-inflation).
5. Nasal air entry both sides.
6. Nasal airway disease.
7. Pharynx.

CNS: It is important to have an accurate neurological record for comparison if a diving accident occurs.

1. Power.
2. Sensation.
3. Reflexes.

Gastro-Intestinal:
1. Abdominal palpation.

Locomotor: Note physical disabilities which would make diving difficult.

Urinalysis: Protein.
Sugar.

To be given to the candidate to pass on to his instructor:

RECOMMENDATIONS

Name: Date:

Address:

1. This is to certify that the abovementioned does not suffer with any of the absolute contraindications to diving, has been fully medically examined and he/she has been found fit for diving without limitation.
2. The candidate has been found fit to dive but has the following medical disabilities which should be taken note of during dive instruction.
3. The candidate is temporarily unfit to dive because:-

   and requires a medical review in:-
4. The candidate is permanently unfit to dive.

Signed:

Name of Medical Practitioner: (print)

Dr A Adair's address is 202 Gowing Drive, Auckland 5, New Zealand. Dr A Sutherland's address is "Outspan", Bush Road, Albany RD1, Auckland, New Zealand.

CONTRA-INDICATIONS TO DIVING

Allan Sutherland

MEDICAL HISTORY

A thorough medical history is an important first step in evaluating any diver, and should include the usual format: history of specific complaints, review of systems, inquiry concerning present medication, allergic conditions, drug dependence and social, family and psychiatric histories. In addition, a diving medical history should be taken to learn about the diver's practices and judgement, as well as specific medical conditions that relate to the hyperbaric environment. The following topics should be addressed:

a. Current diving practices or goals of candidate, whether sport diving or commercial diving.

b. Diving history of candidate:

Where was the candidate trained?
How long has he been diving?
What kind of diving has he undertaken?
To what depth has he dived?
How often does he dive?

c. History of previous diving related medical problems:

Air Embolism
Decompression sickness
Barotrauma, including pneumothorax
Vertigo
Near drowning
Osteonecrosis
Nitrogen narcosis
Oxygen toxicity
Visual disturbances
Treatment in a recompression chamber
Prior medical disqualification from diving

PHYSICAL EXAMINATION

1. ENT

The examiner must be sure that the diver can perform pressure equilibration (auto-inflation) successfully. The Valsalva Manoeuvre, swallowing, or jaw movement may facilitate equilibration. In all cases the Eustachian tube and sinuses must be patent and the tympanic membranes must be proved intact and mobile by insufflation or auto-inflation.

Absolute Contra-indications

(i) otosclerotic surgery
(ii) chronic or serous otitis
(iii) Meniere's disease
(iv) inability to clear the middle ear
(v) chronic mastoiditis
(vi) vestibular lesions

2. CARDIOVASCULAR SYSTEM

Stress of Diving

The aquatic environment can impose severe stress on an individual's cardiovascular system, and physicians must appreciate the nature and extent of the physiologic responses involved in diving if they are to make rational decisions concerning a candidate's fitness to dive.

Absolute Contra-indications

(i) Myocardial infarction within the past year,
(ii) Angina or other evidence of coronary artery disease.
(iii) Congestive heart failure.
(iv) Potential right to left shunts.
(v) Significant valvular disease.
(vi) Coarctation of the aorta.
(vii) Electronic pacemakers.
(viii) Prosthetic valves.
(ix) Intraventricular conduction defects.
(x) Wolff-Parkinson-White syndrome.
(xi) Significant cardiac arrhythmias.
(xii) Stokes-Adams attacks.
(xiii) Peripheral vascular disease.
(xiv) Use of anticoagulant drugs.
(xv) Cardiac surgery for coronary artery disease
(xvi) Hypertrophic cardiomyopathy.

3. CENTRAL NERVOUS SYSTEM

Neurological decompression sickness as well as air embolism can present as subtle or gross neurological deficits. Therefore, it is imperative to thoroughly examine and document the diver's neurological status. Any lesions that could compromise consciousness, judgement, motor control or diagnosis, should be disqualifying.

Absolute Contra-indications

(i) Any demyelinating process, such as multiple sclerosis.
(ii) Brain tumour.
(iii) CVA or transient ischaemic attack.
(iv) Intracranial aneurism vascular abnormality.
(v) Narcolepsy.
(vi) Unexplained syncope.
(vii) Seizure disorders such as epilepsy.
(viii) Decompression sickness with residual deficit.
(ix) Neurosyphilis.
(x) Head injury with sequelae, such as post-traumatic epilepsy.
(xi) A history of intracranial surgery.
(xii) Severe motion sickness.

4. PSYCHIATRIC EXAMINATION

This is one of the most important aspects of the medical examination, yet it is also the most elusive. Divers should be emotionally stable individuals who are capable of good judgement.

Absolute Contra-indications

(i) Claustrophobia
(ii) Suicidal tendencies
(iii) Psychosis
(iv) Neurosis
(v) Anxiety states
(vi) Severe depression
(vii) Manic states
(viii) Drug use
(ix) Alcoholism

5. RESPIRATORY SYSTEM

Pathology in the respiratory system is the major cause of diver disqualification. Any lesions that pre-dispose to air trapping can be lethal. This phenomenon can be responsible for the development of serious over-pressure in susceptible pulmonary structures, provided that gas in the pulmonary tree is not at all times free to equilibrate to ambient pressure. A typical hazard is breath-holding during ascent with scuba gear.

Workup

(i) A thorough history and physical examination.
(ii) A chest x-ray, including an expiratory film is recommended.
(iii) Pulmonary functions test peak flow should be greater than 500 litres per minute, or greater than 75% of the predicted peak flow for size.

Absolute Contra-indications

(i) Pulmonary blebs.
(ii) History of spontaneous pneumothorax.
(iii) Active asthma (opinion - childhood asthma with no recurrence is not necessarily disqualifying).
(iv) Emphysema.
(v) Chronic obstructive lung disease.
(vi) Pulmonary thromboembolism.
(vii) Recurrent thrombophlebitis.
(viii) Pneumoconiosis.
(ix) Silicosis.
(x) Pulmonary fibrosis,
(xi) Bronchiectasis.
(xii) Benign and malignant chest tumours.
(xiii) Granulomatous disease of the chest, TB, sarcoidosis and fungal disease.

6. GI SYSTEM

Abdominal pain can be confused with decompression sickness and any lesion that could predispose to gas trapping in a viscus must be a cause for disqualification.

Absolute Contra-indications

(i) Chronic gastrointestinal disease such as ulcerative colitis, Crohn's disease and chronic hepatitis.
(ii) Chronic liver disease.

7. MUSCULO-SKELETAL SYSTEM

Absolute Contra-indications

(i) Muscular dystrophy.
(ii) Muscular atrophy.
(iii) Myasthenia gravis.
(iv) Osteonecrotic lesions.

8. ENDOCRINE SYSTEM

Disorders of the endocrine system which leave the patient with obvious debility would be grounds for disqualification from diving.

Absolute Contra-indications

(i) Insulin-dependent diabetes.
(ii) Diabetics on oral hypoglycaemic agents, although some diabetics well controlled by diet alone, may be permitted to dive.

9. HAEMATOLOGIC AND IMMUNE SYSTEMS

Absolute Contra-indications

(i) Sickle cell anaemia.
(ii) Haemophilia.
(iii) Any blood dyscrasia or anaemia.

10. AGE

Although scuba training can be undertaken prior to 15 years of age it is recommended that certification be withheld until the age of 15 years is attained.

REFERENCES

1. Hickey DD. Outline of Medical standards for divers. Undersea Biomedical Research. 1984; 11(4): 407-432.

This presentation is based on a paper by DD Hickey, and is presented for discussion.

Dr A Sutherland's address is "Outspan", Bush Road, Albany RD1, Auckland, New Zealand.

MEDICAL STANDARDS FOR SPORTS DIVERS

John Knight

Diving instructors who are paid by results have an economic incentive to teach everyone who comes to them. Sometimes economics overcomes common sense and a person with a problem that will make diving dangerous or painful and damaging is taught to dive. Some of these come to harm but by no means all.

Over the years many people around the world have died while learning to dive, very few of these have died from their medical complaints, but some have. It is these tragedies that a proper medical should prevent. I believe that most instructors now think that a medical for their trainees is a good idea. The problem in Australia is that they are not as yet convinced that it should be done by a doctor with a knowledge of diving medicine. As diving medicals in Australia are outside the medical benefit system many diving instructors send their pupils to their usual GP who, because he does not know the medical benefits rules, gives them an itemized bill so they can claim most of the cost from Medicare. And many of these doctors do not even look in the ears and check that the ear drums move!

In my opinion the doctor is not God who lays down inviolable rules. He or she is an expert adviser who can explain to the person consulting him the risks involved in that particular person going diving. To do this the doctor has to know about diving medicine.

There is a problem with the supply of properly trained doctors so I have produced a "Guide to the examining physician",[1] which explains the essential points to be sought, to be given, with the examination form, to those doctors who have not been trained in underwater medicine. This suggests that if there is doubt as to a candidate's fitness to dive it is safer for him to be classed as unfit and be referred to someone with underwater medicine training.

Let us start with the conditions which I regard as absolute contraindications to going diving. They can either kill or maim or incapacitate. Going unconscious underwater is a good way of starting the drowning process. As a person loses consciousness the jaw muscles relax and as a result the regulator falls out of the mouth of the unconscious diver. This is very inconvenient as the diver has not stopped breathing! A full facemask makes going unconscious underwater much safer as then the diver has air to breathe not water. So any condition that can cause unconsciousness is an absolute contraindication to diving.

TABLE 1

ABSOLUTE CONTRAINDICATIONS TO DIVING

CONDITIONS LIKELY TO CAUSE

UNCONSCIOUSNESS

EPILEPSY
SEVERE HEAD INJURY
INSULIN DEPENDANT DIABETES

PULMONARY BAROTRAUMA

PREVIOUS SPONTANEOUS PNEUMOTHORAX
LUNG CYSTS
OBSTRUCTIVE LUNG DISEASE
LUNGS THAT EMPTY UNEVENLY
ASTHMA
PREVIOUS THORACOTOMY

BREATHLESSNESS

ASTHMA
OBSTRUCTIVE LUNG DISEASE
POOR EFFORT TOLERANCE
ANGINA
CORONARY ARTERY DISEASE

EAR CONDITIONS LIKELY TO CAUSE DAMAGE

INABILITY TO CLEAR THE EARS
PERFORATED EAR DRUM
PREVIOUS MIDDLE EAR SURGERY WITH INSERTION OF A PROSTHESIS
PREVIOUS REPAIR OF AN INNER EAR FISTULA

I think that we can all agree that epilepsy is a condition likely to cause unconsciousness. I do not believe that anyone who is on medication for epilepsy, however well they are controlled at sea level and above, should go diving as we just do not know enough about the effects of the rise in ambient pressure on the drugs. Those who have stopped taking drugs and have not had a fit for some years are a different problem. I would advise against diving until they had been off drugs for 5 years and then have a perfectly normal electroencephalogram (EEG). If the EEG is not normal I would still advise against diving.

For those who have had contusional laceration of the brain or an immediate post head injury fit diving is absolutely contraindicated. If the patient has been unconscious for more than 24 hours he is in the same group as he will have suffered considerable brain damage. Intracranial surgery in the supratentorial region has an incidence of post-surgical epilepsy approaching 10%, and the onset may be delayed many years. I know of one diving death due to this cause. He went unconscious underwater and drowned years after his brain surgery having had his first fit only days before.

There is less agreement about the risks to the diabetic on insulin. There are many such diving around the world. I would not dive if I developed diabetes needing insulin and that is the advice that I give any insulin dependant diabetic who comes to me. The reason is that hypoglycaemia can lead to unconsciousness without warning, and even if the person does recognise his hypoglycaemia it is very difficult to inject oneself with glucagon through a wetsuit or have a drink of sugar solution underwater. If the person concerned was insistent I would want evidence that he undertook strenuous, prolonged exercise on land without hypoglycaemia before I changed my mind. If I did that I would emphasise the importance of not missing any meals before diving and the dangers of unconsciousness underwater. Hyperglycaemia is much safer than hypoglycaemia when underwater.

Pulmonary barotrauma kills. Depending on the position and size of the air embolus the diver may die immediately, go unconscious and drown, or have a period of unconsciousness and recover. While mediastinal emphysema can incapacitate it is a rare occurrence in divers, although it is common in experimental pulmonary barotrauma. Pneumothorax occurring under water usually becomes a tension pneumothorax as the diver rises to the surface. Divers have died from this, but again it is an uncommon presentation of lung rupture in divers.

Anyone who has had a spontaneous pneumothorax, one that occurred without warning, should not dive. He will be playing Russian roulette on every dive. Spontaneous pneumothorax is a condition that often recurs without warning.

Lung cysts are no problem on land but they are a danger underwater, or in caisson work, where the person is breathing at a higher than normal pressure. Many cysts have small communications with the airways which can allow gas in, and the high pressure gas can get in more easily than usual because of the increased pressure gradient. So going down is safe for these people but not coming up when the expanding gas in the cyst cannot get out fast enough. The cyst expands and at some stage reaches its elastic limits and the surrounding lung tears. As they cannot be detected on clinical examination I consider chest x-ray an essential part of the diving medical.

We can take obstructive lung disease and lungs that empty unevenly together. Obstructive lung disease means obstruction to the normal emptying of the lungs which can give rise to pockets of over-distended lung which might burst. Experience has shown that people with a forced expiratory volume in one second (FEV_1) to vital capacity (VC) ratio of less than 75% are over-represented among those who suffer air embolism. So one uses a simple respiratory function test to measure the FEV_1/VC. I believe that those with this ratio between 65 and 75% can probably dive safely as long as they ascend at a much slower rate than the usual 60 feet (18 metres) a minute. It is really quite surprising how slowly one has to ascend to keep down to 60 feet (18 metres) a minute. I recommend that they come up no faster than 20 feet (6 metres) a minute, which is the rate I use. This involves watching one's watch and depth gauge all the way up.

People who have had a previous thoracotomy would be expected to have adhesions tethering the lung to the chest wall. This could give rise to differential stretching of the lung with expansion which would be likely to cause pulmonary barotrauma. However there are plenty of people who have had open heart by-pass surgery who have gone back to diving and as far as I know they have survived. Until there is more evidence of the safety of diving after chest surgery I will continue to advise these people not to dive.

Asthma is a real bone of contention among diving doctors. Some, like Carl Edmonds and myself, believe that it is dangerous for asthmatics to dive, others do not. I have heard of four people with asthma who went unconscious underwater during their training. They only survived because of the vigilance and competence of their buddies. On the other hand I know an asthmatic, who has to take various drugs every day to remain wheeze free, who dives every weekend and has done so for the past 7 years. One of Australia's senior diving instructors is an asthmatic. I incline to the belief that the really dangerous time for an asthmatic is when he is learning to dive and that there is no place for those who need drugs to control their asthma in diving schools.

Asthma has two problems. Not only do asthmatics have airway narrowing problems, producing those wheezes that the bystander can sometimes hear, which were discussed earlier. Asthmatics certainly do figure in the pulmonary barotrauma stakes. But they also suffer from incapacitating breathlessness at intervals with periods in between when they are well. Unlike asthmatics the people with breathlessness from obstructive lung disease are breathless with any reasonable exertion. I think that this is what keeps those with easily recognised obstructive airway disease from wanting to learn to dive. They find exercise exhausting. So do people with poor effort tolerance, angina and coronary artery disease. Incidentally no one with angina has appeared in my consulting room wanting to learn to dive in the ten years I have been doing diving medicals.

It is to detect those whose effort tolerance is low, which usually means that either heart or lungs are not in good order, that a simple exercise test, like the British Army 5 minute step test, is included in a good diving medical. Some people just cannot exercise to that level. This group should not dive. Some are just unfit and need extra exercise to tone them up to a safe level of performance. They should not dive until they have improved their effort tolerance.

Another reason that those with angina and coronary artery disease should not dive is that diving is quite stressful even before one gets in the water. Pulse rates of over 140 are not uncommon even in the young at the end of putting on wetsuit and gear. Then over the side into cold water which induces peripheral vasoconstriction and a sudden and sometimes very large rise in blood pressure. A couple of good ways to bully the heart to death if it is unhealthy.

American statistics on diving deaths, collected by Dr Lynn Eldridge and presented in 1979 at an Undersea Medical Society Meeting, show a large peak in the younger age groups. This is not surprising as the majority of divers are in that group. She divided the figures into those in cold water, less than 20°C, and warm, over that temperature. The divers of Tasmania, Victoria and southern New South Wales, and I expect all New Zealand divers are all cold water divers.

Figure 1 shows the deaths that occurred in cold water, that is less than 20°C. The black blocks are those deaths which were due to obvious non-cardiac causes. The majority were due to human error. These deaths are not going to be influenced by whether the diver has a medical or not. The cross hatched ones were those where there was evidence of a cardiac death at post mortem. The striped ones were, from the history, likely to have been cardiac deaths. The white were where there was insufficient evidence to classify the death as any other group.

Of the 138 deaths in waters less than 20°C the majority of the deaths were due to human error (68). The next largest group was those where the death was due to cardiac causes as shown at post mortem (25), or with a history suggesting that it was a cardiac death (17). There were 28 deaths in which the evidence was insufficient to classify the death. Oddly enough many of the cardiac and probably cardiac deaths occurred at the end of an otherwise normal dive. As far as I know the explanation for these deaths is still uncertain.

In cold (less than 20°C) water, definite cardiac deaths occurred in people as young as 25-30 age group (3 deaths). Three of these deaths also occurred in the 30-35 and 35-40 age groups, four in the 40-45, three in the 45-50, four in the 50-55 and one in each of the 55-60, 60-65 and over 65 age groups. Only one of the 8 deaths over 50 was not due to confirmed cardiac causes.

Diving in warm, over 20°C, water was much less dangerous, or is it just that fewer Americans go to the Caribbean where the warm water is? There were 58 deaths of which 32 were due to human error. Six were shown at post mortem to be due to cardiac causes while another 6 were probably due to cardiac causes from the history and 14 deaths could not be classified.

In warm water there was one definite cardiac death in the 25-30 age group, one in the 35-40, one in the 45-50, two in the 50-55 and one in the 55-60 age group. There was a smaller proportion of cardiac deaths which among other things makes warm water diving attractive to me! Of the over 50s who died, three died from a confirmed cardiac cause, three died from a probable cardiac cause and two from human error.

Some of those who died from cardiac causes had symptoms which should have deterred them from diving but the majority were asymptomatic.

This raises the question of whether the over 40s should have stress ECGs performed at diving medicals. I do not think so, as the number of false positives and false negatives in symptomless subjects makes this expensive investigation useless as a screening test. Every positive should be followed up with coronary angiography to exclude the false positives. The USAF tried this for a while but gave it up in favour of a screening by history taking and simple investigations. They are only using exercise ECGs for those with four or more predictive factors such as family history, hyperlipaemia, smoking, overweight, etc.

FIGURE 1
DEATHS IN COLD WATER (LESS THAN 20°C)

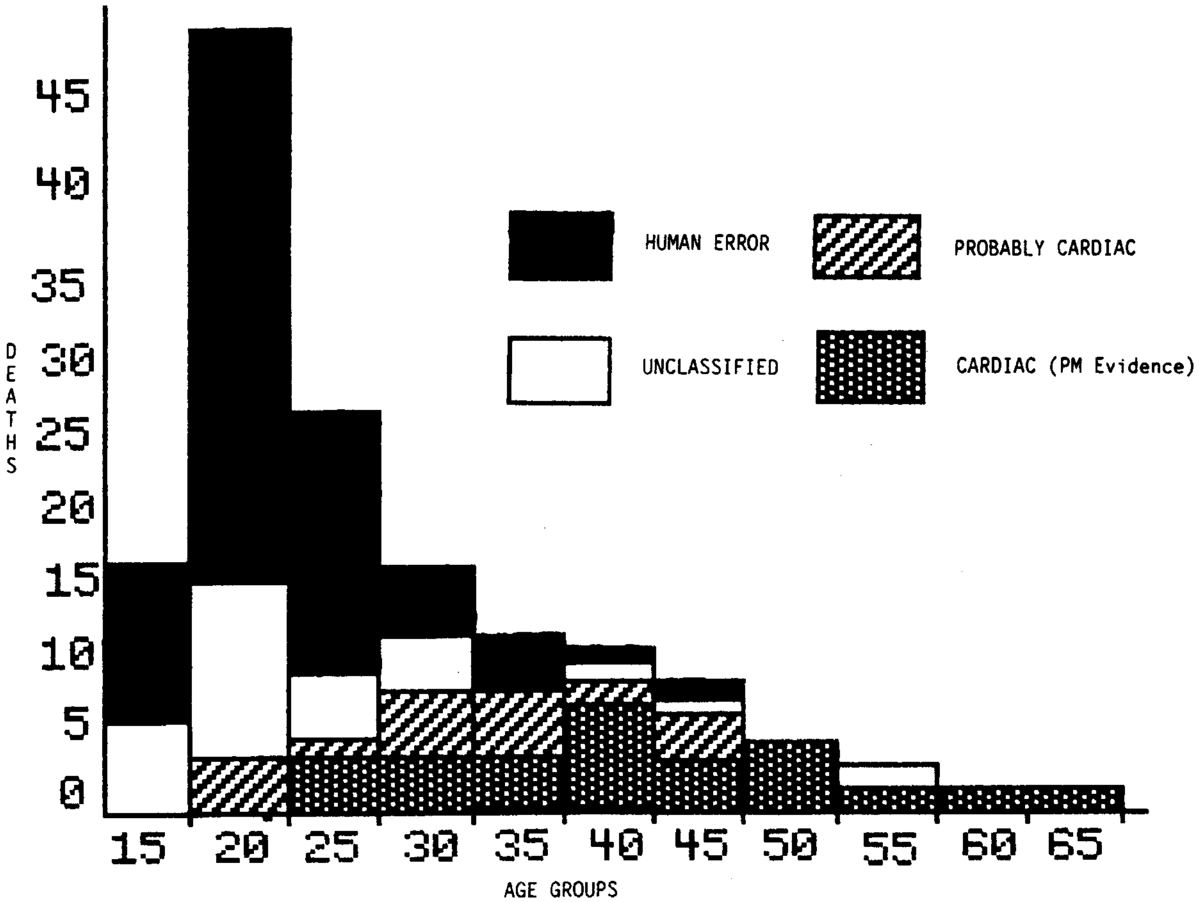
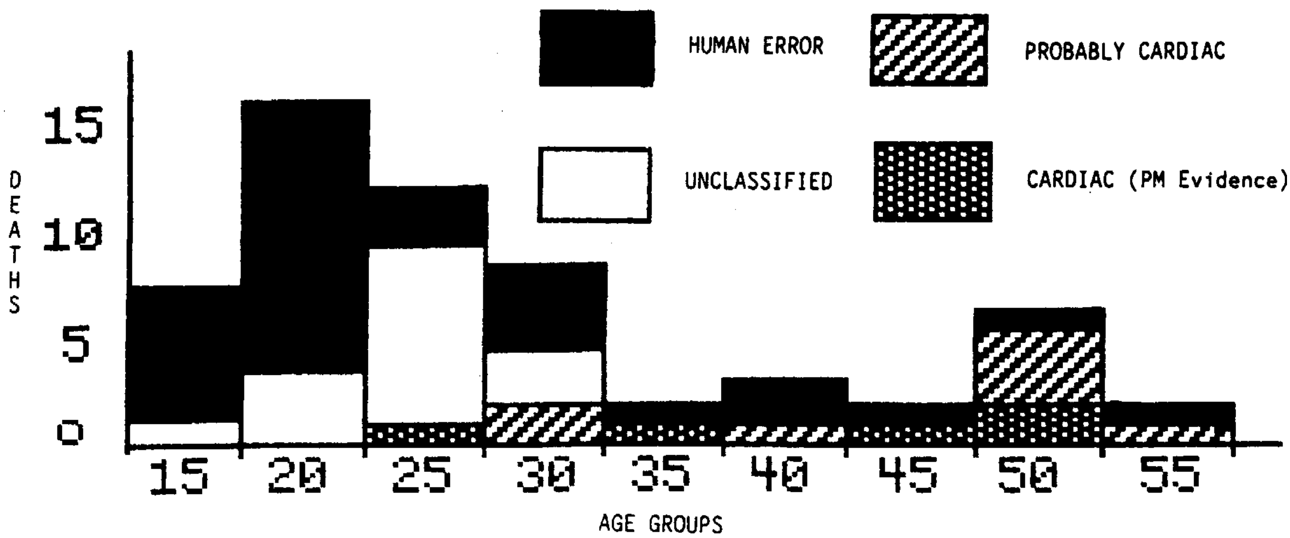


FIGURE 2
DEATHS IN WARM WATER (MORE THAN 20°C)



Redrawn from a poster presentation, by Dr Lynn Eldridge, at the Undersea Medical Society Scientific Meeting at Miami 1979

Divers damage their ears more than any other part of the body. If one cannot clear ones ears going diving is absolutely certain to lead to damage. So no diving for them.

People who have a hole in an ear drum will get water in the middle ear diving. This will be colder than the air in the middle ear on the other side, which leads to uneven caloric (hot or cold) stimulation to the two ears. The result is the rapid onset of vertigo and vomiting. In addition they are very likely to develop a middle ear infection after the dive. The perforation must be repaired and be shown to be mobile before the person can start diving.

One of the advances of surgery in the last thirty years or so is the ability of surgeons to restore hearing by various operations on the middle ear using the operating microscope. These operations are less successful the second time. Anyone who has had hearing restored by an operation, such as stapedectomy, would be an idiot to dive and risk that restoration.

Inner ear fistulae can leave one completely deaf in that ear. If the fistula has been repaired the patient should not dive as he has demonstrated that the inner ear window membrane is weak. It could go again and any hearing that had been saved would go too. Even more worrying is the thought that the other side might leak and lose the hearing in that ear. Bilateral complete deafness is a very large handicap. I would sell my gear if I developed an inner ear fistula. However I know one man who lives for diving and considers the risk of recurrence acceptable. But he is now fanatical about clearing his ears every two feet on the way down and whenever he changes depth.

TABLE 2

RELATIVE CONTRAINDICATIONS TO DIVING

FEV1/FVC RATIO LESS THAN 75%
POOR PHYSICAL CONDITION
PREVIOUS MYOCARDIAL INFARCTION
HEAD INJURY
HYPERTENSION
PREGNANCY

Relative contraindications are things that make diving dangerous either to the diver or her passenger. I have mentioned the people with low FEV_1/VC ratios who can usually dive safely by using a slow ascent rate.

Poor physical condition can be improved by exercise, diet and anything else that is necessary. Until they are able to swim at least 200 metres and undertake 5 minutes moderate exercise, for their own safety, they should not dive.

Those who have had a myocardial infarct, or by-pass surgery, should not dive until they have shown, to their cardiologist's satisfaction, that they have a normal effort tolerance. This will involve exercise testing on a treadmill under electrocardiographic control. Once they have a normal effort tolerance their cardiac condition is no longer a bar to diving. I know two people who have gone back to diving after bypass surgery and two years later have not burst a lung. Perhaps thoracotomy is not as dangerous as we think.

Hypertension is a common problem. The first decision is whether to treat or not. Those who are treated are being given drugs that interfere with the normal action of the heart (beta blockers), reduce the blood volume (diuretics) and interfere with vasomotor control (antihypertensives). Usually as long as the dose required to achieve good control of the blood pressure is small the effects on effort tolerance will be acceptable. Those taking larger doses usually have poor effort tolerance, and may even develop orthostatic hypotension. Each person is a different problem.

Head injuries are pretty common in Australia. I am grateful to David Brownbill, Senior Neurosurgeon at the Royal Melbourne Hospital, for publishing a paper on "Neurological considerations in diving"[2] in the SPUMS Journal as he gave clear guidance about head injuries and diving.

Personality changes sometimes follow head injury and can lead to carelessness and lack of logical thought. Such people are better discouraged from diving.

As mentioned earlier severe damage to the brain and immediate fits are absolute contraindications as is unconsciousness for more than 24 hours.

A two year no diving period is indicated for unconsciousness for more than two hours, for post-traumatic amnesia for more than 48 hours, and for the post-concussive syndrome of sleep disturbance, personality disturbance, headaches or memory disturbance, headaches or memory disturbance for more than a month.

Three months off diving seems appropriate for those who are unconscious for between 15 minutes and two hours.

Four weeks disqualification from diving would be appropriate for mild head injuries with unconsciousness of less than 15 minutes. These are relatively common in Australian Rules footballers.

These days pregnancy is undertaken with the objective of a healthy baby. Whether diving in early pregnancy causes foetal abnormalities is still sub judice. In the meantime I believe that sensible women should give up diving just as they should give up cigarettes and alcohol for the duration of the pregnancy.

TABLE 3

THE DIVING MEDICAL HISTORY
ASTHMA, BREATHLESSNESS, CHEST PAIN, DIABETES, EXERCISE, FITS, HEAD INJURY, OPERATIONS, MEDICINES, PNEUMOTHORAX.

PHYSICAL EXAMINATION
BLOOD PRESSURE, CHEST, CRANIAL NERVES, EARS, EXERCISE, REFLEXES

SPECIAL TESTS
AUDIOGRAM, CHEST X-RAY, RESPIRATORY FUNCTION

I believe that a good diving medical examination must include a history with particular attention to asthma, breathlessness, chest pain, pneumothorax, diabetes, fits, head injury, operations and exercise taken. If the person never takes strenuous exercise he or she may never get symptoms. It must include the drugs being taken.

The physical examination should include checking the state of the ears and the patency of the Eustachian tubes, listening to the chest especially with the patient hyperventilating which often brings out otherwise hidden wheezes, blood pressure, reflexes, cranial nerves, and an exercise test.

The justification for chest x-rays is to detect cysts and other asymptomatic pathology which would make diving dangerous. The respiratory function tests are to detect those with a VC/FEV1% of less than 75% who are over-represented in the burst lung statistics. The audiogram is to establish a baseline in case the diver damages his or her ears at a later date and is deaf. New deafness after diving is significant.

The medical should include advice on how to clear the ears and emphasis on the need to do it every half metre (two feet for the pre-metric generation) all the way down and every time one descends that much. This is because the raised oxygen partial pressure in the gas in the middle ear increases the concentration gradient forcing oxygen into the tissues lining the middle ear and so the middle ear volume decreases faster than at the surface, leading to swelling of the middle ear lining and problems with the next dive or even on that one on the way back to the surface. Of course any other advice that the doctor thinks is necessary to enable the person to dive safely should be offered.

I believe that a diving medical is good value before learning to dive. Having done many routine medicals in the RN and the RAN, and never found more than a rise in blood pressure that had changed since the last medical, I am less convinced of the need for regular medicals, However I think that a diving medical could be good value after any illness that puts the diver to bed for more than a couple of days and if the diver develops symptoms, such as chest pain for shortness of breath on exertion, or a systemic disease such as diabetes (non-insulin dependant) or hypertension. In these cases the diver can be advised on the dangers of continuing diving or how to dive safely in the future.

OD Hickey has published a review article in Undersea Biomedical Research entitled "Outline of medical standards for divers"3 which goes into more detail than I have. It is however based on standards for commercial divers not for sports divers. It is well worth reading.

I would remind you of my opening remarks that the doctor advises the would-be sports diver of the risks and leaves it to him to decide what course he is going to follow. A brusque intimation of having failed the medical may take the budding diver back to the dive shop. There he will be told where to find a more accommodating, if less knowledgeable doctor. It is our responsibility to explain things to him so well that he stops wanting to dive.

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DIVING ACCIDENTS 1985: AN AUSTRALIAN VIEW

John Knight

By the end of October 1985 Project Stickybeak, which is run by Dr Douglas Walker, PO Box 120, Narrabeen NSW 2101, had heard of 10 diving associated deaths in Australia. Project Stickybeak is an unfunded, non-government, confidential enquiry collecting accident statistics and publishing an annual report on the deaths for Australia. The latest report appeared in the SPUMS Journal for July to September 1985.[1] Owing to great co-operation from the various coroners, police forces, justice departments and Attorneys General around Australia, the figures are reasonably complete. However, some of the details take a long time to reach Dr Walker because of legal proceedings and delayed inquests and sometimes because no one recorded what would be, to a diver, a significant fact. I must stress that the figures are provisional.

PROVISIONAL DIVING RELATED DEATHS IN AUSTRALIA

JANUARY TO OCTOBER 1985

SCUBA - 7 DEATHS

Male 21	1st dive after qualification. 35 m Low on air 20 m Out of air. Buddy breathing. Both ran out of air. Both dropped weight belts. Buddy's vest inflated, victim's did not.
Male 46	Dive to 80 feet. Problem at 10 feet. Called for help at surface. No cause of death available.
Female 24	1st dive after qualification 35 m. Out of air on ascent. Could not drop weight belt as shifted weight had jammed buckle. Vest problem. Strong currents.
Male	28 40 m dive using twin tanks. Separated from buddy who raised the alarm. Found with empty tanks.
Male	Sucked into pondage outlet.
Male	20 Scallop dive to 20 m. Out of air.

SNORKEL DIVERS - 4 DEATHS

1	Taken by shark when collecting abalone in shallow water.
1	Spearfishing. Cause of death uncertain.
1	Epileptic.
1	Washed out to sea.

Dr Walker includes in his diving related deaths the deaths of snorkellers. Since 1 January 1985 four snorkellers have died.

The most dramatic was the death of a woman who was taking abalone with her husband in two to three metres of water. A large shark took a bite and she was dead before she could be brought to the beach some 300 metres away. Some blamed the chumming, dumping blood and meat from boats to attract sharks, which had been carried on for most of the previous week in the next bay. This was because the weather had been rough and the organisers of a shark fishing competition had changed the venue to the large protected bay nearby and had done their best to attract sharks.

One snorkeller was carried out to sea. Poor judgement of sea conditions would have contributed to his death.

One epileptic snorkeller died as did a spearfisherman. The details of these two cases are not yet complete but it would seem reasonable to attribute the epileptic's death to a fit and the other death to hyperventilation followed by anoxia underwater.

There have been six deaths using breathing apparatus. All were using scuba.

Lack of experience obviously contributed to the deaths of the two who were on their first dives after completing their course of training. One must question whether a dive to 35 metres (116 feet) is the right one for a newly trained diver's first dive, especially if there are strong currents. The young woman's family is so convinced that this sort of dive is wrong that they have instituted court proceedings so details of this accident have been frozen until the case is complete.

The cause of death of the man who called for help on the surface, after having an unspecified problem at 10 feet, is still unknown to Project Stickybeak.

I know a bit about the after death occurrences in the case of the man, using twin tanks, who died on a 40 metre dive on a scuttled World War 1 submarine. His buddy lost him underwater and, quite properly, surfaced. The diving club was run by a dive shop which always provided an instructor as a dive leader. He kitted up and went down and searched. He found the body, dragged it back to the anchor line and then ran out of air. Also at the submarine was a boat owned by a friend of mine. He was asked to recover the body as he had not dived yet. This he did, and his wife gave the corpse mouth to mouth resuscitation without result. They sent their 12 year old daughter to the bows with instructions not to watch, but of course she did. She had nightmares for some time and her father had not dived for three months when I last saw him. One assumes that nitrogen narcosis had a lot to do with this death.

The last death was on a scallop dive. The diver was not very experienced and apparently got entangled in the line for hoisting the scallops.

Four deaths were due to running out of air, three due to inadequate monitoring of the contents gauge, and the fourth due to entanglement. One was due to dangerous diving practices, investigating the outlet of a pondage. And the sixth is unexplained.

What can we learn from this sad catalogue of deaths?

I think that the first lesson is that beginners must be comfortable in the water or they will make mistakes.

The second is that beginners must be carefully and slowly introduced to deep diving. And I call deep diving any dive over 12 metres (40 feet). I know that the conventional wisdom is to call dives over 30 metres (100 feet) deep. But how many of us have behaved oddly at shallower depths? I know I have. At 18 metres (60 feet) in Truk lagoon I wanted to be in the film my buddy was taking of corals growing on the arm of a derrick, so I undid the buddy line and swam round to the other side of the derrick arm. By the time I got there she had finished taking the shot and was having kittens looking at the empty arm band of the buddy line. Those of you who know me know that it was quite out of character for me to do something so likely to provoke panic. I can only attribute it to nitrogen narcosis. Since then I have been very careful not to act on impulse underwater.

The third is that deep diving is much more dangerous than shallow diving.

The fourth is that one should not dive in strong currents unless one knows how to handle the situation. I am a coward and in strong currents I do not wander far from the anchor line and when I do it is up current and on the bottom hanging on to the rocks or plants.

The fifth lesson is that entanglement can be fatal and that one should always keep all lines taught and clear of oneself.

We have dealt with the visible part of the iceberg of diving accidents. Now to the less publicised part, the accidents that people survive and still need treatment in a recompression chamber for decompression sickness (DCS) or cerebral arterial gas embolism (CAGE).

<u>RAN SCHOOL OF UNDERWATER MEDICINE</u>
<u>CASES TREATED JULY 1984 to JULY 1985</u>

DECOMPRESSION SICKNESS

Servicemen -	5	
Divers	1	Musculo-skeletal.
	1	Cerebral.
		Both recompression chamber dives.
Aviators	3	Musculo-skeletal
Civilians -	33	All Divers.
	12	Cerebral
	9	Spinal
		Three with residual problems.
	8	Neurological.
	3	Musculo-skeletal.
	1	Vestibular. Still has problems.

CEREBRAL ARTERIAL GAS EMBOLISM

Diver	1	Civilian

TOTAL TREATED - 39

I was not, able to gather statistics from all Australian recompression facilities before leaving for New Zealand. However, I have got the majority of the cases that have been treated in recompression chambers. The Royal Australian Navy School of Underwater Medicine at HMAS PENGUIN in Sydney treated 39 people between July 1984 and July 1985, which is a bit down on the year before but still up on five years ago, but down on 13 years ago when the figure was close to 100 a year. In those days the majority were musculo-skeletal with spinal neurological cases as the next largest group with CAGE well represented. Now the breakdown is quite different. Cerebral DCS is the largest group in the Sydney series. However I have not been able to get hold of the figures from the Prince Henry Hospital, Little Bay, Sydney, who do treat a lot of sports divers so I am presenting a distorted (but uncertainly distorted) picture of the Sydney scene.

Spinal DCS still leaves a third of its victims with symptoms inspite of treatment. The sole person to suffer a vestibular bend, which is uncommon with air diving, was left with symptoms.

Only one case of CAGE presented at HMAS PENGUIN.

NSCA MORWELL CHAMBER

CASES TREATED JULY 1984 to JULY 1985

DECOMPRESSION SICKNESS

Servicemen - 3
Aviators 1 Cerebral.
2 Cerebral and Musculo-skeletal. Altitude chamber cases.

Abalone Divers -6
4 Musculo-skeletal.
1 Test of Pressure for chest pain. Not DCS.
1 Symptom free buddy of DCS patient.

Sports Divers -12
7 Musculo-skeletal.
3 Cerebral.
1 Cerebral and Musculo-skeletal. Relapsed and retreated.
1 Spinal.

CEREBRAL ARTERIAL GAS EMBOLISM

Sports Diver - 1

TOTAL TREATED - 22

New South Wales has a population of over 5 million. Victoria has about 4 million inhabitants. New South Wales has wrecks in deeper water than Victoria so it is not surprising that the National Safety Council of Australia, Victorian Division, has treated fewer patients in the same time at its recompression facility at Morwell. Again only one case of CAGE.

Altitude chambers provided three subjects. Abalone divers required 6 treatments, one of which was symptom free, but had done the same dives as a man with symptoms. It is interesting to note that the abalone divers who dive long hours were all suffering from musculo-skeletal DCS. Test of pressure is a worthwhile manoeuvre to decided whether a person is suffering from DCS or not.

In contrast to the Sydney sports divers the Victorians provided more musculo-skeletal DCS than cerebral. Perhaps this is due to the fact that pain gets through to the altered consciousness of the bent diver, while it is his or her friends who notice the cerebral changes. One woman was sent to Morwell because her GP noticed that she was not herself when she consulted him after a weekend's diving. She was normally cheerful, chatty and extroverted , but that morning she was quiet. In the chamber her personality changed completely and she became herself again. Her case has been reported in the SPUMS Journal.[2]

PRINCE HENRY'S HOSPITAL, MELBOURNE

CASES TREATED JULY 1984 to JULY 1985

DECOMPRESSION SICKNESS

Abalone Divers -2
1 Shoulder pain. This man had osteoarthritis in that shoulder from dysbaric osteonecrosis.
1 Sensorineural deafness. He had had multiple cerebral "hits" in the past and is a Punch Drunk Diver.
Neither had any knowledge of decompression tables.

Sports Divers - 4
3 CNS.
1 CNS and Musculo-skeletal.

The final figures that I have are from the single man Vickers chamber at Prince Henry's Hospital in Melbourne. They have had a high proportion of cerebral DCS in sports divers, in fact a 100% incidence. Two of these were fit young men in their twenties who had just done the final weekend of their diving course. It was a long weekend so they did more sea dives than usual, 9 in 3 days. Both of them did a 24 metre dive as their last dive and they worked hard both before and during the dive. Again, inexperience was at work as the instructor considered it a quiet dive, but they both said that they had found the last dive hard work. Both had vague feelings of not being themselves, with skin rash in one, and returned rapidly to normal in the chamber. Both relapsed within 24 hours and needed further treatment.

Once again the complete lack of diving training in abalone divers is shown up. They invest $250,000 and up in their licence and boat and have to earn a lot to pay off their borrowings. They can earn $1,000 a day and most dive about 100 days a year, but financial pressure can get them into the water when the weather says "No Diving".

What can we do to avoid these problems?

I believe that the safest way to learn to dive is to be allowed to take your time to become comfortable underwater. And then slowly taken, under supervision, into deeper and deeper water. Certainly I think that the neophyte diver should work down to 35 metres over a minimum of 6 to 10 dives so that he or she knows exactly how to control their buoyancy and how to cope with a simple dive.

We must make sure that the instructors teach the wisdom of staying out of the water when the conditions are less than ideal until you are certain that you can manage those conditions. Even after 15 years diving I have no hesitation in refusing to enter the water if I feel that I am not going to enjoy the dive.

We must make it quite clear to the diving world that the decompression tables are not 100% safe. The USN tables give between 6% and 8% bends when the no decompression tables are dived to their limits in a chamber. This is not surprising as the acceptance trials gave a 4.75% bends rate. The Bassett tables[3] with built in fudge factors must be safer!

In the meantime, I suggest that we keep on reminding ourselves and other divers of how to avoid decompression sickness. The simple rules are to always do no decompression dives, to stay well within the tables, know your maximum depth, watch your time, ascend at no faster than 18 metres (60 feet) a minute and preferably slower and always do a stop at 5 metres.

If one must do a decompression dive, always decompress on a shot rope with a spare cylinder and regulator at the first and second stop depths, always decompress for the next greater depth and the next greater time and do not fly or cross mountains for at least 12 hours. This applies to no decompression dives also. I will be missing Sunday morning's dive as I have to fly to Australia on Sunday afternoon.

I am sure that better teaching of safe diving practices and publicity for the correct procedures following an accident will reduce the incidence of divers needing chamber treatment.

In 1980 at the SPUMS meeting in Singapore and Pulau Tioman, Mike Davis introduced the idea of giving divers oxygen using their own regulator. I have been pushing this hard ever since. At last a commercial adaptor which allows a diving regulator to be attached to an oxygen cylinder has reached the market. It is the Bendeez,[4] which retails for about $65 in Australia. It screws into a D size or larger oxygen cylinder. So your regulator can be attached to an oxygen supply. If you have an octopus you have two oxygen regulators and a contents gauge on the oxygen cylinder.

There has been a fire in a home made adaptors. Naturally the fire spread to the regulator and destroyed it. Oxygen supports combustion very well indeed. The regulator that was destroyed had been used with a Bendeez the day before without any bother. The home made adaptor was the pillar valve and tap taken from an air cylinder and mated with a bullnose to fit an oxygen cylinder. The tap was turned off when the cylinder was turned on and when it was opened the fireworks started. The likely cause of the fire was the valve seat of the tap which overheated with the sudden compression of the very small volume in that part of the adaptor when the cylinder was turned on. I believe that the risk of fire is so low using a Bendeez that there is no need to complicate one's diving by taking along a regulator dedicated to oxygen only.

A final item of safety equipment which is difficult to get hold of is a waterproof and pressure proof flare which emits orange smoke from one end or a light from the other.[4] The flares should be available through dive shops, or yacht outfitters. If your dive shop does not stock them, the distributors are Pains-Wessex (Australia) Pty. Ltd., whose Melbourne office as at 814 Glenferrie Road, Hawthorn VIC 3122, telephone (03) 818 0786. The flares are not cheap, costing around $40 each, but being rescued when lost at sea is beyond price. The flares depend on O rings for water tightness. So occasional maintenance is required. The flare is small enough to fit in your BC pocket along with your waterproof copy of the Bassett tables.[6]

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SPUMS NOTICES

OBJECTS OF THE SOCIETY

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

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

The subscription for Full Members is $30,00 and for Associate Members is $20.00.

Membership entitles attendance at the Annual Scientific Conferences and receipt of the Journal.

Anyone interested in joining SPUMS should write to the Secretary of SPUMS,

Dr David Davies
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DIPLOMA OF DIVING AND HYPERBARIC MEDICINE

The requirements for the Diploma of Diving and Hyperbaric Medicine are

1. To have completed both the introductory course and the advanced course in Underwater Medicine at the Royal Australian Navy School of Underwater Medicine.

2. To have completed the course in Hyperbaric Medicine at the Prince Henry Hospital, Little Bay, Sydney, New South Wales.

3. To have completed six months full time, or equivalent part time, employment in diving or hyperbaric medicine.

4. To present a satisfactory thesis (suitable for publication, usually in the SPUMS Journal) for consideration.

The decision to award the Diploma lies with the Diploma Committee which is comprised of the President of SPUMS, the Officer in Charge of the Royal Australian Navy School of Underwater Medicine and the Director of the Hyperbaric Unit at Prince Henry Hospital.

Applications should be directed to the Secretary of SPUMS,

Dr David Davies
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INSTRUCTIONS TO AUTHORS

Contributions should be typed in double spacing, with wide margins, on one side of the paper. Figures, graphs and photographs should be on separate sheets of paper, clearly marked with the appropriate figure numbers and captions. Figures and graphs should be in a form suitable for direct photographic reproduction. Photographs should be glossy black and white prints at least 150 mm by 200 mm. The author's name and address should accompany any contribution even if it is not for publication.

The preferred format for contributions is the Vancouver style (Br Med J 1982; 284:1766-70 [12th June]). In this Uniform Requirements for Manuscripts Submitted to Biomedical Journals references appear in the text as superscript numbers.[1,2] The references are numbered in order of quoting. The format of references at the end of the paper is that used by The Lancet, The British Medical Journal and The Medical Journal of Australia. Page numbers should be inclusive. Examples of the format for journals and books are given below.

1. Anderson T, RAN medical officers' training. SPUMS J 1985; 15(2): 19-22.

2. Lippmann J, Bugg S. The diving emergency handbook. Melbourne: JL. Publications, 1985.

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, eg. decompression sickness (DCS) can thereafter be referred to as DCS.

Measurements should be in SI units. Non-SI measurements can follow in brackets if desired.

REPRINTING OF ARTICLES

Permission to reprint original articles will be granted by the Editor, whose address appears on page 2, provided that an acknowledgment giving the original date of publication in the SPUMS Journal is printed with the article.

Papers that have been reprinted from another journal, which have been printed with an acknowledgment, require permission from the Editor of the original publication before they can be reprinted. This being the condition for publication in the SPUMS Journal.

AIRMAIL DELIVERY

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Zone 1	eg. Papua New Guinea and the South Pacific	$6.50
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For further information write to

SPUMS
80 Wellington Parade
East Melbourne VIC 3002
Australia

MINUTES FROM EXECUTIVE COMMITTEE MEETING

Held on 10th August 1985, 1500-1730 hours at Reading Room, Navy and Military Club, Melbourne.

Attendance:

Chris Lourey (President)
Chris Acott (Secretary)
John Doncaster (Treasurer)
John Williamson
David Davies
John Knight (Ass. Editor)
Douglas Walker (Editor)
Peter McCartney

Apologies

None

Business arising from minutes

Minutes from last meeting (Maldives, April 1985) were accepted.

Moved P McCartney
Seconded J Doncaster

(i) NEW ZEALAND SUB BRANCH
It appears to be functioning well.
(ii) LEGAL ADVISOR
Mr Michael Gorton has agreed to be SPUMS honorary legal advisor.
(iii) 1986 ANNUAL CONFERENCE
Venue: Moorea, French Polynesia
Guest Speakers: Dr A Pilmanis
Dr D Gorman
(iv) TREASURER'S REPORT
This was circulated by Dr J Doncaster.
Accepted. Moved CJ Acott
Seconded J Knight

Other business

Journal:

(i) The Editor (Dr D Walker) complained that there was not enough input by the SPUMS membership into the Journal.

(ii) John Williamson: Asked about the future of the Journal. He suggested that the Journal should start publishing photographs and start regular publication of notices to subscribers on how to write articles for the Journal. Perhaps feature issues could be considered in the future.

Index Medicus:

The secretary will write to Index Medicus to see if the Journal can appear in it.

Journal subscription:

The cost for a library to obtain the Journal would be the same as the cost of full membership (at present $A30).

President's Report

(i) UMS conference. There will be greater co-operation between UMS and SPUMS.

(ii) Diving Medical Training. The president proposed that a Diving Medicine Course should be started by SPUMS in co-operation with the RAN and the National Safety Council. The course would be open to any civilian wishing to do it.

The secretary will write to:

1. RAN
2. National Safety Council
3. Australian College of Occupational Medicine

(iii) Bi-centenary 1988: perhaps the meeting could be held in Northern Queensland in September 1988. Dr J Williamson will make enquiries into this.

Morwell Computer and Project Stickybeak:

Information on Diving Accidents will be stored on the Morwell computer, however, the exact format is not yet decided.

Marine Envenomation:

There will be a toll free phone number for the Townsville General Hospital for future victims of marine envenomation.

Meeting closed

17.30 hours.

Next meeting

February 1986.

The toll free number mentioned in the minutes is now in operation for medical advice about marine envenomation, either urgent or routine, and for reporting sightings of venomous sea creatures. The number to ring is 008-015-160.

LETTERS TO THE EDITOR

6 Wallace Grove
BRIGHTON VIC 3186

14th February 1986

The Editor,

AUSTRALIAN ANIMAL TOXINS: THE CREATURES, THEIR TOXINS AND CARE OF THE POISONED PATIENT

I have a number of copies of this available at $45, which includes certified postage anywhere in Australia. The only other primary source is Oxford University Press which is maintaining an ARP of $75.

A revised edition is not planned until about 1990 because only minor additions or alterations are currently warranted.

Copies will be suitable inscribed if requested.

Yours sincerely
Struan Sutherland

DOCTORS WITH TRAINING IN UNDERWATER MEDICINE

We publish below a list of current members of SPUMS, resident in Australia, who have completed at least the Royal Australian Navy School of Underwater Medicine introductory course, or who have notified the Secretary, as requested in the SPUMS Journal (1985, Vol. 15, No. 2, p3) that they have had equivalent training.

The list has been compiled with the cooperation of the School of Underwater Medicine (SUM) and includes all members that can be identified from the SUM records, as well as those who wrote in. As a result it may include doctors who no longer do diving medicals.

The addresses given are those to which the Journal is sent and so may not be their professional rooms.

Those who have had equivalent training and whose names are not in this list are asked to write to the Secretary of SPUMS giving details of their training.

New South Wales

Dr JM Anderson
HMAS Penguin, Balmoral Naval PO NSW 2091

Dr T Anderson
School of Underwater Medicine
HMAS Penguin, Balmoral Naval PO NSW 2091

Dr C Edmonds
25 Battle Boulevard, Seaforth NSW 2092

Dr C Finlay-Jones
165 Morgan Street, Merewether NSW 2291

Dr D Gorman
School of Underwater Medicine
HMAS Penguin, Balmoral Naval PO NSW 2091

Dr R Gray
21Coombar Close, Coffs Harbour NSW 2450

Dr R Green
47 Shorter Avenue, Beverley Hills NSW 2209

Dr JT Horgan
232 Mona Vale Road, St Ives NSW 2075

Dr P Kolisch
33 Mann Street, Nambucca Heads NSW 2248

Dr R Lloyd-Williams
102 Yanko Road, West Pymble NSW 2073

Dr C Lowrey
233 Raglan Street, Mosman NSW 2088

Lcdr CJ McDonald
6/31-39 Elamang Avenue, Kirribilli NSW 2061

Dr W Pettigrew
C/- Lidcombe Hospital, Lidcombe NSW 2141

Dr F Summers
56 Hickson Street, Merewether NSW 2291

Dr I Unsworth
C/- Prince Henry Hospital
PO Box 333, Matraville NSW 2036

Dr A Vane
Police Medical Officer
NSW Police Headquarters
GPO Box 45, Sydney NSW 2001

Dr DG Walker
1423 Pittwater Road, Narrabeen NSW 2101

Dr DB Wallace
1/26 Aubin Street, Neutral Bay NSW 2089

Dr KJ Wishaw
5 Clearly Avenue, Cheltenham NSW 2119

Queensland

Dr Chris Acott
39 Oswald Street, Rockhampton QLD 4700

Dr JW Cairns
65 Potts Street, Belgian Gardens QLD 4810

Dr I Gibbs
PO Box 131, Mackay QLD 4740

Dr J Orton
Townsville General Hospital, Townsville QLD 4810

Dr D Pashen
3 White Street, Ingham QLD 4850

Dr D Richards
5/25 Ascog Terrace, Toowong QLD 4066

Dr P Sullivan
33 Rutledge Street, Coolangatta QLD 4225

Dr RL Thomas
39 Kersley Road, Kenmore QLD 4069

Dr M Unwin
8 Fulham Road, Pimlico QLD 4810

Dr J Williamson
137 Wills Street, Townsville QLD 4810

South Australia

Dr G Rawson
4 Brierbank Terrace, Stonyfell SA 5066

Dr A.W Swain
46 The Parade, Norwood SA 5067

Tasmania

Dr D Griffiths
9 Topham Street, Rosebay TAS 7015

Dr P McCartney
PO Box 1317N, Hobart TAS 7001

Victoria

Dr G Broomhall
472 Belmore Road, North Box Hill VIC 3129

Dr J Knight
80 Wellington Parade, East Melbourne VIC 3002

Dr C Lourey
25 Hastings Road, Frankston VIC 3199

Dr JE Mannerheim
22 Frank Street, Box Hill VIC 3128

Dr I Millar
National Safety Council of Australia, (Vic Division)
1 Chickerell Street, Morwell VIC 3840

Dr R Moffitt
1170 Main Road, Eltham VIC 3095

Dr J Silver
57 Electra Street, Williamstown VIC 3016

Dr G Zimmerman
3/5 Chaddesley Avenue, East St Kilda VIC 3183

Western Australia

Major P Alexander
RAP Special Air Services Regiment
Campbell Barracks, Swanbourne WA 6010

Dr DE Davies
Suite 6, Killowen House
St Annes Hospital, Mount Lawley WA 6050

Dr G Deleuil
135 Dunedin Street, Mount Hawthorn WA 6016

Dr H Oxer
331 Riverton Drive, Shelley WA 6155

Dr A Robertson
Sick Quarters
HMAS Stirling
PO Box 228, Garden Island WA 6168

Dr R Wong
34 Loftus Street, Nedlands WA 6009

Errors in this list should be notified to the Secretary of SPUMS

Dr David Davies
Suite 6, Killowen House
St Anne's Hospital
Ellesmere Road,
Mt Lawley WA 6050

ARTICLES OF INTEREST FROM OTHER JOURNALS

The following papers appeared in the CMAS BULLETIN of July 1984, No. 141, with this apology.

Des retards dans la traduction anglaise des textes sélectionnés font que seule la version francaise originale peut être publiée. La CMAS présénte ses excuses à tous ses lecteurs pour ce retard independant de sa volonté.

Some lates in the English translation of the selected texts make that only french (original) version is to day available. CMAS do apologise about this fact and hopes that its readers will understand ... and forgive.

The papers have been translated in Australia and we beg the authors' forgiveness if their meaning has been changed in translation
.

ENT EXAMINATION OF DIVERS

Dr Delonca

ENT accidents account for 80% of "the pathology" of sport diving. I will discuss some aspects of the work of a diving doctor in the ENT field.

The ENT examination of a diver should be based on:

1. The history which indicates which areas should be further investigated.

2. The initial clinical examination which investigates these areas.

3. The complimentary examinations which will eventually be requested by the ENT specialist.

HISTORY

Diving doctors will find themselves presented with two classes of patients, those who have never dived and those who have already dived.

(a) Patients who have never dived

Enquire about pre-existing chronic or acute ENT problems such as otitis, rhinopharyngitis, sinusitis and tubular catarrh. The doctor should ascertain, for instance, if the patient can equalise his/her ears at altitude, or in a plane, if he has had any operations on the ear drum, nose, sinuses or throat and if he has ever had any hearing problems. It is equally important to discover symptoms of spasmology, seasonal or acute allergies.

(b) Subjects who have already dived

Ask, "Have you had any problems while diving?" Questions should cover barotrauma of the ears and sinuses and the immediately preceding symptoms; vertigo, ascertaining precisely whether this was during descent or ascent; ease of descent; incidents when purulent exudate or blood in the mask was noted on ascent; deafness; and finally toothache.

All this is primary data and gives direction to the clinical examinations.

INITIAL CLINICAL EXAMINATION

A diving doctor should have at least the following instruments.

A head mirror, or an otoscope with three ear speculums (diameters of 2, 3 and 5 mm).
A Siegel's speculum.
A nasal speculum.
A tongue depressor.
A 128 tuning fork.
And if possible a pair of magnifying glasses (of Bartels or Frenzel type).

(a) Investigation of the ear and Eustachian tube

One must see the ear drum, so a wax plug must be removed. If the tympanum is not visible (stenosed canal, or large exostoses) refer patient to an ENT specialist.

Initially: Look for external otitis and then for a perforation of the eardrum which may be dry or running (chronic otitis) which are contraindications to diving.

Next examine: The mobility of the tympanum with a Siegel's speculum, Eustachian tube function by watching the movements of the eardrum during equalisation, the patient using his usual method. If the movement is not observed, one can advise diving carefully to 5 metres, because some people clear their ears better underwater than in a test, or direct the patient to an ENT surgeon for a tympanogram.

One must then check: Cochlear function; a time piece and whisper are employed, first for one ear then the other. All candidates who cannot hear the whisper at a minimum of one metre must be tested with a tuning fork (Weber and Rinne methods). If loss of hearing is suspected refer to an ENT specialist for audiometry (it is desirable that all potential divers have a baseline audiogram).

Vestibular function can be tested using the established methods, eg. Romberg, blind walk and deviation of the forefingers. Spontaneous nystagmus can be looked for with the magnifying glasses.

One must test, particularly with instructor candidates, the reaction of the labyrinth to cold water on the intact eardrum. The simple cold water test is to irrigate, using 20 cc of 15°C water, the right ear then the left. Asymmetrical nystagmic reaction (with a tolerance less than 30% between each ear) is normal. It is better to use the calibrated bilateral labyrinthic test.1

No nystagmic reaction appears during bilateral irrigation in normal subjects. If anomalies are found, refer the subject to an ENT specialist for complete examination of labyrinthial function (electronystagmogram with pendular and calorific tests).

(b) Investigation of the nasal sinuses

Establish the patency of each nasal passage (it is dangerous to dive while suffering from colds or flu).

Looking for a purulent discharge, polyps and deviations of the nasal septum which are either permanent or temporary contra-indications to diving.

A standard, systematic radiographic evaluation to track down certain asymptomatic pathologies, latent sinusitis, cysts or osteomas of the sinuses and mucocoeles.

(c) Further examination

Check for dental pathology such as caries, pulpitis, fillings in poor condition, because one should not dive with teeth in bad condition. Check for the absence of a laryngocoele (a rare condition but a dangerous one). The symptoms are laryngeal tickling during physical exertion and bulging of the side of the neck during coughing or physical exertion.

CONCLUSION

The ENT examination of a diver should not be taken lightly. Often simply, it can also be strewn with pitfalls and a badly understood pathology can make a magnificent athlete a cripple for life, deaf or suffering from vertigo.

The diving doctor should therefore have no scruples about referring patients to an ENT specialist at the slightest anomaly.

REFERENCE

1. Delonca G, Delonca P. Le Depistage Rapide des Troubles Labyrinthiques du Plongeur: le Test Labyrinthique Frigorifique Bilateral Calibre. Med-Sub-Hyb 1981; XX, 78.

The above appeared in French in the CMAS BULLETIN of 7 July 1984, No. 141, 5-6.

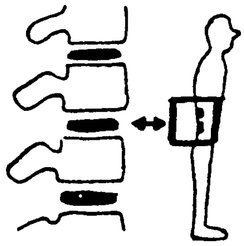
This translation was provided by James Knight.

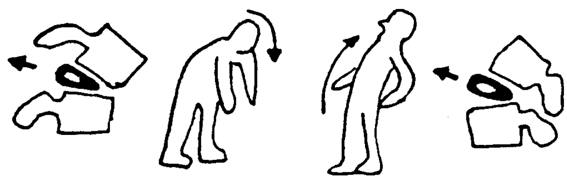
DORSOLUMBALOGIES AND DISCOPATHIES AMONGST DIVERS

Dr R Sancho

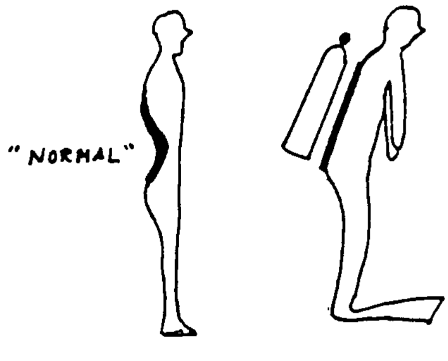
The large number of lombalogies and sciaticas in veteran divers of both sexes have probably developed due to a postural mistake during the act of putting the air bottles on their backs.

Let us examine the anatomy of the vertebral column, between each pair of vertebrae is an elastic disc which acts as a shock absorber. During flexion, the vertebrae incline forward, and push the disk backwards, during extension the reverse is true. Lateral inclination displaces the disc convexly. Axial rotation of the lumbar spinal column is weak, but there is still a shearing of the disc.

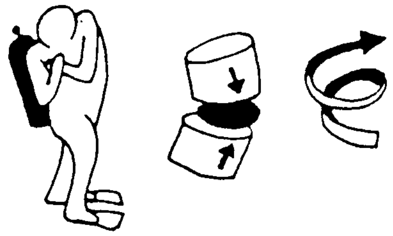




The pressure exerted on the last intervertebral disc (the space between the lumbar vertebra 5 and the first of the sacral vertebrae) increases with the degree of inclination of the lumbar spinal column which has been demonstrated biomechanically by Kapandji. Normally the lumbar spinal column is naturally curved (lordosis).



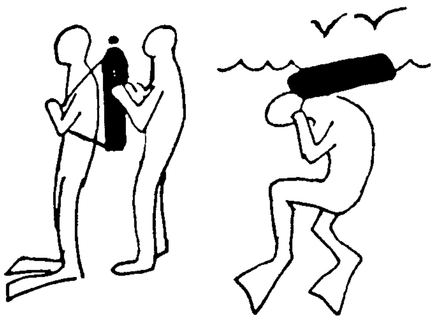
A diver with his equipment on the back, loses this curve and there is a consequent hypertension of the disc between the 5th lumbar vertebra and the first sacral vertebra. The strong abdominal contraction necessary to maintain equilibrium, and the increase of thoracoabdominal pressure can also provoke circulatory problems and a slowing of the venous return from the periarachnoid venous plexus which increases the pressure of the cerebrospinal fluid.



The diver, as he puts his air bottle on his back, makes movements which subject the intervertebral discs of the lumbar spine to a compression and a shearing strain. The mechanism is akin to that of the rotation of the knee which causes the meniscus lesion found in soccer and rugby players.

CONCLUSION

As a member of the Medical and Preventative Commission of CMAS I must warn of the potential danger, for the integrity of the lumbar spinal column, of putting air bottles on ones back, by lifting them from the ground and twisting to settle them in position. I therefore propose that we adopt the habit of dressing each other (I am referring to diving bottles), or putting our own bottles on while floating on the surface.



The above appeared in French in the CMAS BULLETIN of July 1984, No. 141, p7. This translation was provided by James Knight.

The address of the World Underwater Federation (CMAS) is 34, rue du Colisee, 75008 Paris, France.

TECHNICAL LIMITATIONS OF THE OCTOPUS

And A Way to Test Your Own Regulator

Within the past few years, the redundant second stage, or ‘octopus’, has almost become a standard in sport diving. While it is easy to learn, and requires somewhat less constant practice to perform than buddy breathing from one shared regulator, there are limitations which frequently go unstated.

According to personnel in several scuba repair firms, the majority of divers who send in their regulators for annual or semi-annual overhaul do not have their redundant second stage overhauled. Upon discovering that it will increase the cost of the overhaul by as much as twenty dollars, they elect to leave it alone. The logic seems to be that since it is not used, it doesn’t need an overhaul. Nonetheless, divers who don’t maintain the auxiliary second stage still present themselves as being able to provide air if and when it is needed. But they really don’t know if they can and neither does the buddy.

Historically, problems and accidents occur at the start and end of a dive. Out-of-air situations normally occur at the planned end. Thus, low tank pressures and possible anxiety in some cases can combine to place physical limitations on the technique that is unique to the octopus. Dr Glen Egstrom of the UCLA Department of Kinesiology tested five octopus systems for the breathing characteristics on the surface and at 60 feet; with normal breathing and with heavy breathing; with alternative breathing and with breathing at the same time; and at tank pressures of 600 and 300 psi. (An additional test was conducted on the surface with 200 psi). The results of these tests indicated that under certain conditions there is, indeed, a marked increase in breathing resistance.

The surface tests were undertaken to determine if there were variations in regulator performance under conditions of low tank pressure, normal breathing and heavy breathing, breathing alternatively or breathing at the same time.

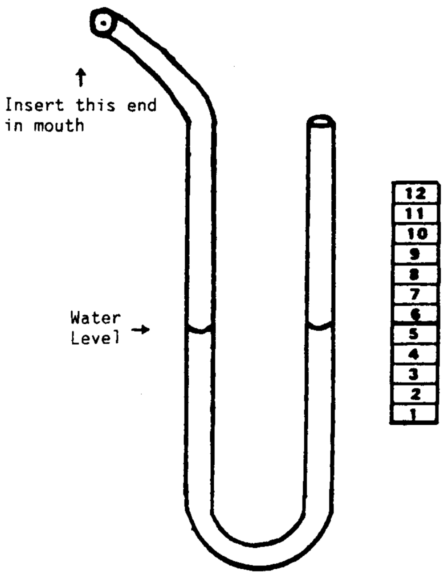
These results indicated that there was little increased breathing resistance during “normal” breathing, whether alternative breathing or breathing at the same time. Yet, as work loads increased, there was a noted increase in the breathing effort required to draw adequate air. Some regulators indicated excessive resistance at 200 psi when both divers breathed “hard” at the same time. These variations were found to be consistent with the baseline characteristics of the individual regulators. That is, the better breathing regulators demanded less effort under the increased demands of heavier breathing with low tank pressure. These tests conclude that there is indeed, variability in performance, but at the surface this variability is only significant for quite low tank pressure.

For underwater tests, two highly experienced divers made a series of dives to 60 feet, and again breathed the octopus rigs with alternative breathing and simultaneous breathing under their “light” and “heavy” breathing patterns. The results were enlightening.

A normal differential pressure measurement for a regulator is ± 3". Differential pressure is the difference in effort or pressure required to open the valve and deliver air. It is also sometimes called “cracking” or “breaking” pressure. The tests indicate that at 60 feet with 600 psi and with “light” breathing, all five units tested resulted in 5 inches or less of differential pressure. Heavy breathing at the same configuration showed over 10 inches of differential pressure in 3 of the five units. At 300 psi, 4 of the 5 units were over 10 inches of differential pressure under heavy breathing conditions. This means that with low tank pressure and heavy breathing, such as might be encountered in a stressful situation, the work effort needed to obtain air can triple when an octopus is being used. In fact, although air remains in the tank, it’s conceivable that it cannot be withdrawn. As previously mentioned, the divers involved in the tests were highly experienced, the equipment in good working order and the tests conducted under controlled conditions. Take the case of two divers in the open ocean, with only a couple of years experience, in an out-of-air situation, and there could be a major problem. The potential for problems increases if the redundant second stages are not in as good condition as the primary second stages.

Does that mean that the octopus should be scrapped? By no means. But every diver should realize that under some circumstances, two second stage regulators on the same tank may not deliver air at all. Understand the limitations of your own equipment and your buddies. Keep the equipment well maintained and know the critical tank pressure for your particular set-up. This knowledge will help you to plan your dive more safely - that is, to be prepared for out-of-air situations - and know when the dive should be terminated, based upon the regulators limitations and the available air supply. In short, your regulator may not be able to deliver air adequately to you at sixty feet with only 200 psi in the tank, especially if you are in a current or in a state of pre-panic. Using an octopus under those circumstances would compound the problem.

A MANOMETER FOR REGULATOR TESTING



Several years ago Undercurrent published a simple technique for checking the performance of your regulator. We are reprinting that technique, which was provided to us originally by Dr Glen Egstrom:*

1. Get a 12-inch ruler, a roll of masking tape and find a board of any thickness - about a foot wide and a couple of feet high.

2. Purchase four feet of clear tubing, 3/16 inch interior diameter, from a scientific supply house, your local pharmacy, or anywhere you can find it. Glass tubing can be bent by heating it over a gas flame, or straight glass tubing can be used with 3/16 inch surgical tubing to form the "U."

3. Following the diagram, tape the tubing to the board in a "U" shape. One side (a) should be about 15 inches long, while the other side (b) should be at least 30 inches long. Be careful not to crimp the tubing at the curve.

4. You now have a "manometer".

5. Fasten the ruler to the centre of the board.

6. Pour water in the tubing until the water level on both sides comes up to 6 inches on the ruler, just as in the diagram.

7. Hook your regulator up to your tank, open the valve, and put the mouthpiece into your mouth.

8. Insert the long tube into the corner of your mouth.

9. Breathe normally and watch the water level in the manometer fluctuate.

10. If the fluctuation exceeds three inches in either direction, your regulator needs an overhaul.

You may run this test with two regulators to determine the differential pressure when they are both working at once and at variable tank pressure. Have your buddy breathe on the second regulator at the same time and let him try the manometer as well. You should see quite a difference in differential pressure. That difference will increase dramatically as depth increases, tank pressure decreases and work of breathing increases.

Realize, then, that the octopus system is not fool-proof and has severe technical limitations in situations that can occur at depth, near the end of the dive when the tank pressure is low, or when the divers are under great physical or psychological stress. To overcome the problems, keep your buddy breathing skills up to snuff and remember that your best choice in an out-of-air situation might very well be to head directly to the surface.

Reprinted by kind permission of the Editor from UNDERCURRENT, July 1985. The address of UNDERCURRENT is PO Box 1658, Sausalito, California 94965, USA.

* Dr Glen Egstrom is a member of SPUMS and was the guest lecturer at the 1978 Annual Scientific Meeting in Fiji.

DIVING SAFETY MEMORANDA

Department of Energy
Diving Inspectorate
Thames House South
Millbank London SW1P 4QJ

July 1985

AMENDMENT TO DIVING SAFETY MEMORANDUM NO. 4/1985
GUIDANCE ON MAXIMUM PLANNED DURATION OF BELL RUNS

The diving rules required by Regulation 5(1)(b) of the Diving Operations at Work Regulations 1981 shall include provision for securing the health and safety of persons engaged in diving operations and in particular shall make provisions relating to such of the matters specified in schedule I(3)(h).

Bell runs should be planned not to exceed 8 hours' duration. However, for reasons of diver safety, this period may be extended at the discretion of the diving supervisor.

The commencement of a bell run is defined as being when an effective pressure seal has been achieved so that the bell is ready for lowering to the work site and the completion as being when the bell has been recovered to the surface and is ready to be mated to the deck chamber.

Divers should not be required to man the bell in readiness for diving until all other preparations, which may delay the launching of the bell, have been completed. Immediately divers have manned the bell and completed the necessary safety checks, a pressure seal should be made thus effectively starting the bell run.

Lock out time for a diver in the water should not exceed 4 hours in the course of a single bell run,

Divers should have at least 12 hours rest in each period of 24 hours.

DIVING SAFETY MEMORANDUM NO. 5/1985

SUPERVISORY RESPONSIBILITY FOR EVACUATION OF DIVER(S) UNDER PRESSURE FOR MEDICAL REASONS

The Diving Operations at Work Regulations 1981 specifically refers to the responsibilities of every diving contractor and every other person involved and in the case of:-

1. An offshore installation - the owner.
2. A proposed offshore installation - the concession owner,
3. A pipeline - the owner.
4. A proposed pipeline - the person who will be the owner when it is laid.

The above are required to ensure, so far as is reasonably practicable, that these Regulations are complied with.

Paragraph 103 in the Guidance Notes of the said Regulations suggest the requirement for a Transfer Under Pressure facility for certain operations and Diving Safety Memorandum 8 of 1984 explains in some detail the responsibilities for the provision of meeting the regulatory requirements.

This Memorandum is for the guidance of all those who have responsibilities under the Diving Operations at Work Regulations 1981 and to indicate where certain diving supervisory roles change in the effecting of the transfer of an ill or injured diver(s) from a designated work site to a place where treatment can be given safely under pressure:-

1. The diver to be transferred will remain the entire responsibility of the diving supervisor of the spread on which he is employed until such time as the supervisor of the Transfer Under Pressure Diver Rescue System facility has received the diver into the evacuation chamber on board the helicopter.

2. The responsibility of the diving supervisor of the Transfer Under Pressure Diver Rescue System shall continue until such time as the diver within the helicopter chamber shall be placed in another chamber either belonging to the National Health Service or to another third party.

3. On transferring the diver into the chamber where he is to receive treatment (whether sited offshore or onshore (either a National Health Service or other facility)) the responsibilities of the diving supervisor of-the Transfer Under Pressure Diver Rescue System shall cease when the diver has passed through the entry lock into the treatment chamber, responsibility then passing to that chamber's diving supervisor.

September 1985

DIVING SAFETY MEMORANDUM NO. 6/1985

DANGERS OF OXYGEN EXPLOSIONS DURING GAS MIXING AND GAS TRANSFER

1. During a recent gas mixing operation offshore, using an oil lubricated piston compressor, an explosion occurred. The explosion was of such a magnitude that extensive damage was caused to the compressor room and adjacent compartments but fortunately no one suffered serious personal injury. In similar circumstances such an incident could have resulted in a multiple fatality.

2. Attention is drawn to the dangers of using compressors and gas transfer systems to handle a mixture having an oxygen content in excess of the designed limit of the equipment.

3. The following points should be noted when establishing a safe procedure for mixing gases:-

(a) The maximum pressure and percentage of oxygen which can be handled by the compressors/pump and the other items of equipment in the gas transfer system should be ascertained from the manufacturer.

(b) A notice stating the maximum oxygen percentage and pressure is to be posted in a conspicuous position by the compressor/pump.

(c) Before starting to pump mixed gases, whether for the purposes of making a new mixture or to gather residual amounts of gas in depleted storage units, the level of oxygen in each individual storage unit from which gas is to be taken is to be measured, and the level in any one of them is not to exceed the oxygen level specified for the gas transfer system.

(d) At predetermined stages the predicted and measured values of pressure and oxygen content should be compared and any discrepancies investigated before proceeding with the next step.

(e) Written procedures for gas mixing and gas transfer should be established and used at all times by personnel practically trained to carry out these tasks. In making up mixtures, those gases with a high oxygen content should be decanted first into an empty receiver and inert gases or low oxygen content mixtures pumped in subsequently.

(f) The planned maintenance procedures as recommended by the manufacturers are to be strictly adhered to. When portable items of equipment are removed from the system, open pipework should be sealed to prevent contamination.

Note: This recommendation refers principally to the use of oil lubricated piston compressors. Where diaphragm or oil free piston compressors are used, many of which are designed for use with pure oxygen, the advice given above concerning good operating practices is also relevant.

November 1985

DIVING SAFETY MEMORANDUM NO 7/1985

BATTERY CHARGING PROCEDURES

1. Recently a number of explosions have occurred during or following the charging of batteries. As batteries are widely used by the diving industry attention is drawn to the need to ensure that personnel are adequately trained and safe systems of work are established for the charging and use of batteries.

2. When establishing such procedures attention should be paid to the advice given by the suppliers and manufacturers of the batteries and charging equipment. In particular, attention should be given to the need for good ventilation of battery storage and charging areas, the proper design and use of battery charging equipment and to the potential dangers inherent in the use of sealed battery containers.

3. The following list, which is not definitive provides points for consideration:-

(a) The Hydrogen gas produced during charging can easily form an explosive mixture with air.

(b) The higher the charging rate of the battery the greater the amount of gas released.

(c) Batteries are often charged in “series”. Splitting a set of batteries can result in too high a charging rate and consequently high levels of gas.

(d) The disconnection and re-connection of batteries during charging operations may produce sparks which could be a source of ignition for an explosive gas mixture.

(e) Batteries should not be charged in enclosed or poorly ventilated spaces.

(f) When batteries are enclosed in pressure containers the gas will accumulate and may cause an additional hazard due to its pressure.

(g) Many battery enclosures do contain small vent holes or “breathing valves”. Such vents and valves should be positioned at the highest point of the container and provisions made to ensure that any vented gas is not a hazard.

(h) Such vents and valves should be maintained in accordance with the manufacturers’ specifications to prevent overpressures or water leaking into the enclosure.

(i) Sea water ingress onto some types of batteries may cause explosions.

Yours faithfully

DIVING SAFETY MEMORANDA

It has come to my attention that because the majority of the Department of Energy’s Diving Safety Memoranda have been addressed to a named person who has either changed offices or companies the mail has been returned to this office marked “unknown”. Subsequently, a representative of that company contacts the Diving Inspectorate to advise that they are now not receiving the Diving Safety Memoranda.

To overcome this problem and unnecessary expense your co-operation is requested in providing the following information:-

Addressee - TITLE NOT NAME (eg. Safety Manager or Librarian)
Name of Company
Address
Postcode

Please note that only companies who provide the above information will be included in the new mailing list.

GUIDANCE NOTES FOR SAFE DIVING

With the agreement of the European Diving Technology Committee (EDTC), the Mines Safety and Health Commission of the EEC has agreed to publish this document with a view to making it widely available.

These Guidance Notes for Safe Diving present a summary of the views of the EDTC, which has been considering for several years steps which can be taken to increase safety of diving, particularly in deep water, and puts forward their generally agreed recommendations. It supersedes Volume I of Guidance Notes for Safe Diving 1977 (Eur 5695e).

This document can be obtained by writing to:-

Mr P Walker
Mines Safety and Health Commission
Commission of the European Communities
Floor C4
Jean Monnet Building
The Kirchberg
L-2920
LUXEMBOURG

July 1985

R GILES
Chief Inspector of Diving

MARINE ENVENOMATION

A NEW EMERGENCY SERVICE

Medical advice for the treatment of marine envenomation is now available from a toll free number 008-015-160 at the Townsville General Hospital, Queensland.

The number is available for emergency or routine advice. Reports of sightings of toxic marine animals can also be made to this number.

SPUMS ANNUAL GENERAL MEETING 1986

The guest speakers at the 1986 Annual Scientific Meeting will be Dr Andy Pilmanis, Associate Director of the Institute for Marine and Coastal Studies at the University of Southern California, and Dr Des Gorman, who is on the staff of the Royal Australian Navy School of Underwater Medicine at HMAS PENGUIN in Sydney.

The venue for the 1986 AGM and Annual Scientific meeting will be the Hotel Ibis, Kavika Village, Morea, French Polynesia.

Departure date from Australia is 4 June 1986, and owing to the International Date Line arrival in Tahiti is on 3 June. Departure date from Tahiti is 12 June arriving in Australia on 13 June.

Travel arrangements are in the hands of Allways Travel of 168 High Street, Ashburton VIC 3147 (telephone (03) 25 8818).

COURSES IN UNDERWATER MEDICINE

AT THE RAN SCHOOL OF UNDERWATER MEDICINE

An Introductory course and an Advanced course will be held later this year.

There will be up to 20 places on each course. The majority of places will be available for civilians. There will be a fee for attending the courses. Last year the fee for the two courses was $536. Those who consider that the fee should be waived for themselves should supply the reasons in writing to the Officer-in-Charge SUM who will pass them on to the Defence Department with his recommendations.

Accommodation is not available at HMAS PENGUIN.

Those interested in attending should write to:-

The Officer-in-Charge
RAN School of Underwater Medicine
HMAS PENGUIN
Balmoral Naval PO NSW 2091

It is understood that there will be a course in Hyperbaric Medicine at the Prince Henry Hospital, Little Bay in the week between the two RAN courses.

IX INTERNATIONAL CONGRESS ON HYPERBARIC MEDICINE, 1987

The IX International Congress on Hyperbaric Medicine will be held at the Hilton International, Sydney, from 1st-4th March 1987.

For further information write to

The Congress Secretariat
PO Box 233
MATRAVILLE NSW 2036
Australia

DIVING AND HYPERBARIC MEDICINE MEETING 19 APRIL 1986 AT MORWELL, VICTORIA

The Australian Society of Anaesthetists (Victorian Section) is holding an afternoon meeting at the National Safety Council of Australia (Victorian Division) Hyperbaric Facility at 1 Chickerell Street, Morwell (approximately 145 km east of Melbourne on the Princes Highway) on Saturday 19 April 1986.

THE ASA HAS INVITED ALL MEMBERS OF SPUMS TO ATTEND.

The speakers and their topics are

Dr John Knight	Hyperbaric & Immersion Physiology
Dr Geoff Macfarlane	Treatment in chambers
Dr Ian Millar	Oxygen therapy
To be nominated	The NSCA

There is no charge for the meeting which starts with a buffet lunch between 12 and 1 pm. The lectures run from 2 to 5 pm.

A subscription dinner will be held at one of the motels in Morwell that evening.

Those who wish to attend are asked to notify

Dr Rod Westhorpe
Department of Anaesthetics
Royal Children's Hospital
Flemington Road
PARKVILLE VIC 3052

Telephone: (03) 345 5240

9TH INTERNATIONAL SYMPOSIUM ON UNDERWATER AND HYPERBARIC PHYSIOLOGY

16-20 September 1986
Portopia Hotel, Kobe, Japan

For further details contact

Undersea Medical Society
9650 Rockville Pike
Bethesda
Maryland, 20814
USA

Telephone: (301) 530 9225

PROJECT STICKYBEAK

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

Dr D Walker
PO Box 120
NARRABEEN NSW 2101