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CONTENTS

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EDITORIAL

Viewed dispassionately, the existence of a bird which cannot fly, finds its food by swimming underwater, and has to balance its eggs on its feet to prevent them freezing, is patently absurd. If you now postulate an attempt by a mammal, which is adapted to the warm areas of the world landmass, which has poor tolerance of cooling and pitiful breathholding ability, to explore the underwater portion of a very cold environment, you will be ready to read Carl Edmonds' admirable account of Antarctic diving. One can only guess at the successes and failures which marked the development of efficient thermal protection and enhanced breathholding ability by all the warm blooded creatures which live in the polar waters. Penguins, seals, whales and other cold land creatures had, however, an empiric approach to adaptation which sharply honed their abilities: those who were unsuccessful died. Man is too impatient to try to adapt, and dislikes the idea of allowing Natural Selection of scientific staff, so much effort is being expended into learning to survive in polar areas, and polar waters. Man has an advantage over other creatures, technology, unfortunately allied to lack of thought for the consequences of his intrusion into an ecosystem of which his understanding is minimal. It is sincerely to be hoped nothing of commercial value is discovered by investigators.

Drowning is the most common untimely conclusion for those who die in water and John Doncaster's paper sheds light on the procession of events which occur. It is hoped no reader ever has a personal subjective interest in such pathology. On a more cheerful note is the report by Rettenmaier and his colleagues, who conclude that to use oxygen therapy correctly is safe. There have been suggestions by some that the safety of oxygen use had been over stated and it was more dangerous than admitted. It is salutary to remember that in everything we do in life there will be an interplay of factors for and against the action, dangers to set against gains. If faced with a diving related problem, the advantages of oxygen will often outweigh the dangers. Careful divers are aware that our knowledge of diving is a working theory rather than true understanding.

Commercial imperatives are accepted as being the driving force in deeper diving. They also no less critically rule the technologically simpler fields of sponge and abalone diving. It is a sad but sobering reminder of the way of life of such divers that the well attested dangers of their ways of diving are tolerated as being a necessary and unavoidable fact of life which cannot be changed to any significant degree without financial ruin to their industry. The damage to the nervous and skeletal systems which result from this attitude are well documented and the papers by Carl Edmonds, John Hayman, and John McKee reinforce this message.

There are many more matters of interest contained in the articles of this issue, including a new factor to consider when asked about fitness for saturation diving by a female applicant. Now that the oil rigs allow women aboard, diving supervisors may have to take cognisance of more than the conventional increased decompression requirements of women. As ever, change brings new problems.

SPUMS ANNUAL SCIENTIFIC CONFERENCE 1985

THE DEEP FROZEN DIVING PHYSICIAN

Carl Edmonds

Introduction

I was scheduled to lecture on diving environments, but the abbreviated time available has obliged me to reduce the extent of the lecture. I have decided therefore to discuss only one environment, which greatly appeals to me, and discuss the lessons which have been learnt from it. The environment that I wish to share with you is that of the Antarctic.

The Antarctic is almost twice as large as Australia. It is the highest, driest, coldest, windiest continent on earth. This massive land mass has an ice covering which, if spread over Australia, would form a layer 2 km thick. If it should melt, the ocean would rise by as much as 60 metres, causing devastation to my harbourside home in Sydney.

Throughout the history of Antarctic exploration, Australians have cloaked themselves with honour. Names such as Sir Douglas Mawson, Sir Edgeworth David, Dr Forbes Mackay, and many others are entwined in the history and development of this magic land. Australia now lays claim to 40 per cent of the continent and modern day pioneers, geologists, engineers, biologists, metallurgists, meteorologists and physicians, staff our four permanent bases, three on the mainland and one on Macquarie island. The Department of the Antarctic is responsible for administering these, whilst adventurers such as Dick Smith and Dr David Lewis add a touch of glamour and excitement to our involvement. The Oceanic Research Foundation is a privately run organisation that is determined to preserve our contribution to that continent.

My reputation in the world of diving medicine is unfairly associated with the development of a method of treating decompression sickness (bends) in remote localities. Specifically, this system involves giving oxygen underwater, and was devised to be used in the tropical waters of the Pacific Islands, an area which does not have a surfeit of recompression chambers. Most people would agree that the treatment is not appropriate to the colder waters of Sydney and Melbourne (where there are recompression chambers available).

It was therefore somewhat perplexing when I was invited to contribute to the development of a diving facility in the Australian Antarctic. Could my underwater oxygen treatment, especially designed for the tropics, be used in the event of a decompression emergency? As I am not an armchair researcher, there was only one way to find out. I packed my woollen undies, hot water bottle, guitar and windsurfer (the last item was denied passage on the otherwise serviceable vessel, the “Nella Dan”), but before embarking into the Southern Ocean, I decided to obtain advice about the potential problems of working in this region.

The information was gained mainly from the Department of the Antarctic, which has expertise in a whole range of scientific fields, including a most knowledgeable Department of Medicine, effectively run by Dr Des Lugg. I also received information from the US Navy, especially from their “Project Deep Freeze”. Other data was obtained from some sleazy bars in Hobart, but this perhaps should be the subject of a different dissertation.

As I was travelling to the Antarctic in summer, I was to expect almost constant daylight, temperatures from between 0°C and -30°C, winds up to 100km per hour, waves up to 15 metres high and a sideways roll of the ship to approximately 100 degrees. Under such circumstances, the possibilities of frost bite, hypothermia, seasickness and hangovers were to be expected. Special clothing had to be worn to protect against the temperatures, the sun, blizzards and the effects of snow.

Vehicles wear out approximately 10 times faster in the Antarctic. Brakes often do not work, and handbrakes tend to freeze on if they are applied. Pedestrians are protected from hearing and seeing vehicles before the collisions, by wearing a large woollen hood. Cameras play silly games. I attempted to clean the lens by breathing heavily over it, as a prelude to wiping it with Kleenex. An almost transparent lens became totally fogged with ice crystals. Similar condensation occurs when the camera is taken from a warm environment to outside. The more intricate and complex the camera, the more likely the mechanism is to freeze. Batteries have a short life, and the cold, dry conditions result in film either breaking, if wound on too fast, or having static “flashes” on the negative due to the very low moisture content of the air.

Equivalent problems seem to occur with all other equipment. The low temperature changes the strength, elasticity and hardness of metals and reduces their impact resistance. Metal becomes so cold that it, if touched without the protection of gloves, may freeze to the skin.

Leather, fabrics and rubber become rigid and break. Glass (being a poor conductor) may crack if exposed to the sudden temperature changes from the habitat to the environment. Lubricants must be specifically developed for subzero conditions, and static electricity affects everything, including hair, giving the expeditioners a rather startled and woolly appearance.

Injuries From Cold

The two major types of injury are frost bite and hypothermia. I intended to avoid both these by always staying indoors, overdressing, growing a beard (this allows an ice layer to form on the surface of the beard, enclosing an air space which gives good insulation and protection to the face), and following all the rules. I soon found out that the rules were frequently the opposite to what I had planned.

One of the most dangerous errors, and one likely to induce cold injury, is the wearing of excess clothing. When coupled with exertion, this causes sweating and increased heat loss, as well as a loss of insulation in the clothing when the sweat freezes or evaporates. Any sweat, water, snow or frost must be removed to prevent it wetting the clothing and reducing insulation. Even boots must be dusted off and hung up, never laid on the floor where they may get damp from the melted snow and freeze when re-exposed to the environment. One absolute requirement to prevent hypothermia and frost bite is to remain dry. Hardly encouraging advice for the aspiring diver.

The lips, nose and other protrusions, are particularly vulnerable to exposure, and need protection. Especially dangerous is the loss of gloves, mittens or headgear. These are often removed for various reasons, only to be whipped away by the wind or lost down a ravine, so they have to be firmly attached to the rest of the clothing when the weather conditions are difficult. Wind, with its more terrifying cousin, the chill factor, aggravates any of these exposure conditions, and produces frostbite. Constant vigilance is needed in checking each other to ensure that the face is not affected (looking for ischaemic white patches). Each expeditioner is responsible for his own hands and feet.

Included in protection is the use of ultraviolet blockout skin preparations and good quality sun goggles (not those with the clear lower half, as most of the light is reflected upwards from the snow). Glasses do not work very well, as they tend to become fogged up by condensation from the breath. Exposure to the very bright ultra-violet light arid its reflection from the snow, produces a painful and disabling "snow blindness". A "whiteout" is an entirely different phenomenon, but causes a similar inability to visualise the environment. It develops because of a diffuse shadowless illumination, against a white snow background. With blizzard conditions or clouds, the sun is not visible, and, as everything is covered with a bright white mat, it is impossible to perceive depth or discriminate articles or topography.

Diving Operations

There were US Navy diving expeditions in the Antarctic as early as 1946. Their ability to operate in extremely cold waters (-1°C) has also been repeated by Canadian work in the Arctic circle and early Australian dives in the Antarctic.

Diving suits for the Antarctic need some special features. Almost every part of the body needs to be protected by the suit, so that only the lips are exposed - and these are covered by a thick layer of Vaseline, which can also be put over the beard to help form a seal with the face mask. Velcro is easier to use than zippers, which often freeze.

Three types of suits are available. The dry suit, which is made of closed cell neoprene and a nylon lined interior, is a one piece suit and can be inflated to produce an air layer over the body and ensure good insulation. Unfortunately, the valves on these suits are subject to freezing, and if the air inlet valve freezes in the open position, the diver faces a potentially hazardous and uncontrollable ascent to the surface. Most divers wear these suits.

Wet suits are also available and are made of foam neoprene, which produces an effective insulation for shallow dives. A small but invigorating trickle of water runs between the skin and the material when the diver immerses himself. These suits lose some of their insulation as the diver descends, because the air spaces within the neoprene tend to collapse. Because I had no other, I used this type of suit, and as it was very well fitting, it worked effectively for me. Non-compressible wet suits are available, but because of price can only be afforded by the Americans.

Dive Equipment

To breathe the air underwater, it needs to be decompressed via a regulator, from a high pressure (Scuba) cylinder. Then it is passed through a low pressure hose to a demand valve (mouth piece) where it is reduced again, to environmental pressure. This decompression results in a very severe drop of temperature, probably about -40°C, in the Scuba regulator.

Because of the very low temperature and the sometimes small amounts of water vapour in the compressed air, or water in the equipment, it is possible for the regulator to freeze up with ice particles. When this happens it either totally occludes the air supply or results in "free flow", a very large air loss which then "freezes" the low pressure part of the system, the demand valve at the diver's mouth. In either event, the diver loses his air supply and may be in a precarious situation if he is under an ice shelf or on a 'deep dive. Special cold-water regulators are available, the most sophisticated and expensive being that one that froze first!

Much of the other diving equipment was routine and caused no problems, but there were potential difficulties wherever there was a valve, and especially when there was a rapid flow of gas. Thus there were potential difficulties with buoyancy vests, which use either an air feed supply or a carbon dioxide cylinder attachment. The one bit of diving equipment we did not have to worry about was the compass. Colleagues supplied me with a compass with the needle fixed to read North, no matter which direction one turned the compass. An excellent modification for diving at the South Pole.

Results

With this background for disaster, it may interest people to know what major problems I encountered while diving on air and oxygen, using a wet suit and conventional diving equipment for periods of up to 75 minutes and at depths of up to 18m (60 feet).

The main reason for visiting the Antarctic was to test the underwater oxygen unit. I certainly tested it. I put it onto the oxygen cylinder, screwed it on with a spanner, and it snapped into two pieces.

Metal in the Antarctic is very fragile because it is so brittle with the reduced temperature. Here was a fairly average type medico, not particularly strong, breaking a stainless steel regulator, merely by turning it on! This had to be modified. We acquired an old oxywelding unit, and put that on the oxygen cylinder, and it worked wondrously well. Tony Dick was the Antarctic doctor when I was down there. We tossed up as to who would get the dry suit, and who would go on oxygen. The lucky person would achieve both. The loser would obtain the wet suit and compressed air.

Tony is still not sure if he won or lost. He used the dry suit and the oxygen, and I was dressed in a very routine type wet suit, fairly thick, and very tightly fitted.

The results were very informative. A dry suit, not closely fitting and not tailor made, tends to become compressed in its lowermost area and we were in the vertical position, it meant that Tony lost a lot of heat from his legs and lower abdomen. My wet suit was much more effective, and I really did not get as cold as Tony did. Thus the value of a well fitting suit.

It is true that Tony was probably a little hypothermic at the end of the dive, and he could not even be bothered taking his gear off when we were hauled on board.

The diving was sometimes spectacular, usually beautiful, and always interesting. There were iridescent blue ice caves to negotiate, free floating ice packs to dive under, and large irregular shaped icebergs floating by us. Hundreds of penguins, demonstrating a speed and dexterity that they lack on the surface, joined us during the dives and welcomed their underwater visitors.

It is true that we encountered some minor problems with cold fingers and toes. To prevent this, we experimented with the CSIRO heat producing iron/magnesium sachets. Held in gloves and bootees, these produced enough warmth when contact was made with sea water to allow us to continue the dive. Although they look and feel almost the same as commercial tea bags, they produce only a lukewarm beverage of inferior quality, very metallic and devoid of the tannin aroma.

These little heat producing sachets can also be interspersed through the wet suit, ensuring that the whole body is kept warm throughout the dive. If the particle size of the iron and magnesium is too small, excessive heat is produced and burns can be experienced to the skin.

With Antarctic diving, if Scuba gear is used, it as essential to have a line connecting the surface to the diver. It is of value in finding the body afterwards. It may even help the diver retrace his pathway, in the event of accidents. Another similar approach is to use a compressor with a surface supply. It works the same as the safety line, and ensures an adequate supply of gas. With either Scuba or the surface supply, a bale-out or pony bottle is essential.

It was not relevant in the summer diving, but in winter a real problem is to ensure that the hole in the ice is kept open. The water freezes over rapidly even though it is only zero degrees, because the air is at -30° or -40° Centigrade. In the Australian base we had a large shelter which protected the surface crew from freezing, and also allowed a heater to be used which tends to keep the ice hole open. The hole must also be capable of taking at least two people so that a rescue procedure can be conducted in the event of incapacity of one of the divers.

Diving is now being performed throughout the year, and if needed they can use the underwater oxygen unit for emergency treatment of decompression sickness. Of course, the ideal is to ensure that one does not get this illness, by remaining well within depth and duration guidelines.

There are other ways to keep warm, and these are very effective. If you wear a wet suit under a dry suit, this is the most effective. Another technique is to have a hot water supply similar to that used by the abalone divers, ie. with that water being heated from the outflow of the compressor, and being pumped from the ocean around the outflow and then back down to the inside part of the wet suit of the diver. The degree of heat then is related to the gearing up of the compressor.

No-one goes to the Antarctic without falling in love with it. Everyone wants to go back, and many expeditions have been down there on numerous occasions. The attraction is in the beauty and majesty of the land. I was fortunate enough to extend the experience to include the underwater scene.

DROWNING

John Doncaster

Drowning can be defined as death through asphyxiation following immersion in a liquid medium.

Near drowning refers to the survivor of submersion, to which may be added resuscitation and survival, for 24 hours, whether or not fluid has been aspirated into the air passages.

INCIDENCE

The incidence world-wide is roughly three to ten per 100,000 depending on the figures given. In our Geelong area, in the past 24 years, we have had 258 deaths from a population in the summer which is around 200,000 and that gives a yearly average of about 5 per 100,000 per year. Less than 10 per cent of the deaths have occurred from our surrounding beaches. Since 1964, we have had 5,000 admissions to our Intensive Care Unit at the Geelong Hospital, and of these 43 were immersion victims. There were four moribund on admission, the remainder survived.

Not everyone who enters the water drowns, some come out of it in a delightful way. There is usually some problem which helps set the scene, such as alcohol, boats, poor swimming ability, unexpected currents, fatigue, waves, cramp or entanglement in wires, ropes, etc. While increasing the bravado, alcohol lessens the ability to cope, and it impairs intellectual and motor function and reaction times lengthen. Haight and Keating have shown that small volumes, just 30 ml of alcohol, without any carbohydrate ingestion, superimposed on exercise will lead to marked hypoglycaemia, with resultant weakness and confusion. Impaired temperature regulation is also associated with alcohol ingestion leading to a rapid cooling. At Easter, just before coming away, we had a chap who wandered off the edge of the pier falling into the bay. He was drunk, even though it was only 10.00 am. He was rescued virtually immediately by a bystander, who jumped in after him and dragged him out of the cold water. By the time he got to the Casualty Department of Geelong Hospital, which was half a kilometre away, his rectal temperature was 33° which shows how the cooling effect can occur quite rapidly.

Plueckhahn in the Geelong Studies of 238 drownings, found that 168 were accidental, with 117 deaths occurring in adults. Thirty-four were associated with boating accidents: overcrowding, overturning, inexperience, lack of lifejackets and inability to swim. Seventy two were swimming, surfing or in falls from wharves, jetties and rocks, or diving or in vehicles. In more than 50 per cent of the accidents, there was an association with alcohol. In 58 males in the over 30 age group, 53 per cent had blood alcohol greater than 0.08% and 45 per cent were greater than 0.15% at autopsy, and figures from the Surf Life-saving Association of Australia suggest that about one third of near-drowning adults had recently ingested alcohol.

Panic may well be the response to the problem, what ever it is, and this can lead to purposeless struggling, with consequent rapid shallow breathing and this can lead to loss of buoyancy, and submersion, exhaustion and collapse follow. Especially with water in the pharynx in the vicinity of the larynx, breath-holding will occur, water in the pharynx is swallowed, which could well lead to vomiting and gasping with subsequent aspiration into the lungs, leading to blood stained, frothy sputum. Drowning without aspiration occurs in about 10-20 per cent of victims due to laryngo-spasm and asphyxia.

Diving is of interest to most of us here and the deliberate excursion beneath the surface brings added problems, such as entrapment by inanimate objects or in blind caves. Just before I left home, a diver in a local reservoir got too close to the outlet and was sucked into it and he subsequently popped out dead, and so this can be added to the list of inanimate objects which can trap divers. The equipment problems which may lead to aspiration can be from a faulty purge valve or damaged diaphragms or in the exhaustion of air supply, while faulty techniques, for example buddy breathing or free ascents or loss of a demand valve may all lead to disaster. The loss of consciousness, whilst an uncommon immediate cause of death on land, is lethal under water, and this can be due to air embolism or faulty gas supply or faulty usage. Hypothermia may result in impaired consciousness with subsequent drowning.

Coincidental medical problems such as myocardial infarction, cerebrovascular accident, diabetes, epilepsy and even head injury may occur. Drugs such as the central nervous system depressants, tranquillisers, anti-depressants and antihistamines may all alter the perception of, and the response to, potentially dangerous situations. Vomiting and aspiration of swallowed water, sea-sickness, hangover, or caloric stimulation from ear disorders may all lead to drowning, as may nitrogen narcosis. To put things in perspective however, in the Geelong region, of those past 238 deaths in the water, only eight were associated with diving. They were all males between 17 and 50 years.

PATHOPHYSIOLOGY OF DROWNING

The physiology of drowning is worth considering. The first thing is ventilation-perfusion imbalance occurring due to alveolar collapse, with the shunting of blood past unventilated areas of the lung. It is a common factor following aspiration of both fresh and salt water, due to alteration to, or destruction of surfactant. Foreign bodies such as sand, seaweed or vomit may block the airways. Falling lung compliance is due to the above plus reflex airway closure (through even a small volume of fluid aspirate) which may respond to vagal block and bronchodilators, as shown experimentally by Colebatch and Halmagyi. Pulmonary oedema is a very common, though sometimes a delayed, sequel to the presence of fresh or salt water in the lungs, due to osmolarity changes and the presence of particles of sand, weed, marine organisms or chemicals such as chlorine and gastric contents. An aspiration pneumonitis often results, with outpouring of a plasma-rich alveolar exudate. Alexander demonstrated detachment of the vascular endothelium from the basement membrane of the alveoli, along with alveolar cell oedema, following aspiration of both fresh and salt water. The biochemical changes include metabolic acidosis associated with impaired circulation, hypoxaemia due to pulmonary oedema and shunting, and increased oxygen use due to tachycardia caused by CSF acidosis and/or local pulmonary irritation. Unlike the animal experimental findings of a raised serum sodium, chloride and calcium in salt water aspiration, with the opposite findings for fresh water drowning (except for potassium (which raised due to the haemolysis)), minimal changes are often found in human victims, possibly because of the small volumes actually inhaled.

Hypokalemia may be observed during recovery, probably due to rapid correction of acidosis with bicarbonate, with the exchange of potassium and hydrogen ions across cell membranes. Rewarming, with rapid glucose metabolism, may also increase the movement of potassium into the cells.

Cerebral hypoxia will depress neural function and cause oedema, hyperaemia (through vase-motor paralysis) and acidosis within the cranial cavity.

Hypothermia may cause confusion below 35°C and unconsciousness below 32°C, and interfere with circulation by causing bradycardia, arrhythmias, ventricular fibrillation at about 25°C and asystole below about 22°C. When hypothermia develops before asphyxia, the brain may be protected for long periods of circulatory arrest, as oxygen requirements fall linearly with temperature.

Cerebral irritation may be manifested by straining or by grunting respiration, purposeless movements or even convulsions, all of which further raise cerebro-spinal fluid pressure.

Decerebrate rigidity, if present, raises the CSF pressure as does lowering the head or endotracheal suctioning with resultant straining.

Delayed necrotising pneumonitis may especially follow aspiration of contaminated water or of gastric content.

SURVIVAL

Survival from a near drowning accident is influenced by many factors. The physiological status has a big part to play, the young having a greater chance of neurological recovery after a period of immersion, possibly in part due to initiation of the diving reflex with selective sympathetic vasoconstriction producing a profound redistribution of blood flow to the heart and brain.

The clinical importance is that profound bradycardia and peripheral vaso-constriction may make the palpation of pulses difficult, which along with cyanosis or pallor, plus unreactive dilated pupils may lead to the unwarranted diagnosis of death.

The immersion medium may be significant, as survival from potentially fatal salt water immersion is about 80 per cent, whereas only about 50 per cent survive fresh water immersion. This may be related to the chance of being observed and rescued from the sea, rather than the nature of the fluid per se. These figures relate to children.

<u>TABLE 1</u>

CHILDHOOD ACCIDENTAL DROWNINGS

	Fatal	"Near"
Ocean or bay	17	10
Lakes or rivers	10	—
Dams, creeks	11	4 *
Home pools or ponds	10	3
Public patrolled pools	3	6

* 2 died subsequently.

There was quite a significant difference in recovery if the child was rescued from a pool by trained attendants, rather than if it was dragged out of a backyard swimming pool, dam or river etc. or even from the sea.

Hypothermia can be lethal, so reduction of heat loss as important in surviving immersion, by reducing the gradient between the body surface and its environment. We can do this by eating as much as possible to improve our insulation, or by wearing a wet-suit. We can reduce the surface area by assuming a spheroid position if we are drifting in the water. Undue exercise and alcohol ingestion should both be avoided of course, to further minimise heat loss.

SALVAGE

Salvage of immersion victims really depends on skilled rescue and resuscitation and subsequent management. The ABC of resuscitation (Airway Breathing and Circulation) is well known to us all but once again worth reiterating. The maintenance of the airway is not necessarily so easy, and during the past decade, the Surf Life-saving Association of Australia was involved in 148 salt water rescues, of whom 48 victims died, with only one being from a patrolled beach (and he had a fractured cervical vertebra). Among the deaths, 41 had foreign material in the airway. This consisted of vomitus in 27, fluid in 12, loose dentures in 3, and sand in a further 3 subjects. Difficulty in keeping a clear airway was reported by the rescuers in half of those who died.

TABLE 2

48 deaths

Difficulty with airway		24
Due to:	Vomitus	20
	Water/Sand	2
	Clenched jaw	1
	Neck shape	1
	Edentulous subject	1

Heart-lung resuscitation was attempted in all but the one case. Among the 100 survivors, expired air resuscitation was performed alone in 39, and of these, vomiting occurred in 54%. Of the 15 who required cardiopulmonary resuscitation, 87 per cent vomited. Of the 57 who were breathing and had a pulse present at rescue, 40 per cent vomited. The application of mouth to mouth expired air resuscitation is not without its difficulties, and it is obvious from these figures that it can be a nauseating experience for the rescuer. In rescues in deep water, floatation devices of some sort are required, if more than one or two breaths are to be delivered to the patient, and for this reason alone buoyancy vests are essential for deep water activity.

Three inter-related phases of resuscitation exist as outlined by Goldin and Rivers. The first aid requires rescue, if the patient is not breathing the airway should be checked and cleared if necessary. It is probably worthwhile attempting to drain the lungs, especially of salt water, by gravity, then mouth to mouth respiration should be commenced immediately, as adequate cardiac rhythm may return following just this. The pulseless patient should have external cardiac massage commenced after three or four breaths, except the patient who has been supported by a life jacket in cold water for a long time, where marked hypothermia may be associated with extreme vaso-constrlction and apparent pulselessness. External cardiac massage in this situation may precipitate ventricular fibrillation. Rewarming may be all that is required.

The application of effective cardiac massage requires at least yearly practice. For a single operator 60 compressions per minute are required for an adequate cardiac output at above 25 per cent of normal. Two breaths are required for every 15 compressions. The lower half of the sternum, above the xiphoid cartilage should be compressed by the heel of the hand by 3 to 5 cm. Straight arms are required to prevent undue fatigue. With two operators, a rate of 60 compressions per minute must be maintained, with a breath being delivered after every five compressions. There should however, he no pause for the breaths to be given. It takes about three compressions to get up to the necessary 25 per cent of normal cardiac output. So if you stop after every five, you are not going to be very effective. Death should not be declared until a patient has been warmed, as resuscitations of over two hours have been rewarded with full neurological recovery, especially in cold patients. In the hospital first aid continues, to which is added the correction of acid-base disturbance. If the patient is not breathing, he should be ventilated with 100 per cent oxygen and intubated. Ventilation should continue with 100 per cent oxygen and positive end expiratory pressure.

Various methods for rewarming have been proposed and do depend on the facilities available. Surface rewarming by bath immersion is difficult to organise and may compound the problem by allowing flushes of cold peripheral blood to get back to the central core. Heated oxygen for ventilation helps to raise the body temperature and certainly is a little easier to apply, but it is not as effective as warm peritoneal lavage or better still cardiopulmonary bypass. If the patient is breathing, then progress over the subsequent few hours is monitored with chest x-rays, electrolytes and blood gases.

Modell of Florida and Conn of Toronto have written copiously with regard to the cerebral salvage of the near drowned victim and have suggested that patients should be assessed after immediate resuscitation and categorised as awake, blunted or comatose.

Category A

Patients who are alert and fully conscious need observation in case neurological, pulmonary or other deterioration occurs. History and examination and laboratory tests of blood gases and electrolytes and chest x-rays should be obtained as a base line. Twenty-four hours is usually a sufficient period for observation, although later complications, such as chest infection may occur.

Category B

Patients who are semi-conscious but rousable, with purposeful response to pain, normal pupil reaction and normal respiratory movements, require close observation, as for a head injury, and the tests should be as for Category A.

Therapy should be aimed at prevention of a raised intracranial pressure by the use of diuretics, restricting fluids to half daily maintenance and added oxygen and the maintenance of normothermia. They usually require a longer time in the intensive care unit because of pulmonary problems following resuscitation. They may well develop respiratory failure, requiring ventilation usually with positive end expiratory pressure (PEEP). They may progress into Category C, with neurological deterioration, but should all survive with normal neurological function.

Category C

Patients who are comatose, are further sub-divided by Conn into:

C1: Decorticate, with flexor response to pain and Cheyne Stokes respiration.

C2: Decerebrate, with extensor response to pain and hyperventilation.

C3: Flaccid, with no response to pain and either apnoeic or have cluster breathing.

These patients have a generally worsening prognosis, with regards to survival and normality of central nervous function.

Therapy is aimed at preventing or relieving raised intra-cranial pressure which might cause further damage to neurones which have survived the initial hypoxic insult. Pulmonary oedema and hypoxaemia is usual in these cases and requires diuretics, hyperventilation with PEEP, and a high inspired oxygen concentration to reduce the inevitable cerebral hyperaemia and consequent cerebral oedema.

Conn's concept of "hyper" therapy is based on the findings in the comatose patients of hyperhydration, hyperventilation, hyperpyrexia, hyperexcitability and hyperrigidity.

Hyperhydration is controlled by using Frusemide, 1/2 to 1 mg per kilogram, repeated until an adequate diuresis occurs. Fluid restriction to 1/3 daily maintenance is started and fluid balance is monitored with ECG, central venous pressure, blood pressure and urine output being charted.

Hyperventilation, here nasotracheal intubation and a volume cycled respirator is required. The arterial PCO_2 is maintained at about 30mm Hg to reduce cerebral vasodilation, although this is a very transient effect. A high arterial PO_2 level should favour the diffusion of oxygen through oedematous areas of the brain and so is aimed for. Conn risks pulmonary oxygen toxicity by aiming for an arterial PO2 level of about 150mm Hg. 5-10 mm of positive end expiratory pressure is usually employed to prevent a fall in the functional residual capacity of the lung and atelectasis without raising the cerebral venous pressure. Cardiovascular stabilisation, with the correction of metabolic acidosis, arrhythmias and effective volume repletion may be required to allow hyperventilation to take place and dopamine or dobutamine may also be required to improve cardiac output, without the infusion of large volumes of fluid which would worsen both pulmonary and cerebral oedema.

Hyperpyrexia commonly follows drowning and should be controlled. Active cooling to 30°C is recommended by Conn to reduce cerebral oxygen requirements and intracranial pressure. The core temperature must be monitored, and because of the suppression of normal immune responses, daily bacterial cultures from blood, trachea and urine are required. White cell counts and platelet levels may also indicate infection. Prophylactic antibiotics are probably not indicated.

Hyperexcitability is prone to raise the intracranial pressure but barbiturates have been used recently with a beneficial effect on neurones. Conn recommends Phenobarb 50mg/kg on the first day in three divided doses and 25mg/kg daily subsequently for three days. He also used methyl prednisolone, 1mg/kg daily, and he believes this helps to lower the intracranial pressure.

Hyperrigidity, both lowering of the head and tracheal suction, may raise the intracranial pressure and so should be limited or avoided. Muscle relaxants help to reduce the reaction to tracheal suctioning and also reduce straining against the respirator and facilitate adequate ventilation. Monitoring of the intracranial pressure using a Richmond screw or ventricular catheter is also called for, and so limit this technique to a unit geared for this. Conn's results before hypertherapy were rather dismal. He had a high incidence of central nervous damage at 42 per cent and had 21 deaths. 21 per cent of the deaths were in groups C1 and C2. Since introducing the hypertherapy, deaths have not occurred in these groups and the central nervous system damage has been reduced to 9 per cent. Since they introduced all the factors mentioned at the same time, it is difficult to know whether one or all aspects are in fact essential. Modell has very similar figures without resorting to deliberate hypothermia or barbiturate therapy.

It is to be hoped that we shall soon know which of the above measures are in fact essential to improve results in the managements of near drowning victims.

References for this article are available from Dr John Doncaster, whose address is 220 Noble Street, Newtown VIC 3220.

AUTOPSY METHOD FOR INVESTIGATION OF FATAL DIVING ACCIDENTS

John Hayman

INTRODUCTION

Fatal diving accidents should be investigated with a thoroughness at least equal to that involved in the investigation of fatal aircraft accidents. As with such aircraft accidents, the investigation requires a meticulous post-mortem examination of the body using several special techniques.

A complete autopsy protocol is given in this article. It is appreciated that such a protocol may not be applicable to every diving accident; for example, there may be no indication to remove the femurs from a sports diver, although these should be examined as a routine in every deceased professional diver. In general, the pathologist should collect all appropriate material, for even if he does not intend to examine it himself, it should be available for examination by others.

The autopsy technique involves submersing the body using a special autopsy tray and hydraulic lift, within a water filled stainless steel tank (Atherton AE and Sons, Melbourne). If this apparatus is not available, it may still be possible to detect small intravascular gas bubbles by opening the head beneath water, and opening the chest by using a local water seal. It is assumed that the pathologist is familiar with normal autopsy procedure. Details of such procedures are readily available.[1] In recording the post-mortem, negative as well as positive findings must be noted, and photographs taken of any abnormality.

The technique described may be applicable to other fatal accidents, such as where cerebral arterial gas embolism is thought to have *occurred* subsequent to open or closed chest injury.

AUTOPSY TECHNIQUE

1. External Examination

   Look for suffusion of skin, mottling, petechiae, subcutaneous crepitus, bites or marks from marine animals and other injuries. Suffusion and petechiae may occur with fatal decompression illness and resemble the changes seen in crushed chest injury. Localised skin bruising and conjunctival haemorrhage may occur with barotrauma of descent. Crepitus may occur with lung or airway injury occurring either as a result of the initial accident or following resuscitation attempts, or may be evidence of cutaneous decompression disease.

2. Ophthalmoscopic examination

   This may be carried out with avoidance of direct contact and disposable cap. The fundi should be examined for exudates and haemorrhages and the retinal vessels examined for gas bubbles. Haemorrhage may also occur into either chamber of the eye, or beneath the conjunctivae.

3. Radiological examination

   Underpentrated films should be taken of the skull (antero-posterior and lateral), chest, abdomen, shoulders, hips, and knees. Gas may be seen in blood vessels, the gut, and soft tissues, or in the chest, pericardial and abdominal cavities. The upper humeri and femurs, lower femurs and tibiae should be examined for evidence of osteonecrosis. Other lung changes should be sought, particularly evidence of pulmonary congestion, oedema, and collapse, and the bones of skull, chest and limbs examined for fracture.

   Ultrasound examination may also be of value in detecting gas in the blood vessels or tissues of the limbs, but the author has had no experience with this procedure. Modern, small ultrasound units are easily transportable and may be used in the mortuary.

4. Examination of the brain

   The skull is opened before the other body cavities. The skin is first incised under water, and the scalp reflected. The body is then raised above water in the tank, and the calvarium opened with a vibrating saw, using careful control to keep the dura intact. The body is then submerged again, the calvarium removed and the dura incised under water. The brain is removed and inspected under water for bubbles in the cerebral circulation, then placed in formalin in a submerged container, remaining under water the entire time. In this way the brain is taken from the body and fixed without exposure to air. Any gas present in the cerebral circulation must have been present prior to the post-mortem.

   After fixation the brain is examined with serial sections, and blocks taken from standard areas[1] and areas of any macroscopic abnormality.

5. Examination of Thoracic Contents

   After the brain has been removed and placed in fixative, the tank is drained and refilled with fresh water. Any pneumothorax, pneumopericardium or pneumoperitoneum is needled under water, the gas pressure and volume measured, and a gas sample taken for analysis. The thorax is opened under water, using bone cutting forceps and taking care not to damage the lungs. The pericardial cavity and great vessels are incised and the presence of gas in the pericardium, pericardial vessels, pulmonary artery and aorta noted. The heart is then removed from the pericardial sac, and again opened under water, noting the presence of gas in any of the chambers. The body is then elevated and water drained from the thoracic and peritoneal cavities. The coronary arteries are dissected and standard blocks[1] taken from the myocardium after the entire heart has been weighed.

6. Examination of the lungs

   The lungs are removed together with the trachea and larynx taking care not to damage the pleural surfaces. They are then reinflated through a cuffed endotracheal tube with compressed air or oxygen to a pressure of 30cm of water, producing slight over-inflation. The reinflated lungs, with the tube in situ, are then placed beneath water using a stainless steel grid to obtain complete submersion. Air leaks to the pleural surfaces and into the pulmonary arteries or veins are demonstrated using this technique.

   The lungs are allowed to collapse and are again inflated, this time using 10% neutral formalin solution. Filled and submersed in formalin, they are fixed for 48 hours before blocks are taken from the pleural surfaces of each lobe and from the hilar areas of each lobe to include the segmental bronchi and associated branches of the pulmonary artery, and intervening pulmonary veins.2

7. Abdominal contents

   The bladder is punctured from the peritoneal surface using a 10ml syringe and 19 gauge needle, and urine withdrawn. This is transferred to a plain tube and tested for glucose, blood, and protein using a test strip method (Ames). Urine is also tested for the presence of fibrin degradation products using a latex suspension test (Wellcome). The presence of fibrin degradation products in the urine, in the absence of blood, is evidence of intravascular coagulation occurring prior to death, which, in the case of a diver, is most likely due to antemortem intravascular bubble formation. Gas bubbles should be looked for in the mesenteric vessels, and blebs of gas beneath serosal surfaces. All abdominal organs are weighed and blocks taken for histological examination.

8. Spinal cord

   The spinal cord is removed intact using a posterior incision and fixed intact, after incising the dura. Care is taken to avoid artefactual changes from kinking or twisting during removal. (There appears to be no practical way of removing the cord under water, and in any event the removal of the brain and thoracic viscera allows air to enter the vertebral circulation).

9. Further examination

   The scalp incision is extended inferiorly to allow removal of the mastoids. The middle ears are opened and examined, and cultures taken from both areas. Bone blocks from ears and mastoids should be retained and fixed in 10% formalin.

   The head and neck of both humeri, and both femurs, the lower ends of the femurs and upper tibiae are removed even in the absence of radiological abnormality. This tissue should be divided longitudinally using a vibrating or band saw and fixed as for the ear and mastoid blocks.

10. Interpretation of findings

   The post-mortem findings must be interpreted with a full knowledge of the dive, diver training and experience, water conditions, equipment and its operational condition, safety equipment, circumstances of the accident and resuscitation attempts. Details such as the brand and thickness of the wetsuit, type of weight belt release mechanism, total weights, brand of tank and regulator, and residual air supply all should be recorded.

   The cause of the death can only be assessed with a knowledge of these details and the post-mortem findings. As an example, bubble formation represents a physical rather than a physiological event, and bubble formation will occur after a body is removed from a decompression chamber or brought up from depth. Thus the presence of bubbles at post-mortem does not necessarily mean that the diver died from decompression illness, and their significance can only be assessed with a knowledge of the circumstances of the accident and resuscitation attempts. The reinflation of the lungs under water is a crucial step in the post-mortem diagnosis of cerebral arterial gas embolism and without this, the diagnosis is only one of surmise.

   Even if the pathologist himself does not wish to examine all the post-mortem material, samples should be collected for evaluation by others. Decompression sickness and other illnesses associated with diving have been identified clinically for over 100 years, but their pathogenesis is still poorly understood.

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DISCUSSION

Question

Do you have post-mortem figure on air embolism in people who have actually died in diving accidents or from chest trauma?

Dr John Hayman

I have found it difficult to evaluate air embolism. I have done a series of 12 post-mortems and it is only through doing that series of post-mortems that I have reached what I think is a satisfactory technique for performing them.

In three of those 12 cases I think death was due to cerebral air embolism, and in all these cases it was mainly circumstantial evidence. It was the nature of the dive and onset of symptoms that led to that conclusion. Only in the last case was there definite evidence. The victim was an SAS diver who was diving at 15 feet in the dark, his buddy surfaced for some reason. He was left in the dark and all of a sudden he shot to the surface from 15 feet, 5 metres, down. He was diving on one of the gas rigs and there were a lot of seals in the area and it was thought he was nudged by a seal in the dark which caused him to panic and come to the surface. He convulsed as soon as he got to the surface and was virtually dead when the rescue boat reached him. So on clinical grounds at least he was a case of cerebral air embolism. And at post-mortem in his case I was definitely able to demonstrate that there was this leak in the lungs. That is the only case where I can say definitely but there were two other cases earlier on that I thought were probably due to the same cause.

Question:

What are you looking at in the retina?

Dr John Hayman

I am looking for bubbles in the retina. I have found them in patients who have blunt chest trauma; I have not found them in any of the divers that I have looked at.

Question:

Do you routinely open the mastoid when you are doing a post-mortem.

Dr John Hayman

Yes, I should have gone into that in more detail.

Question:

And what have you found?

Dr John Hayman

Nothing. When I open the skull and then remove the brain, I then go on to look at the middle ear. The incision we use goes up around the side and exposes the mastoid on the way up. There is also the question of examining the spinal cord and examining the hips, knee and shoulder joints, which are the usual sites for articular bends. My feeling is that if I am dealing with a professional diver who may well have these changes then I should go ahead and so that full post-mortem. In a professional diver and certainly one of the abalone divers I would want to get as much tissue as possible and not necessarily to look at myself but to pass on to somebody else who would be interested in it.

Dr Carl Edmonds

I would like to go on record as saying that I have slung off at pathologists for the last 15 years and I now withdraw those comments.

Dr John Hayman

I think that your slinging off at me at least would be firmly justified 15 years ago when I first went to Sale. I think I have only just acquired this experience. I would like to think that I am now much better at doing post-mortems on divers than I was 15 years ago.

ABALONE DIVING IN NSW, INCLUDING A CASE REPORT

John McKee

My first interest in abalone divers occurred some twenty-five years ago, after I had spearfished for some years, then undertaken a Scuba course, and then observed the activities, from a medical point of view, of New South Wales Far South Coast abalone divers.

In those days, it was a rather frightening observation in many ways, because of their rather extraordinary dive profiles and diving habits, which if adopted by we amateur divers would almost certainly have led to our demise.

In 1962 the first diving and medical text book; written by Stanley Miles, became available in Australia, and during my four or five years overseas I studied that book, and on my return I found that things really had not changed very much in regard to the way abalone divers behaved in the water in New South Wales.

In the early 1970s, as some of you may be aware, abalone reached a very high price, and it produced a very good income for many professional divers, varying between $500 and $1000 per week. At that time, some 10 to 15 years ago, I found that school leavers were taking up abalone diving, as a means of obtaining an income, and many of them had no training, and some tended to drink excessively at night before diving, and also take drugs. Unfortunately, in my area, when the abalone were fished out or they went too deep, some of these young men would then have a one week course in using a chainsaw, and they would then become tree fellers, and regrettably some of them came back to me as surgical patients!

In recent years regulations have come into the abalone diving industry, and in New South Wales there are now some 60 professional divers, of which 20 are on the North Coast. Those 20 tend to dive in shallow and surge conditions, whereas the 40 in my region, between Narooma and the Victorian border, dive much deeper, anywhere between 1 metre and 40 metres, although the average would be between 13 and 25 metres.

In southern New South Wales the average abalone diver, weather permitting, does three dives per day, each to around 22 to 25 metres. These usually last for one hour, following each descent, and then the diver brings up his abalone bag. After a brief rest, he then goes down again. He basically does three deep dives, of approximately one hour each, of 2025 metres, and then the final, usually fourth dive, the so-called “shallow dive”, tends to be between 8-10 metres. It is that latter dive, which for some unknown reason, seems to prevent the abalone diver from developing one of the most serious complications of diving, decompression sickness.

Abalone diving may be hard work, and in fact it is estimated that a diver who is working at about 20 metres, in reasonably heavy conditions, perhaps in one hour does as much physical work, as does a labourer doing manual work at atmospheric pressure, on the land for seven hours. The abalone diver in our area may be wearing a 20-30 lb weight belt, he may be dragging behind him an abalone bag of varying size and weight, he will have a hookah connection to the surface supply air, of between 75 to 100 metres length, and this often has to be dragged through a current of 2 to 3 knots.

Abalone divers suffer from numerous medical conditions, diving related, similar to those which may afflict amateur divers. One of the most troublesome ones is the so-called ear drum “scarring” or perforation, related to changes in pressure. The abalone diver makes frequent ascents through the water, often from great depths, bringing back bags of abalone, and as he is constantly in the water over many hours, he probably has inflamed and rather waterlogged ears. Every now and again he is subjected to an emergency free ascent, when his hose gets cut by a propeller, or the hose bursts.

Another complication of abalone diving is decompression sickness, but we have been rather fortunate in our area. Over the last eight years there have been about 15 cases of decompression sickness, of which several have been severe. All of those in recent years have survived, but until about 1975 there were a number of deaths on both sides of the Victorian border.

From a subjective point of view, abalone divers consider that they acquire a partial deafness defect, due to prolonged ear drum exposure in water and it is probably reasonable to say that in our area some 80% of the divers are afflicted in this way. Probably all veteran divers have some permanent form of ear problem, as a result of their diving. From the subjective point of view, I am told by friends of mine who are abalone divers, that as time passes, they notice that the screeching of the kids and cats is no longer an annoyance as it used to be. From the objective point . of view of their families however, when Dad comes home from a tiring day at diving, he comes into relax and turns on the hi-fi or the TV,, adjusts the volume, and then the whole family, including the cat, leave the room!

A further problem is dysbaric osteonecrosis, bone infarction from exposure to pressure, and this condition does frighten abalone divers, from the

long range point of view. They are concerned as to whether or not their repetitive dives over the years will produce a defect in or around a joint.

The abalone divers on the Far South Coast of New South Wales are far more educated than they were in the past, and they are far more sensible. Most of them are aged between 30 and 45, they have wives and children, and they take a much greater interest in their own welfare, and in the welfare of their fellow divers.

I have had one diver recently, who went through quite a lot of stress, because he had been involved in the re-organisation of the abalone industry in New South Wales, and he had been subjected to perhaps unfair harassment, verbally and in other ways. He was diagnosed as having a stress problem, he was treated with lithium, and later he displayed quite a lot of intermittent aggressive behaviour, ‘smashing up dishes and throwing furniture around, and finally crashing cars and wrecking boats. There was some doubt as to whether or not this behaviour was related to the lithium. I am interested to know whether lithium is a safe drug for divers.

DISCUSSION

Dr Carl Edmonds

Lithium has been used at depths of 1500 ft, without showing any serious effects. I would not worry about the effects of that drug under pressure at all. However, one would question whether or not lithium was the appropriate treatment for the particular medical condition afflicting that diver.

The business of divers smashing things up is very common, especially after a dive. In fact, in some other areas, such as Port Lincoln, where abalone divers are more wealthy, and as wealthy people tend to look after their property, there is one diver there who has an old car, which he goes and smashes up whenever he feels aggressive! Aggression is something that has been commonly recorded in abalone divers.

Dr Janine Mannerheim

I have a patient who has been diving for twenty years. He has been taking lithium for about six years, and he dives 200 to 300 times a year, averaging between 24 and 39 metres, and it does not seem to have made any difference to his behaviour.

Dr Peter McCartney

You mentioned that the abalone divers in your part of the world tend to collect their catch, and ascend after a long session. I have often raised this with the Tasmanian abalone divers, and to my knowledge, only two of them do that. They have developed a little rig, with snap hooks, and this allows the catch to ascend on the hookah line, although this is not an ideal thing to do. The common practice is for these divers to ascend and descend, with fairly small loads. I think this is a very dangerous practice. I have been trying unsuccessfully to get them to convert to only making a minimum number of excursions to the surface.

Dr John McKee

In our area I think there are possibly more ascents and descents, than there used to be, perhaps five years ago. Since then abalone are being bought on the shell, so there is no need for a sheller always to be aboard the boat. The sheller was often very useful if there were changes in the weather, or the Fisheries Inspector arrived, etc., etc. Since the sheller has been done away with on many of the local bats, this is a major reason for more ascents than in the past.

Dr Peter McCartney

Our divers are specifically prohibited from shelling on the boats, and that is an official Fisheries Inspector’s ruling, to ‘which they seem to adhere.

THE PUNCHDRUNK DIVER

Carl Edmonds

Unlike my other lectures, I have found this presentation to be particularly difficult. I am going to try and give an overview of this history of the problem, and a statement regarding our current position.

Some years ago, a group of divers asked me if there was any truth in the common belief of “divers’ dumbness”. Because I was not aware of any such problem, and because I had previously demonstrated that intelligence is positively correlated with success in diving courses, I had no compunction about reassuring them.

Unfortunately, the problem did not go away. More references to the “punchdrunk diver” and to the “tunnel-brain caisson worker” made me question again the possibility of brain damage associated with excessive diving exposure. Indeed, I began to believe that the reassurances I had given may only have served to conceal my ignorance.

About the same time, a group of navy wives contacted the Royal Navy Physiological Laboratory, complaining that their husbands had appeared to suffer from a variety of disorders associated with their saturation diving. Of the seven husbands (divers) concerned, six appeared to have an atypical or sensitive response to alcohol, five showed aggressive behaviour and short temper, four had an inability to concentrate, tiredness, short memory, visual problems and a disinterest in appearance. Three were said to be secretive, slow and anxious, two had an inability to communicate, and one had become antisocial.

This type of anecdotal information is very difficult to evaluate. Certainly, the same type of things had been said amongst the wives of our own professional abalone divers, many of them stating that the husbands were very irritable, aggressive, non-communicative and inconsiderate following their diving day. The director of one of our major abalone co-operatives has stated that he would not consider contacting the diver after his day’s work, even to transmit good news. “Phone him up that day, and you get into a fight, phone him up the next day and he is very reasonable”.

Literature

It is not difficult to summarise the literature on this subject. There is not much of any great note. In one series of papers, it appeared as if divers who suffer severe neurological decompression sickness are likely to become effected to some degree.

Rozsahegi, in 1959, from the Hungarian Institute of Industrial Medicine, examined 100 subjects between two and a half and five years after they had developed neurological decompression sickness and over half were said to have had some form of neuropsychological disorder. He pointed out that three quarters of these patients had evidence of neurological disease on clinical examination. He also noted that, often quiet men would become irritable and uncontrolled after the injury. Pathological drunkenness and alcohol intolerance were also frequent.

From Hawaii, Peters, Kelly and Levine, showed neurological and psychological problems following decompression sickness affecting the central nervous system. Of the ten cases, two had no neurological deficits, and eight had evidence of such damage. Unfortunately, all patients had litigation proceedings underway, and this may have influenced the psychological assessments.

Beirsner and Rynan showed a psychiatric incidence rate in the US navy divers, of twice that of the normal diving control group.

Vaernes and Eidsvik in 1982 in Norway, showed neurological damage after diving accidents, related often to cerebral gas embolism or hypoxia. Eight out of the nine divers showed some abnormalities on a barrage of neuropsychological tests, and five of them had specific memory defects.

In a symposium held on the long term neurological consequences of deep diving in 1983, at Stavanger, Norway, it became clear that many attendees believed that the long term neurological abnormalities were absent, rare or transient. In fact, the question is now enmeshed in the problems of litigation in the USA, and it has almost become a matter of which expert you wish to buy, to prove your position on this subject.

At the Stavanger symposium, there had been apparent acceptance of the neuropsychological complications of diving with compressed air at shallow depths, even though it appeared no consensus was reached regarding the deeper diving, and the complications of that.

Even though it is obvious that brain damage could result from neurological decompression sickness, it does not follow that the average or even the extensive professional diver has a significantly increased likelihood of this problem developing. Comex representatives claimed that, after 13,000 professional dives and 3,000 saturation dives, they were adamant that there was no neurological or neuropsychological complications. It appears as if the administrators at the deep diving unit at Duke University also have the same approach.

Dementia

Permanent brain damage leading to a deterioration of intellectual capacity is described as dementia. To demonstrate that dementia has developed, it is necessary to measure the degree of deterioration in intelligence.

This requires a knowledge of intelligence and its measurement. I shall explain some of these tests later, but at this stage, I would like to dispense with some popular misconceptions. Some think that, because a diver is young, he will be able to overcome minimal brain damage. Unfortunately, the opposite is probably the case. Regeneration does not develop in the central nervous system. It may well be that he can reorganise his current functions and abilities to give the appearance of improvement, but the tissue which has been irreparably damaged, will not regenerate.

Another belief is that, if you have had brain damage and get over it, you are then all right. Unfortunately, such is not the case. We all have a certain potential of intelligence, an innate ability, and once a part of the brain has been damaged, and the potential diminished, this is going to show up with increasing age. If you lose intellectual potential at a young age, then you are closer to the threshold at which the subsequent brain damage, dementia, or senility, will occur.

A characteristic of brain damage is the "drop and rise" effect. There is an immediate impairment of intellectual function which will appear to improve as time goes by. It may take half to two years before the subject is apparently normal. Even when he is back to his apparent normality, he is then much closer to the threshold at which dementia can and will occurring the future. In fact, it has been estimated that about 50 ml of brain tissue needs to be destroyed before the threshold is reached. Whether brain is destroyed by decompression sickness, carbon dioxide toxicity, hypoxia, arterial disease or age the results are summated.

The measurement of intelligence

There is no direct measurement of this faculty. Some cynics have suggested that "intelligence is what intelligence tests measure". This somewhat cyclical argument is meant to avoid the definition of intelligence.

There are a variety of acceptable ways in which brain function can be measured. Apart from a good history and clinical examination, a variety of electrophysiological tests are available. These include the electroencephalogram, evoked cortical potentials involving visual and/or auditory stimuli, somatosensory evoked cortical potentials, etc. These may often reflect the dysfunction of both peripheral and central sensory functions as well as the ascending reticular activation systems.

A variety of other neurophysiological tests can be given, including the fusion of flicker frequency, reaction time and complex interactions between learning curves and reaction times.

Other clinical investigations are also possible, including such established procedures as angiograms, pneumoencephalograms, CAT scans, NMI and PET investigations.

Perhaps the most established method of assessing intellectual deterioration is to use the intelligence tests. These are very highly standardised investigations, and they will often measure different aspects of intelligence. Probably most of you remember the WAIS. This is an internationally established test which will allow testing of specific intellectual functions.

Some aspects of intellectual function are better preserved than others, following injury. Verbal fluency is likely to be retained, long after the ability to perform new functions has dropped. It you were to become demented at the age of 30, then the words that you had learnt would remain with you fairly well. Only when you become very senile, will you actually forget those words. In lesser degrees of dementia, the verbal fluency is retained. That is why old people talk so well, they can outtalk the younger ones. Their verbal fluency is still good, but their ability to handle new information is not.

We can thus say that their conceptual ability or their intellectual performance in handling new problems is impaired, but their verbal intelligence is unimpaired. These things are comparable, so that if one looks at the WAIS and finds that, the verbal intelligence and the performance intelligence is about the same, then that intellectual deterioration is unlikely. If, however, verbal intelligence is 140 and the performance is 100, then that infers a dementia with a loss of approximately 40 IQ points. This is a gross over-simplification, but it demonstrates the concept of comparing different sorts of intelligence.

In fact there are a variety of sub-tests for Intelligence, and if enough of these tests are done, then one can obtain a profile of the intelligence. Different profiles may well be consistent with different types of injury, eg. carbon monoxide poisoning, hypoxia, etc. Unfortunately, we are not aware of the type of profile that would be consistent with multiple cerebral arterial gas embolism or decompression sickness.

The number of neuropsychological tests have increased in sophistication, and require trained administrators to perform them.

CURRENT INVESTIGATIONS

Background

We decided to look at a different population from those previously studied by others. In Australia, litigation is not a terribly important point. Most of the extensive divers are those involved in the abalone industry and these are self-employed people to whom compensation is not a factor.

Also, the question being considered was not whether a severe neurological decompression sickness could produce brain damage. The question was whether long term diving is likely to result in this problem, without a gross neurological decompression sickness incident.

The Studied Population

Because we wished to find out whether diving produces intellectual impairment, we decided to study not the average diver, but the type of diver who would be most likely to be affected by a diving related illness, ie. one who performs an enormous amount of diving. The rationale behind this was that of the Null hypothesis.

By selecting the most extreme of the diving groups, we could reasonably conclude that, if the investigations showed no significant abnormality, then it is unlikely to be a major problem amongst the lesser exposed diver.

I was aware of Rozsahegi's similar concern for his caisson workers, but I must admit to believing that his data was not applicable to our divers. Perhaps I was too rash in this judgement, and I should also have made more allowance for the complexities of the problem. Nevertheless, I decided to look into this more closely when the opportunity arose. Now that I am no longer in full time practice, or have to fight for research approvals, I can follow up these whims.

"Chance favours the prepared mind" (Pasteur). Within a few months, Chris Lowry and I headed off to Twofold Bay, at Eden, to test out some of our hypotheses on a very special diving group. One hypothesis was: if this group showed no evidence of dementia, with the enormous diving exposure they had, and with their flagrant disregard for decompression requirements and safety aspects, then dementia was not likely to be a widespread complication of diving.

In New South Wales, Australia, abalone divers are a closed community. They were obliged to register for licences in 1980, and a prerequisite was to have had three years full time professional abalone diving prior to that. Thus the minimum duration of diving was six years, without any formal training being required. They tended to be ex-fishermen, from small fishing families, who had moved from their previously profitable and traditional occupation to the more lucrative abalone industry, taking with them their maritime skills, but little else.

The diving was strenuous, with the divers carrying bags of abalone and enduring the tidal drag on their long hoses, for most of the dive. Each diver would average approximately 100 days diving per year and in each diving day, he would be underwater for a total of four hours, and this was unrelated in any way to his depth. The average depth would be about 60 feet and the surface intervals vary from ten minutes to one hour, being the time required to move his boat to another area. No decompression staging was performed.

Results

Of the 31 divers who were tested, 6 had to be removed for technical reasons. Of the remaining 25, 12 showed no evidence of intellectual impairment whatsoever compared to their previous status, and adjusted for age. In one case the results were questionable. In the remaining 11, there was evidence to support the possibility of dementia.

Obtaining the co-operation from such an independent group was not easy. Chris and I gave some lectures, especially tailored for these divers and their type of diving. We socialised with them, windsurfed with them and finally we dived with them (but we decompressed along conventional lines). We gained their full co-operation when we admitted our ignorance regarding many of the questions related to the diving industry, eg. personality profile of people who were more likely to be successful divers, people such as themselves. With a little praise and some soft talking, they agreed to assist us by undergoing some of our tests.

Present Study

Because of the Eden data, there was no alternative other than doing a full scale investigation encompassing many of the neurological and electrophysiological tests referred to earlier, and combining them with a much larger battery of neuropsychological tests performed by experts in each area.

This is where we are at the moment. We are carrying out a great number of neurological investigations including EEG, CAT scan, neurophysiological tests such as fusion of flicker frequency, and the Sternberg reaction time investigations. We are also performing a whole battery of psychological tests, both on divers and controls, to clarify the findings referred to above.

As a separate but integral part of the investigations, we are also testing subjects who have recently been affected by decompression sickness (neurological type) and decompression sickness (non-neurological type). The data is pouring in, and the little computer is running hot.

Different skills are represented in the survey, to ensure that there is no consistent bias. Neuropsychologists, behavioural psychologists, neurologists, psychiatrists, electrodiagnosticians and diving physicians have all had an input, both in design and in the assessment of the abalone divers from most states of Australia, and the amateur divers who have required recompression therapy from the Royal Australian Navy School of Underwater Medicine.

Comparing the results of these groups and correlating the findings with the degree and type of diving exposure, should allow us to draw conclusions about the possible relationship of diving with dementia.

MORE ON THE SPONGE DIVERS OF KALYMNOS

John Hayman

Kalymnos is a small island measuring approximately 30 km by 15 km in the eastern Aegean, very close to the shore of Turkey. Is roughly comma shaped, the comma being inverted and very mountainous and barren. The only commerce that exists, exists because of the excellent port facilities which are available on the island. There is very little agriculture apart from a few citrus trees; most of the place consists of rock. The population is about 15,000 of which 14,000 are in the port of Kalymnos, which is in the south side of the island.

The island is very close to the island of Kos, which is quite famous because of its association with Hippocrates. You can get to Kos very easily, it has an international airport and there are regular flights from Athens, as well as international flights from various places in Europe. From Kos you travel to Kalymnos by ferry and there are two or three ferries each day as well as other ferries which travel to other islands in the Aegean.

Kalymnos is the home of sponges and these sponges are sold throughout Greece. They are sold throughout the world and virtually every natural sponge that is sold has made its way through Kalymnos. Sponges have a long history and have been part of human civilisation for many centuries. They were used in Roman times as padding for armour and even before Roman times they were used as contraceptive devices. They certainly are a very versatile material. The Kalymnians have gathered sponges for centuries. Originally they collected sponges from boats where they could hook them directly from the water. They could look through glass and with a long boat hook, pull them in. As time went on the sponges became less numerous and they had to go deeper and further afield. Nowadays, the sponge fleet does most of its sponge gathering off the coast of Libya. There are several small fleets which operate from the harbour and they are not all away at the same time. The sponge season lasts about 6 months and during that time, the five or six fleets are away for about 3 months at a time, some coming back and then going out again, and some staying away for the whole six month period.

Near the harbour there is a small sponge factory close to the church. The sponges are laid out on the wharf to dry. The harbour is also used for fishing and most of the boats there when we were there were fishing boats. Most of the sponge gatherers were at sea and only the veterans remained. There is a rather stylised statue of a diver in the square immediately adjacent to the harbour. Most of the population live in that tiny portion of the island and most of the population, if they are not looking after the tourists, are concerned with the sponge trade or the fishing trade.

As well as the main port of Kalymnos, there is a smaller port around on the eastern side, called Vathis. This is a very much smaller port, with very clear water, suitable for diving but there are no air filling facilities on the island. You can snorkel with some success in the little estuary there. There are the remains of an Italian merchant vessel which was sunk by the RAF at the opening stage of WWII.

On the other side of the island, on the western side, there is the island of Telentos. It consists of a large rocky pinnacle with the little town at the bottom. Telentos is separated from the small settlement of Massouri on the west coast of the main island by the narrow straits of Telentos. It is reputed that there is the sunken city of Telentos in the channel between the two islands. It is quite a deep channel, I had a look for the sunken city without success. My efforts were rather derided by the locals in Telentos. I was assured it does exist. There is a little ferry which goes between the two islands, it shuttles backwards and forwards about once every 20 minutes and the fare is $1.00. The small village of Tetentos is very attractive. As well as the main village, there are the ruins of other settlements on the island which date back before Roman times. Many of these settlements are still used by shepherds and other people. You can see on the waterfront Roman ruins going down into the water. It is believed that this channel formed around about 2,000 years ago when the land sank and the original city of Telentos was flooded. Telentos has its own fishing fleet as well as a sponge gathering fleet which was at sea when we were there.

Most of the residual adult male inhabitants of Telentos were severely affected by decompression sickness in one shape or form. At least two older people both had the sequelae of severe decompression sickness. One man was beating a squid using his left hand. He was paraplegic and as well he had a fixed flexion deformity of his right hand. Still photographs do not depict the disability of these people very well. It is when they try to walk that you appreciate just how severely handicapped they are. One retired diver who still goes fishing, can only walk with the greatest of difficulty. He has a fixed extensor spasm in both legs. It would be ideal to have a movie camera to show how these people do get around. They are very affable, very kindly, friendly people who certainly do not mind being photographed or showing their disabilities.

When we were there, there was only one restaurant and hotel open at the time and we were the only people staying at the place. It was a combined “guest house and restaurant with a liquor licence”. The proprietor is a man in his 40s who was severely afflicted by the bends when he was aged 17. Now he has severe spastic paraparesis and in addition he has a gross arthritic deformity of both knees. He was quite happy to let me examine him, but as you know, by trade I am a pathologist and not a neurologist. The deformity was such that you would find in a Charcot’s joint. There was gross arthritic deformity and yet no pain, and he seemed to lack any position sense as far as his toe or foot was concerned. I concluded that he had not only motor paralysis but also dorsal column loss. His condition had been virtually unchanged since the age of 17. There is no opportunity for remedial therapy or any form of surgery available in the islands.

The island of Kalymnos now not only processes its own sponges but takes sponges from Cuba and the Carribean and is the main centre for processing sponges throughout the world. The sponges are soaked in hydroxide and potassium permanganate solutions. I do not pretend to understand what happens, but the process involves getting rid of the organic matter which is present and leaving only the clean fibre. The sponges, as well as being cleaned, are trimmed to various sizes. The final trimming is using a pair of sheep shears. Finally the sponges are sorted according to different types. It is the large, round sponges that are very valuable and these are now found at the greatest depth. The sponge divers in fact, work for long hours, perhaps up to six hours a day. The deeper they dive, the better the sponges, so there is an incentive for them to dive deeper and stay there longer with the results that we have seen. Many of the sponge factories, there would be about 10 in the main city, have various momentoes of the past, including old type of diving helmet which they used. They are probably relics from the French or British Navies. There are also relics from even earlier times and they are strewn around with some disdain. They are used as doorstops in the houses although quite clearly they are tile genuine article.

The sponge boats are all brightly coloured, are very attractive vessels, but no bigger than the boats we have been on board today. The compressor is usually in the hold of the ship and is driven by the main engine in the boat. It does not have a separate engine. The air intake is in the hold also. There is no separate air intake in the bow of the boat. There is an accumulator on top of the cabin, usually with two hoses for the divers. The arrangements for the divers seem to be extraordinarily primitive. Most of the masks look to be old gas masks that have been cut down to size. It is joined to a length of garden hose, with the hose attached to a length of copper pipe and then to a mouthpiece by rope. On the other side of the breathing apparatus there is a piece of soft rubber, perhaps a piece of old bicycle hose, which seems to act as a valve so that any excess air gets blown off. The garden hose is tied to the belt and then passes on to the mask itself. These may have two divers working from the one compressor down at the same time. As they are both relying on the one air supply, admittedly there is an accumulator, their chances of being able to help one another if the compressor broke down would be fairly remote. They dive using this type of apparatus to depths of about 120 to 140 ft. I was told by one person that they went down to 200 ft but I find that hard to believe. They dive for up to 6 to 8 hours per day. They dive for weeks on end.

The island itself has some 16 doctors, one of whom describes himself as a pathologist, but I think he is in fact a general practitioner who does tests in a side laboratory. There is a recompression chamber of some sort in the local hospital. But as these boats are working off the coast of Libya and there are no facilities of the coast of Libya that they are aware of, the recompression chamber on the island of Kalymnos is not of much value to them.

I saw a diver using the apparatus, cleaning and painting a boat in the harbour. It worked with the excess air being bypassed and he just took air as he needed it. There is a basket that goes down with the diver. He puts the sponges in this and it is drawn up to the surface while the diver himself stays at depth.

On the island of Kalymnos there is a cross erected to the memory of those who have lost their lives at sea. On average (this information came from the pathologist on the main island) they lose two or three divers each year, and up to 10% of the divers suffer some disability each year from diving. It seems a tremendous mortality and morbidity, but when you look at the type of equipment they use, you can see that the possibilities for disaster are considerable. Not only do they suffer the possibility of barotrauma from coming up quickly and the bends for staying down at such depths for such lengths of time, but the equipment seems very primitive and liable to failure. With that type of breathing apparatus they could develop carbon dioxide retention as well as carbon monoxide poisoning from the fumes in the hold.

DISCUSSION

Question:

Do you have any idea why the equipment has not been updated. After all this is not a very poor community. Is it just a slavish adherence to tradition or is there some specific reason why new technology has not been introduced?

Dr John Hayman

I really do not know. I think that it is a very traditional community. I think that the art as it is has been handed down from father to son, but I think things are now being improved. Some divers go to Marseilles for training at the school there and I know there is a team that comes out from the Massachusetts Institute of Technology once a year to survey the divers to see what has happened. However I do not think they have actually improved their techniques to any great extent. It is surprising and I was horrified to see the type of equipment that was used. But the island itself is very primitive in many regards. There is no scuba gear available anywhere in the Greek Islands apart from Rhodes. This is their only industry. The only thing they can do for a living is to go and gather sponges and the only place to get them is to go diving off the coast of Libya. My only regret is that there have been no post mortems. It is really a pathological paradise with all those cripples walking around the place. Unfortunately, they are very reluctant to have post mortems. A very large number of Kalymnians have migrated to Australia and most of them are living up in Darwin. I am hopeful that some of the ex-divers may also be there, and I may be able to collect some pathological material in Australia. Apparently the Kalymnians are doing very well in Darwin. They own most of real estate and the real estate agencies as well as the fish and chip shops.

The Greek sponge beds have been fished out entirely and it is only the very poor quality sponges now that are found around Kalymnos itself. If it was left entirely to Nature I do not know how long it would take for the sponges to come back. But one problem with the Mediterranean now is that it is so polluted. There is so much oil and rubbish floating around that you just wonder whether the sponges would survive anyhow.

Question:

Could the man with the Charcot's joints have had syphilis?

Dr John Hayman

There is no need to invoke syphilis to explain the man's Charcot's joints. All one needs to develop Charcot's joints is lack of pain sensation.

There was a pathologist on the island and he did do tests, but whether he was actually tested for syphilis I do not know. I do not think the joints were syphilitic. I cannot produce any evidence, but it is a fairly traditional community and they are not normal seafarers in that regard.

He had a definite sensory loss which could best be explained by spinal cord decompression sickness. He had horrible knees. As I moved them up and down they made a terrible crunching noise which you could have heard from 3 or 4 feet away. But it did not bother him at all. He certainly had loss of position sense in his foot. A lot of the disability would be due to secondary osteo-arthritis.

It really needs a team to go in and assess these people, not only a neurologist but also a radiologist. It really is a goldmine of diving related pathology.

THE BANDOS NIGHT DIVE

'Twas on the stroke of eight o'clock
In those islands of the moon
When Herwarth shouted "Tally Ho"
And not a bit too soon.

For sixty men and women bold
Each donned their BCD
Then, like a pack of lemmings
Marched, backward, through the sea.

Atop the dropoff, thumbs went down
Vent hoses were held high
When all at once rude torch lights
Pierced the evening sky.

So now the party has begun
And chaos was to reign
As drunken glowworms wandered
'Cross the undersea terrain

Like search lights in an air raid
Spotting bombers in the blue
The waters of the Bandos reef
Resembled World War II.

Corals crashed, fishes fled
Crayfish ceased to creep
Even fearless reef shark
Retreated to the deep.

No one knows what havoc
Took place beneath the foam
But sixty minutes later
The raiders left for home.

As years go by and divers
Hang up their fins and masks
They'll still remember '85
And SPUMS night diving farce.

PROVISIONAL REPORT ON DIVING-RELATED FATALITIES IN AUSTRALIAN WATERS, 1984

Douglas Walker

SUMMARY

There were four breath-hold diving fatalities identified in 1984, twelve scuba divers and one hookah diver. Two of the incidents resulted in double fatalities, though in one of these a higher toll was only averted through the skill of those involved and their avoidance of panic under extremely adverse conditions. Of particular interest is the fact that two of the victims were found to have an asthma type problem which was apparently quite unsuspected by their fellow divers, however examination of the events shows that the outcome could well have been the same even in the absence of such a factor. Cardiac problems were almost certainly critical in several cases. The occurrence of the fatal dissecting aneurism of the ascending aorta (Case SC 84/7) was an example of an undetected/undetectable fatal situation presenting during a carefully conducted dive, a tragic event occurring during a dive but almost certain to have occurred however quiet a life style he had followed. Case SC 84/11 may be usefully treated as the basis for a discussion of the responsibilities devolving on anyone who organises a dive, particularly if they hold instructor status, and the importance of buddy diving procedures, using a J-valve rather than a contents gauge, the value of buoyancy vests, and whether boats should be left empty while divers are below. These are all matters of significance when the diver runs into trouble.

CASE REPORTS

All these reports are based on depositions provided by those involved to the police investigating the incident or told to the Coroner, though sometimes other sources have been available to aid clarification of certain aspects of the events.

Breathhold divers

Case BH 84/1

Although he had trained in scuba diving his choice was breath-hold diving, which he had been doing for over 20 years. On this occasion he took a scuba diving friend with him in his 3.6m (12 foot) outboard aluminium dinghy. The dive site was off some cliffs where there was a large boulder "bommie" separated from the rock platform by a channel, a good place for crayfish but only divable in the period 3/4 to full tide, being too turbulent at other times. This day was calm though an unusual wind direction resulted in a more than usual water run off into the channel from the platform.

They were diving separately, the scuba using friend being a keen underwater photographer and the victim a breath-hold diver. The friend who was slower equalising his ears, saw the victim dive past him, which was the last time he saw him alive. When he returned to the boat he found several fish there and assumed that the victim had changed from spearfishing to hunting crayfish in the channel. The friend reported that the victim was missing but darkness prevented any search till the next day. The body was washed ashore, minus weight belt, nine days later. It is probable that the power of the water coming off the rock platform was more than he expected and held him underwater until he drowned, then washed the body away.

EXPERIENCED BREATH-HOLD DIVER. UNRECOGNISED SIGNIFICANT EXTRA WATER FLOW OFF ROCKS INTO CHANNEL. SPEARFISHING/CRAY FISHING. NO BUOYANCY VEST. SEPARATION/SOLO.

Case BH 84/2

Like most visitors to the Barrier Reef, the victim joined a day trip to a Reef cay. The boat anchored near the beach and passengers were offered the loan of fins, mask and snorkel for swimming ashore, or ferrying in a dinghy. The victim looked rather elderly and was pressed to accept the dinghy ride, but declined. He was urged to wear a life jacket and refused this offer too. They all swam independently in the calm water towards the beach and no signal or sign of distress was noticed by those on the boat until the man in the dinghy realised the victim was too stationary and not just watching the underwater scenery. He quickly motored over and jumped into the water to offer assistance. It was possible for him to stand on the bottom there. He commenced EAR and towed the victim ashore where others with knowledge of resuscitation gave assistance. Some response was obtained but not sustained. His previous health and snorkel swimming experience is unknown but the observation that he was dog paddling rather than finning suggests total inexperience. Autopsy revealed evidence of acute coronary insufficiency (a cardiac death).

INEXPERIENCED SNORKEL USER. ELDERLY. CALM SHALLOW WATER. ON THE SURFACE. NO INDICATION OF DISTRESS. REFUSED BUOYANCY AID. SOLO. RAPID EFFICIENT ASSISTANCE ONCE THE PROBLEM WAS SUSPECTED. HEART ATTACK.

Case BH 84/3

Three employees at an island resort decided to go spearfishing to obtain fish for the 21st birthday party being prepared for another employee. They used one of the resort's small aluminium dinghies to reach the dive area, anchoring 18m (60 feet) off the rocky shore. The fourth member of the party, a non diver, remained in the boat as they dived. All returned to the boat to rest about 1 hour, the victim well pleased with his successful hunting. He entered the water again after 10 minutes, followed in a couple of minutes by one of the others. They were diving independently about 100 feet apart. When the buddy saw a large Queen Fish swim past towing the victim's gun he retrieved gun and fish (which had been hit in the abdomen so been able to swim strongly to seek to escape) and placed them in the boat then started to search for his friend. The visibility was 15 feet and the current slight but a surface chop reduced ability to see anything at the surface. When his search proved to be unsuccessful, other divers were summoned and an air search was made. The body was not found until next morning when a search was organized using a grid pattern.

When found, in 15-17m (50-55 feet) deep water, his mask was in position, snorkel in his mouth, and weight belt on. The circumstances point to this being a post-hyperventilation blackout drowning incident, his known ability to dive to 12m (40 feet) and the evidence of the fleeing fish being supportive of this diagnosis. It was difficult to drop his belt to assist recovery of the body because the weight belt's end had been tucked in, making quick release impossible.

EXPERIENCED BREATH-HOLD DIVER. FISH SPEARED NON-FATALLY AND ESCAPED TOWING GUN. WEIGHT BELT NOT CAPABLE OF QUICK RELEASE. SEPARATION/SOLO. POSSIBLY POST-HYPERVENTILATION BLACKOUT.

Case BH 84/4

During an interclub spearfishing competition the victim and three others were diving from a boat moored in calm water 20 feet deep. After about 45 minutes one of the group happened to notice that the victim's line was hanging down from the boat and swam over expecting to find him in the boat. He found 3 or 4 fish on the catch line and the float line hitched over the outboard motor, the spear gun hanging below. The victim's snorkel was later found in the boat. When the second diver looked down she saw the victim floating below her just above the sea floor. At her second attempt she managed to reach and release his weight belt and bring him to the surface, and her cry for help brought the other two divers to assist her. They got him into the boat and commenced EAR and ECC and sent a call for help via a nearby boat's radio. Police and helicopter rescue services soon arrived but resuscitation attempts were unsuccessful.

Autopsy showed the cause of death to be drowning. There was also some fibrous replacement in the interventricular septum. Although the coronary arteries and aorta showed relatively little atheroma the circumstances of the incident suggest a sudden incapacity, and the hitching of the spearfishing equipment on the boat indicates a probable awareness of illness, so a cardiac problem, possibly angina, is a highly likely critical factor. He had a reputation as being one who did NOT practice hyperventilation. No details of his previous health are available. A buoyancy vest would have made it possible for him to avoid drowning even though incapacitated by illness.

EXPERIENCED BREATH-HOLD DIVER. SPEARFISHING COMPETITION. NO BUOYANCY VEST. WEIGHTS ON, NO SURFACE COVER. SEPARATION/ SOLO. SUDDEN INCAPACITY AFTER BEING FIT ENOUGH TO SPEAR SEVERAL FISH. PROBABLE INTIMATION OF ILLNESS. RESCUE AND RESUSCITATION ATTEMPTS EFFICIENT. EVIDENCE OF PREVIOUS MYOCARDIAL DAMAGE.

<u>Scuba divers</u>

Case SC 84/1

Two friends of many years decided to go recreational scuba diving together. The victim was a large, strong man involved in a number of active sports who claimed to have acquired scuba diving experience over the past year and had his own equipment. His friend, who had been diving for about 20 years, was using borrowed equipment. Neither had received formal instruction, which was the reason for the buddy being unable to hire scuba. Nevertheless they were able to obtain air fills. During this dive, their 2nd or 3rd together, the victim indicated that his reserve lever had become displaced and the buddy pulled it for him before they started their return swim underwater. Separation soon occurred and when the buddy came to the surface he saw the victim apparently standing on the rocks in waist deep water, then both were hit by a wave. The buddy managed to stagger ashore, fatigued, after ditching his weight belt, then he took off his backpack lest he be washed back into the water from the rocks. There were other divers and some children nearby and he expected that they would assist his friend ashore. Apparently a little later the victim was seen floating unconscious, moved by the surge of the water, by a more distant diver while those nearby appeared oblivious to these events. The weight belt was still on, though witnesses stated the contrary (demonstrating the fact that eye witnesses may be fallible). He did not respond to efforts to resuscitate him. Witnesses also differ concerning whether he wore a (deflated) buoyancy vest.

His medical history revealed an occasion a year previously of an episode of "wheezy bronchitis" but no other significant ill health, though hyperlipidaemia had been noted. He was neither regarded nor treated as having "asthma" and not prescribed ventolin. The reports which circulated after this fatality concerning finding a ventolin unit in his bag were not mentioned at the inquest and at the autopsy there was no histological evidence of asthma. A detailed examination of the heart discovered a significant degree of atheroma in the left coronary artery and histology revealed the unexpected presence of both old and recent myocardial damage. The cause of death was by drowning.

UNTRAINED. EXPERIENCE UNKNOWN. WASHED OFF ROCKS BY WATER POWER. UNCERTAINTY ABOUT BUOYANCY VEST. OWN EQUIPMENT. NO CONTENTS GAUGE ON 62 CU FT TANK. BUDDY ACTIVATED RESERVE AS VICTIM COULD NOT REACH LEVER ON RESERVE BEFORE THE PROBLEM AROSE. EVIDENCE OF HEART DISEASE. POSSIBLY LIABLE TO ANGINA WITH SEVERE EXERTION.

Case SC 84/2

The victim and a friend were diving at night to retrieve golf balls from a water hazard on a golf course. As the victim broke the surface (or possibly a little later) a shot was fired. The other diver immediately yelled out "DON'T SHOOT!" lest he be shot. The person charged claimed that he had been after ducks and had seen the surface change through his telescopic rifle sight so fired. The case has not yet been formally tried so it is neither possible nor correct to discuss the matter further.

SHOT WHILE MAKING A NIGHT DIVE FOR GOLF BALLS.

Case SC 84/3

Experienced diver with Cat 2 cave diving certification.

Case SC 84/4

Experienced diver, some cave dive experience: no CDAA test.

This double fatality illustrates the special care required by those entering sink hole waters where cold, narcosis, visibility loss, restricted space and impossibility of a frantic

AUSTRALIAN DIVING RELATED FATALITIES 1984

CASE	AGE	DIVE SKILL VICTIM	DIVE SKILL BUDDY	DIVE GROUP	DIVE BASE	DIVE PURPOSE	WATER DEPTH M (FEET)	DEPTH INCIDENT M (FEET)
BH 84/1	44	Experienced	Experienced (Scuba)	2 Separation	Boat	Crayfish	N.S	N.S
BH 84/2	68	Inexperienced	N/A	Group solo	Boat	Recreation	1.5 (5)	Surface
BH 84/3	19	Experienced	Experienced	3 Separation	Boat	Spearfishing	15 (50)	N.S
BH 84/4	62	Experienced	Experienced	4 Separation	Boat	Spearfishing	6 (20)	N.S
SC 84/1	41	Inexperienced Just Trained	Experienced Not Trained	2 Separation	Rock	Recreation	6 (20)	Surface
SC 84/2	25	N.S	N.S	2	Land	Golf balls	?	Surface
SC 84/3	28	Experienced CD2	Experienced CDX	2	Land	Recreation	70 (230)	60 (200)
SC 84/4	30	Experienced CDX	Experienced CD2	2	Land	Recreation	70 (230)	60 (200)
SC 84/5	31	Inexperienced Not Trained	N/A	1	Rock	Crayfish	N.S	Surface
SC 84/6	25	Experenced Trained	Experienced Trained	3	Boat	Recreation	18 (60)	Ascent
SC 84/7	20	Experienced Trained CD2	Experienced Trained CD2	2	Land	Recreation	42 (140)	42 (140)
SC 84/8	33	Experienced Trained	Experienced Trained	4 (9)	Boat	Recreation	21 (70)	12 (40)
SC 84/9	22	Experienced Trained	Experienced Trained	4 (9)	Boat	Recreation	21 (70)	12 (40)
SC 84/10	21	Inexperienced Trained	N/A	1	Dock	Work	10 (33)	10 (33)
SC 84/11	26	Inexperienced Trained	Inexperienced Trained	2 (14) Separation	Boat	Recreation	24 (80)	N.S
SC 84/12	30	Experienced	Experienced	3 Separation	Boat	Recreation	48 (160)	48 (160)
H 84/1	27	Experienced Not Trained	Experienced Not Trained	3 Separation	Boat	Work	16 (54)	Ascent

KEY
CD2 = Qualified as category 2 Cave Diver
CDX = Unqualified but with some cave diving experience
Trained = Had completed a course of instruction
Just Trained = Had just completed a course of instruction
N.S = Not Stated
N/A = Not Applicable

AUSTRALIAN DIVING RELATED FATALITIES 1984

WEIGHT BELT KG (LB)	WEIGHT BELT POSITION	CONTENTS GAUGE	BUOYANCY VEST	REMAINING AIR	EQUIPMENT TESTED	EQUIPMENT SUPPLIER	WET SUIT	SIGNIFICANT FACTORS
N.S	N.S	N/A	No	N/A	N/A	Own	Yes	Water power in narrow channel. Separation/solo; more than usual runoff water.
None	None	N/A	No	N/A	N/A	Loaned	No	Tourist. Swim to sand cay, calm shallow water. Refused offer of vest. Heart attack.
5.5 (12)	On	N/A	No	N/A	N/A	Own	Yes	Spearfishing, hit fish in belly and it fought hard. Blackout.
N.S	On	N/A	No	N/A	N/A	Own	Yes	Solo return, placed equipment in boat. Presumed to have had a heart attack. No buoyancy vest so drowned.
7.5 (16)	On	Yes	No	Nil	Yes	Own	Yes	62 cu ft tank. Separation expected. At surface hit by wave. Possibly asthmatic. Heart disease fatality.
?	?	?	?	?	?	?	?	Searching for golf balls in a dam. Shot by duck shooter at night.
7 (15)	On	Yes	Yes	Nil	Yes	Own	Yes	Little sleep with an early start to avoid the ranger. No permit. Excessive depth and weights.
7 (15)	On	Yes	Yes	Nil	Yes	Own	Yes	Danger grade dive. Nitrogen narcosis. Cold. Dark. Excessive loose line. Return wrong side rock. Entangled.
N.S	N.S	N.S	No	Low	Yes	Own	Yes	Buddy leaky hose, no dive. Swell and breakers sea dangerous.
9.5 (21)	On	Yes	Yes	Low	Yes	Own	Yes	10 divers. "64" tank so planned solo ascent. Inflated vest ascent. CAGE. Delayed death. Asthmatic.
N.S	On	N.S	N.S	N.S	No	Own	Yes	Careful diver. Pre-dive feeling of chest tightness. Pain at depth. Taken to hospital. Delayed recognition serious illness. Aortic rupture.
13 (29)	On	Yes	Yes	N/A	Yes	Own	Yes	Two Groups (4+5) in sea cave. Wrong cave. Hit by swell. 2 died trauma.
10 (22)	On	Yes	Yes	N/A	Yes	Own	Yes	Damaged tanks vented air. Successful rescue of 2 others.
9.5 (21)	On	No	No	Nil	Yes	Employer	Yes	Used small "get-home" ungauged tank to dive narrow dark area. Poor air supply from tank. Solo. Inexperienced.
7 (15)	On	No	No	Low	Yes	Hired	Yes	End of course dive; instructor took no responsibility. Not in favour of strict buddy discipline, nor vests, nor contents gauges, nor surface cover. Separation. Solo. Speared cuttlefish. Out of air.
8 (17)	On	Yes	Yes Faulty	Ample	Yes	Own	Yes	Had previously dived this wreck. Separation on wreck. Twin tanks. Plenty of air. Buoyancy vest had defects. Nitrogen narcosis? Boat well prepared for diving, but no radio.
N.S	On	N/A	No	N/A	No	Employer	N.S	Pearlshell collecting. Suddenly pulled himself up line to surface. CAGE. Old and recent pleurisy noted.

rush for the surface add to the usual problems of diving. The approach to this problem by the Cave Divers Association of Australia (CDAA) is by way of assessing and giving grades to both cave risk and the diving applicant. There are three test grades, plus caves too deep or dangerous for other than, possibly, a major dive effort by a special team. Diver A was graded as allowed to dive in this cave but NOT to enter the passage in which he and his friend were found. The friend had not applied for testing of his knowledge of cave diving so was diving "illegally", though his experience could well have been adequate for safer cave dives.

The tragedy was discovered when some divers saw a van near the entrance of the sinkhole. They waited patiently for a time as they did not wish to compromise the divers already down, then gradually realised that there were no bubbles to be seen coming up and that the time was too great for a dive in this depth of hole. A check dive was therefore made and a line found tied off at 20m, and 15m lower there was a tank evidently intended for use during the decompression stop by the missing divers. After descending to 45m they saw the glow of two torches possibly 15-20m below them. There were no bubbles to be seen. They surfaced and notified the police of what they had observed.

The police divers made an initial assessment dive and they found two bodies at about 59m depth. Nitrogen narcosis was noted during this dive so the recovery effort was postponed until it was possible for a team to dive using full-face masks, lines, and a communication link diver-to-surface. All conversations were taped. A "body line" was attached to the bodies and then it was discovered that it was not possible to raise them far because not only were they completely tied together by their line but also tethered to a rock bridge. It became apparent that their descent had been one side of this rock and ascent the other, which looped their reel line below the rock. Later measurements showed that they had permitted about 10-15m of line to float free, not reeling it back in. This formed the fatal trap. They were too closely tied together to have been able to reach their knives even had narcosis allowed them clarity of thought, and their knives were not sufficiently sharp to easily cut their line. Maximum permitted cave diving depth is 37m. They had reached about 69m before starting their ascent. The fact that they retained their 15lb weight belts during this dive was one of their additional mistakes.

The victims had little sleep the night before making this dive and started out early, possibly in order to avoid meeting the Park Ranger who would have asked to see the dive permits they did not possess.

This case received great publicity and it is probable that if the CDAA had not been in existence, and been seen as exercising real regulatory function, there would have been punitive (and most likely inappropriate) political and legal intervention to control diving in this area. A brief flurry of ruffled feathers did occur when the safety of the police divers was made the subject of some newspaper correspondence. These events highlighted the importance of diving organisations having a spokesperson who can provide the news-hungry media (and politicians) with information in a totally non-partisan manner. It was this factor which defused a situation threatening to spill over into parliamentary point-scoring.

DOUBLE FATALITY. ONE DIVER CDAA CAT 2. OTHER DIVER NOT CDAA TESTED. BOTH EXPERIENCED. SINKHOLE DIVE. WENT FAR BEYOND ADVISED/PERMITTED DEPTH AND INTO A CAVE DANGER GRADE BEYOND CATEGORY HELD. NITROGEN NARCOSIS. COLD, DARK. NARROW PASSAGE. WRONG WAY BACK ROUND OBSTRUCTION. EXCESS LINE UNREELED FREE FLOATING. TIGHT ENTANGLEMENT. KNIVES COULD NOT HAVE CUT LINE. WEIGHT BELTS ON. EXCESS WEIGHTS. OUT OF AIR. NOBODY TOPSIDE.

Case SC 84/5

It was arranged that the victim was to dive with a recent acquaintance, an experienced diver who claimed to be highly safety conscious. The victim was untrained but had made several scuba dives over the previous year, receiving advice from this man and other divers he met. He was described as "a strong swimmer but no good at reading the sea conditions". Before entering the water the experienced diver noticed that his air hose had developed a leak and decided not to dive, but apparently did not seek to dissuade his companion from entering the water unaccompanied to search for crayfish. The entry was from the rocks, the non-buddy agreeing to return to the spot in an hour to meet the diver on his return. It was high tide when he returned and he saw the victim surface in an area 500-600m away in an area where the swell was breaking over rocks. The diver was seen to submerge after breakers reached him, then seen floating at the surface, face down. His friend bravely immediately entered the water wearing only his wet suit pants and brought the victim back onto the rocks. EAR was unsuccessful. The police did not make any recorded check of the equipment but the "buddy" reported that the victim, who lost his mask after being hit by the breakers, had worn a buoyancy vest of unstated type, apparently not inflated by buddy or victim, and must undoubtedly have been low on air after an hour underwater. It was not noted whether the weight belt was still on or what weights were worn. He was said to be short sighted, though currents or the dive pattern rather than this factor probably led to his presence in an area so dangerously unsuitable for exiting.

UNTRAINED. SOME EXPERIENCE. SOLO DIVE BECAUSE INTENDED BUDDY EQUIPMENT PROBLEMS. SURFACED IN ROUGH WATER AREA THEN HIT BY SEVERAL BREAKERS. LOW AIR. BUOYANCY VEST UNINFLATED. RAPID DEATH. "BUDDY" MADE VALIANT RESCUE EFFORT. COLD. EXPERIENCED BUDDY SANCTIONED SOLO DIVE. SURFACE NO POLICE EXAMINATION OF EQUIPMENT.

Case SC 84/6

A charter boat dive was arranged for 10 divers but strong winds forced a change of dive location from the intended one to a more sheltered area off the chosen islet. The divers were paired, though the victim was in a group of three as one of the party did not choose to dive. Both the boat's captain, a diving instructor, and his wife, an experienced diver, remained in the boat and maintained position a short distance from the dive area. The victim was seen to surface alone, with his mask off, buoyancy vest inflated and his regulator out of his mouth, about 20m from the boat. He appeared to be helpless. The boat was brought to him and he was pulled aboard quickly. It was noted that there was no blood or frothy saliva in his mouth, but he was incoherent. So he was placed on his left side and given oxygen, which produced a rapid improvement. A radio call was made for the helicopter rescue service, which evacuated him to the nearest RAN recompression unit. Although he appeared to be making a satisfactory response to treatment his condition deteriorated and he rapidly died during the decompression stage, a clinical failure ascribed to the severity of the pulmonary damage (plus consequent cerebral anoxic damage) rather than the direct effects of cerebral arterial gas embolism (CAGE).

His buddies and the other divers surfaced and came aboard soon after his resuscitation had been initiated and all agreed that he had suffered an air embolism (CAGE). A "Ventolin" inhaler was found in his belongings, though nobody could recall seeing him using it. His buddies reported that they had remained together as a group and turned back together to avoid getting too dangerously near an underwater gully at 18m (60 feet) depth. When the victim showed them that his contents gauge showed only 500 psi they indicated to him they would continue diving as they had more remaining air (he had only a 64 cu ft tank, while theirs were of larger capacity), while he was to ascend alone. He showed no signs of panic or concern and this separation seemed a safe decision to them. It was suggested later that he had carried excessive weights (20-25 lbs) and accidentally over inflated his vest to assist his ascent, unfortunately failing to vent it successfully. The contents gauge was read after he was brought onto the boat and then showed 250 psi, indicative of having used air freely for vest inflation. The vest had no crutch strap so would have ridden up and pushed the regulator out of his mouth during his rapid ascent, a factor very likely to distract him from following correct ascent procedures.

He was described as a "mild smoker" but likely on occasion to smoke heavily. A visit to his unit revealed 4 empty "Ventolin" inhalers but his sister and mother vigorously denied he suffered from "asthma", though admitted "he did until he was 8 years old". Both he and his sister self medicated with "Ventolin", which can be purchased without prescription, but vigorously rejected the label of "asthma".

This apparently "Polaris" type of ascent could have caused CAGE even in an experienced diver who inflated his vest and found it suddenly rise up and push the regulator out of his mouth, so an inexperienced one could be excused a failure to react immediately and correctly to the situation. However the severity of the lung damage indicates a probability that his "asthma", which means that his air passages were over-reactive, converted a lung over-pressure incident with associated CAGE into a situation where lung damage was of unsurvivable severity.

TRAINED BUT INEXPERIENCED. PRE-DIVE AWARENESS THAT UNEQUAL TANK CAPACITIES WOULD RESULT IN A SOLO ASCENT WHILE BUDDIES CONTINUED THE DIVE. SEPARATION/SOLO. BUOYANCY VEST PROBABLY OVERUSED TO COMPENSATE FOR EXCESS WEIGHTS. FAILED TO VENT VEST ON ASCENT. NO CRUTCH STRAP SO VEST PROBABLY DISPLACED REGULATOR. EXCELLENT INCIDENT MANAGEMENT RESPONSE. VALUE OF OXYGEN. SEVERITY PULMONARY DAMAGE PRECLUDED SUCCESSFUL RESPONSE TO RCC. ASTHMA HISTORY. DELAYED DEATH.

Case SC 84/7

This unfortunate young, trained, experienced and apparently healthy diver suffered an unpredictable fatal medical event while making a well conducted dive, death occurring 6 hours later.

The victim was a Cat 2 certificated Cave Diver diving with other trained CDAA divers. They made a morning dive to 36m (120 feet) and carefully followed the pre-calculated dive profile, which included a decompression stop. Shortly after surfacing he walked across to a nearby cave and made a quiet dive through a passage about 12m (40 feet) long, maximum depth 3m (19 feet), returning to his entry point after being seen at the open end by his friends. He mentioned having a minor ear problem on the first dive but it did not trouble him with his subsequent dives. He did not seem unusually fatigued by his dives, though he ate little at the picnic held by the group before going to the sink hole chosen for the afternoon dive.

He was considering purchasing a backpack buoyancy vest and when one of the party who had such a vest decided not to dive he borrowed it to try it out. While putting it on he mentioned that it felt tight across his chest and that he could not seem to make himself completely comfortable, a remark only retrospectively seen to have possible significance. This dive also was very carefully planned, with allowance for residual nitrogen from the first dive. The victim (still troubled by this chest tightness) and his buddy made an uneventful descent to 42m (140 feet), commencing their ascent when 13 minutes had elapsed. They were severely aware that the water temperature was 15°C so swam slowly to conserve energy and increased the 3m (10 feet) decompression stop from 6 to 13 minutes. The buddy did not note anything amiss with the victim and they spent 3 to 4 minutes talking at the surface before leaving the water. As they reached the exit ledge the victim coughed out a little blood, which his companions thought strange after an uneventful dive but assumed to come from a nasal source. It was as he started to remove his wet suit that he complained of his chest pain, which quickly worsened, and it was immediately realised that he required urgent medical attention so friends drove him to the nearest hospital. They were agreed that neither the dive profiles nor the symptoms supported a diagnosis of either decompression sickness (DCS) or pulmonary barotrauma, and his previous health had been good, though he admitted to often suffering “indigestion” .

A nurse in the dive group managed to get him oxygen for a trial but this produced no improvement, strengthening his friends' belief that this was not a “diving” problem. Though the victim was breathless and could barely remain still because of the severity of the pain, he tried to make out it was a strained muscle, or even his indigestion. There was no evidence of any “surgical emergency” having occurred so the symptoms were regarded as being due to some undiagnosed but non-serious cause.

He was advised to rest at home but his condition worsened so his friends returned him to the hospital and ensured his being admitted for observation. A chest X-ray taken at this time failed to illustrate the pathology then occurring. This report reassured his friends, though they remained concerned about whatever was the cause of his severe chest pain. He suffered a cardiac arrest that night and resuscitation attempts were unavailing.

The autopsy revealed the presence of a blood in the chest cavity (haemothorax) and a tear in the aorta. The sequence of the fatal events had been a tear in the lining of the aorta with the pressure of the blood separating the layers of the aorta until a time came when the outer layers gave way and the blood escaped. It is possible that some of his “indigestion” was pain due to aortic pathology, but it may have been an unrelated problem. In all other respects he had been healthy.

This case has been reported earlier (SPUMS J 1984, 14(4): 34) and will be subject of a further paper later (James R and Hayman J).

TRAINED. EXPERIENCED CAVE DIVER. APPARENTLY IN GOOD HEALTH. CAREFUL DIVE PATTERN. COLD WATER AND MODERATE EXERTION ADVERSE FACTORS. FATAL DISSECTING ANEURISM OF AORTA. DELAYED RECOGNITION OF THE SEVERITY OF THE ILLNESS. NON-DIVING ILLNESS WHILE DIVING. DELAYED DEATH.

Case SC 84/8

Trained, experienced, with divemaster qualifications.

Case SC 84/9

Trained and experienced.

This was a boat dive taking a group of trained divers to a cave under the cliffs guarding the entrance to a bay. None of the divers had visited the cave previously and in the event there was incorrect identification and a cave adjacent to the intended one was entered. The boat was left anchored a short distance from the cliffs and the nine divers swam on the surface to the entrance of the cave. Two groups had been arranged, the divemaster who was the organiser taking four divers, the two victims leading the others. The dive boat was left in the care of the crewman, a trained diver.

The sea conditions appeared to be suitable and both groups dived, meeting together at 15m before splitting once more into two groups. There were two groups because there were only two torches available, one for each group leader. All descended to the floor of the cave entrance, 21m depth, where a rock column was present which divided the entrance. Here the two groups diverged with the group of four going to the left to explore. While the two experienced divers who led this group were down a passage and the two others waited at its entrance there was a sudden powerful surge of water within the cave, the result of a large wave arriving at the cave's entrance and being funnelled in. Till this time the water movement within the cave had not been severe, though causing some problems to one of the waiting pair even before the major surge separated them and forced them to the surface within the cave. It was rough so they hurriedly both descended again, and both reported the torch was still to be seen in the passage so they believed that the two leaders were still alive at that time, just before the arrival of the second surge. The two divers were again forced to the surface where one hit his head on the rocks as he was pushed round in the cave. Fortunately he came into contact with his buddy, now near to panic after losing her mask. He inflated her vest (a CO_2 sparklet system which fortunately worked) and assisted her from the cave.

Outside the cave they came across two divers from the five diver group supporting an unconscious diver and giving EAR. He was got aboard the dive boat, which had been brought closer inshore to assist, the crewman having seen the sudden waves at the cave mouth and observed the surface events. On the boat a head count revealed that two divers had not returned, but they were experienced and no real concern was felt for their safety, though one diver snorkelled back to the cave entrance in case they surfaced needing help. The divemaster donned scuba and descended to look for them after the near-drowned diver appeared to be recovered, about 20 minutes from the time of surfacing. After about 10 minutes searching he found one of the missing divers lying on his back under the ledge at 12m depth, weight belt and one fin missing, regulator lying loose, vest uninflated and tank on his back. He removed his own weight belt and brought the victim to the surface, making no attempt at EAR in the water but going direct to the boat because he could not palpate a pulse. CPR was immediately commenced on the boat and a MAYDAY call transmitted. The boat quickly returned to land, it being realised that there was no hope of the other diver still being alive. They were met on arrival by an ambulance, resuscitation being continued for a further 25 minutes before death was formally certified.

The five diver group had also experienced the dramatic sea surge. One was pushed upside down and held against a crevice till the current changed direction and he was able to get free. He then met another of the group and together they managed to survive the second surge and make their way out of the cave to signal for the boat to come closer. Another of the group suffered a knock on his head from the rock roof, had the regulator torn from his mouth and had his arm injured, so found himself unable to reach and replace his regulator. By chance he found himself near another diver, who noted his problem and commenced buddy breathing. The second wave surge separated them and dislodged the buddy's mask, despite which the buddy managed to re-establish contact and resumed attempts at buddy-breathing, holding the injured man's weight belt to prevent further separation. This victim remembers no more until he heard himself breathing heavily on the dive boat. A noteworthy rescue.

Police divers made a search for the missing diver the next day but the dangerously turbulent conditions within the cave made it necessary to limit their search. The following day, attached to a securely belayed lifeline, two divers penetrated the full extent of the cave, about 85m, and found the body wedged under a rock, then divers and body were pulled from the cave. Despite their line the police divers were swept 10-15m in either direction as 3-4m waves swept into the cavern's entrance, and they required torches while making their search. Within the cave the most dangerous place was at the surface where anyone was at serious risk of being brought into violent contact with a rock. It was a very dangerous place.

Examination of the equipment revealed that both tanks had vented after receiving damage to the attachment of the 1st stage, undoubtedly from contact with rocks, this creating an unsurvivable situation.

It is noteworthy that although five of those involved had completed their training only 2 to 4 months previously they acted in a way that prevented at least two additional deaths, despite so many adverse factors. Also of note is the successful resuscitation after the recovery of one diver and the evidence that life may be still present even after significant time underwater without any air supply. There can be no doubt of the value of training divers to perform resuscitation. It can indeed be lifesaving.

TWO EXPERIENCED DIVERS DIED IN SEA CAVE. INCORRECT CHOICE OF CAVE. DANGER FROM WATER POWER DUE TO WAVES ENTERING CAVE MOUTH. EQUIPMENT DAMAGED BY ROCKS SO TANKS VENTED ALL AIR. ONE DIVER WAS RESCUED AFTER A PROLONGED TIME UNDERWATER WITHOUT AIR. EARLY RESPONSE TO CPR NOT MAINTAINED.

VALIANT RESPONSE BY NEWLY TRAINED DIVERS. RESCUE AND RESUSCITATION OF UNCONSCIOUS INJURED DIVER.

Case SC 84/10

Though classed as a professional diver this man was only an occasional diver. He was employed as a fitter/machinist with a small firm which included among the services it provided that of scrubbing the hulls of ships as they lay at the harbour wharfs. He had received scuba training at the firm's expense and on this day was acting as tender and watching the compressor while the senior diver was underwater using hookah. They were to change roles when one side of the hull had been cleaned. When another employee, a non-diver engineer, came by, the victim persuaded him to watch the compressor while he took the truck to collect their lunch. As he was leaving the dock area he met another employee, who had lost his spectacles into the water while packing up after working on a fishing boat and intended asking the senior diver to look for them whenever it was convenient. He immediately offered to find them and drove back to obtain an air cylinder.

With the scrubber when it was purchased there had been two small (23 cu ft) bailout bottles and these were among the diving equipment taken to the wharf, though not used by the divers. After attaching a regulator to one of these he drove to the dock where the spectacles had been lost. Because of their design these small cylinders cannot be gauged but he checked that air was available by operating the regulator before entering the water, without line or tender, in the restricted area between the fishing boat and the wharf. After a short interval a large bubble was seen to burst at the surface, followed by a stream of small bubbles which very soon ceased. This alarmed the employee who had lost the spectacles and he drove back to inform the senior diver, who accompanied him back to the fishing boat. He made an immediate but unsuccessful breathhold dive, next tried to use the other bail-out bottle but it was empty, then made a successful search using hookah (cylinder supply type) hurriedly brought from the works. About half an hour had elapsed before the victim was brought up and pulled onto a wooden catwalk where his equipment was removed. The limited space restricted EAR attempts so he was hoisted to the wharf and resuscitation efforts were resumed. When the ambulance men arrived they noted that chest compression was being given over the xiphoid, that expired air resuscitation (EAR) had been abandoned, that mucus and froth blocked the victim's mouth and that an OXYVIVA with suction was nearby but unused. However it was now 45 minutes since he entered the water and lost his air so resuscitation efforts were unlikely to be successful however well conducted.

Examination revealed a very heavy build-up of rust in the air cylinder, and the first stage reducing valve had a mixture of dry salt, slime, and verdigris over the parts. Testing showed that the line pressure fell when the air was used and was only 19 psi, less than dive ambient, when the tank was near empty. It is likely he started with a part filled tank, took a few test breaths before entering the water, purged the regulator on reaching the bottom and then unexpectedly got no air when he took his next breath because of the poor airflow resulting from the depleted tank pressure. He was in a cold, poor visibility restricted space, possibly below the boat, and out of air without warning before he could adjust to his water entry and descent. He probably drowned before resolving the situation. He had no lifeline and no buoyancy vest to assist him. Vests were available but not worn because "they got in the way".

TRAINED. INEXPERIENCED. LEFT HIS RESPONSIBLE POSITION TENDING DIVER TO CARE OF UNTRAINED PERSON. SOLO UNPLANNED DIVE. USED SMALL BOTTLE WITH UNKNOWN REMAINING AIR. NO LIFE-LINE. NO TENDER. NO BUOYANCY VEST. RE-STRICTED SPACE. NIL VISIBILITY BETWEEN WHARF AND VESSEL. POORLY MAINTAINED EQUIPMENT. RUSTY CYLINDER. FAILED TO DROP WEIGHT BELT. POOR APPLICATION OF RESUSCITATION REPORTED. OXYVIVA AVAILABLE BUT UNUSED.

SC 84/11

This incident is possibly unique and concerns the fatal embrace of a cuttlefish and the diver who speared it. It happened during a dive organised by a dive school as either the conclusion of the course or a post-course social before the presentation of certificates (opinions differ on this point). Two boats were used to reach the dive area, one owned by the instructor and the other by his assistant. Neither belonged to a national diving instructor organisation, nor accepted usual scuba safety protocols. There were 16 divers in all. There was no provision for anyone to remain as surface observer and boat minder, though two divers aborted their dives so one boat was manned.

All entered the water as buddy pairs. The victim, a former breath-hold spearfisherman, carried a handspear. It is not known how many others also intended spearfishing. About 12 minutes after entering the water the victim's buddy realised that he was low on air (J valve, no gauge), signalled this to the victim, who pulled the reserve for him but indicated that he would remain below so the buddy surfaced alone. He would have acted similarly. When he returned to the boat and found a diver there with a full air tank he exchanged his empty one for it and dived again. He was certain that such was correct behaviour and he made no attempt to rejoin his buddy or any other divers. He continued to dive until he had completely used this tank also, an air management plan that seems to have been expected of all those present.

At some stage two of the divers saw the victim apparently with a fish on his spear and a cuttlefish on the spear tip. At an earlier time the buddy had prodded a cuttlefish trying to shelter beneath a ledge. As divers used up their air they returned to the boats and ultimately only the victim remained absent. The surface was watched in the hope he had surfaced and been washed away and there was a flurry of hope when something surfaced, disappointment when it was seen to be the headless body of a cuttlefish. Neither of the instructors attempted an underwater breathhold search, nor was there any questioning of the incorrect assumption that nobody had any air remaining.

It was 25 minutes after the last diver had returned to the boat with empty tanks that open concern was first expressed. It was decided that one boat should return to shore to notify the police and obtain three full tanks. It was not possible to radio for assistance because neither boat's radio was working. The body was found on the sea bed, with all equipment in place except for one fin, which lay nearby. It had an old nick out of the heel piece and in consequence would have been loose fitting.

At the autopsy some neck marks and a bitten ear were noted to be consistent with an attack by a 30cm cuttlefish. It is said that cuttlefish may hold onto divers but they do not attack. This one may have disliked being speared and attacked when shaken from the end of the spear. Both middle ears contained blood, a sign of recent barotrauma. His tank was empty. It was suggested that when the injured cuttlefish attached itself to his head he grabbed hold of it and tried to tear it off (ultimately he tore it apart, some indication of his desperate strength) while vigorously finning to reach the surface, by which time he was possibly out of air. When his fin came off he sank down, weighted by his equipment, suffering distracting pain in his ears in addition to his previous troubles and drowned, having no buoyancy vest and not having ditched his weights. The J valve was in the OFF position when the body was found so it is probable that he had been diving with it OPEN and pulled it to the OFF position when intending to utilise the reserve air.

Several students spoke highly of the course they had just completed and the instructor defended his belief that there is no need to leave anyone in a dive boat as surface cover, to be strict with buddy diving discipline, to use contents gauges, wear buoyancy vests, or take an extra tank of air for emergency use. The Coroner was told that it would have put the divers at risk of decompression sickness if air had been available and they dived again, a remarkable argument as they had been diving at only 18-25m and if this was a real risk for participants in a search-and-rescue dive then in-water decompression stops could have been arranged. Here a diver's life was at stake as contrasted with a slight risk of the rescuer suffering the treatable condition of DCS. The false wisdom of placing reliance on a J-valve reserve is highlighted here, as when a diver enters the water with the valve OPEN, as may occur by some chance knock, he finds himself completely and unexpectedly without air when he moves the reserve's lever in anticipation of more air.

Nowadays there is a growing acceptance that those who have a professional status must accept a requirement that they provide an appropriately greater responsibility for their actions than is required of others. A diving instructor, or anyone who runs diving trips commercially, must shoulder a burden of care for everyone on the dive which would not be expected from a diver taking out some friends. This would include careful listing of all dive pairs as they entered and left the water, ensuring that some capable person remained in the boat to provide surface cover and ensure the boat did not drift away, and have a “disaster plan”. This should include a first aid box, oxygen, a spare air cylinder, and a working radio. If dives were to be made where decompression stops were required, or made prophylactically, a shot line with tank should be provided.

JUST TRAINED. INEXPERIENCED. THIRD OPEN WATER DIVE. SCUBA SPEARFISHING. SPEARED CUTTLEFISH. “CUTTLEFISH ATTACK”. NO CONTENTS GAUGE, DIVED WITH J VALVE OPEN. NO BUOYANCY VEST. NO SURFACE COVER THOUGHT NECESSARY. FAULTY BOAT RADIOS. BUDDY SOLO DIVED OFTEN SOLO SURFACING AND BORROWING FULL TANK. MOST OF THE DIVERS ONLY SURFACED WHEN OUT OF AIR. DELAYED SEARCH. SEPARATION/SOLO. FAILED TO DROP WEIGHT BELT. LOW OR OUT OF AIR. BITTEN ON EAR. LOST FIN. MIDDLE EAR BAROTRAUMA.

Case SC 84/12

Three friends anchored their boat over a wreck which lay in 48m deep water and descended together to its deck. After they had checked that their anchor was secure they swam above the deck to the stern. One noticed the victim swimming as if he had orally slightly inflated his vest to compensate for being overweighted. At this time one of the divers left the others and swam forwards to examine the bridge section, and a little later the other buddy turned round after looking in at a porthole and found that he was alone. Such separation was not unexpected when wreck diving and did not alarm him when it occurred. He arrived at the anchor after 12 minutes underwater in accordance with the dive plan and joined the first diver. They assumed that the victim had started back to the surface earlier but made a short (4 minutes) search swim over the wreck before starting their ascent. They expected to find the missing diver at either the 6m (20 feet) or 3m (10 feet) decompression stop or even waiting for them in the boat. There were no bubbles to be seen coming to the surface so they became worried, fearing that he had washed away after surfacing before them. They made a surface search about one mile in each direction over the next one and a half hours, only giving up and returning to land when their fuel began to run low. They made a personal appearance at the nearest police station to report the loss of their friend, lest a phone call be mistrusted, refuelled the boat, and returned to the wreck area to await the police boat.

There were no police divers immediately available so they brought out a local diving instructor who knew the wreck and they asked the helicopter rescue service to supply one of their divers to buddy him. However the diver was not considered to be equipped for a deep dive and the search was postponed until the arrival of the police divers. They did not locate the body that day or next morning, but one of the victim’s buddies, with a friend, succeeded a short time later. It was found lying free on the sea bed near the stern of the wreck, all the equipment was in place.

The victim had dived on this wreck previously, was healthy, and showed no signs of panic when last seen. He was wearing a twin cylinder scuba unit and it was over 3/4 full. Examination of his buoyancy vest revealed why it could not be inflated to assist body recovery. The CO_2 sparklet was empty and the inflator button for the tank-feed inflation of the vest was missing. Both faults had been present for some time and the wearer must have known of their presence. Although the vest fault was a significant adverse factor it is believed that nitrogen narcosis was the most likely critical factor in this fatality. The dive boat was well equipped for diving and carried oxygen. It did not carry a radio.

TRAINED. EXPERIENCED. DEEP DIVE (48M). HAD PREVIOUSLY DIVED ON THIS WRECK. SEPARATION BEFORE INCIDENT. FAILED TO DROP WEIGHT BELT. TWIN TANKS. PLENTY AIR. KNOWINGLY WORE FAULTY BUOYANCY VEST ON DIVE. POSSIBLY OVERWEIGHTED. NITROGEN NARCOSIS PROBABLE.

Case H 84/1

In the heyday of the pearl fisheries entire lugger fleets were sometimes lost in storms but it was divers who suffered the highest mortality rate, with air embolism, drowning, and decompression sickness managed by in-water treatment claiming most, though some pearl-shell beds had the added danger of sharks. In recent years there have been few such fatalities, though this has reflected the downturn in the pearling industry rather than any improvement in diver training or diving methods.

The victim was one of the seven man crew of a pearling lugger, all of them licenced divers. A licence is granted to an applicant when he can document his claim to have served as a diver’s tender on a lugger. There is no requirement on the applicant to attend a formal course of instruction, and despite requests no such courses have been available, although this recruitment route provides some learning opportunities and an exposure to the diving community’s folklore. The Japanese, who monopolised the diving pre-war, used to give their recruit divers a basic training. Difficulties arise in ensuring that recruits not previously exposed to such concepts gain an understanding of the physiology and pathology of diving. However all divers must pass a basic medical fitness check each season.

He was an experienced diver making this first dive of this day, one of three sent down following a favourable report made by a diver sent down to check the presence of shell. Sea depth was 16m (9 fathoms, ie. 54 fsw) and although they descended at about the same time they naturally were not watching each other. One thought the victim was near him as he started collecting shell but it is also reported that he aborted his descent, for no discovered reason, and ascended rapidly by climbing up his lifeline after descending only 40 feet. There was no interruption of the air supply, which was from a compressor supplying all three, and his fellow divers were very surprised to be hauled unceremonially back to the surface.

The victim was seen to surface, regulator hanging loose and mask on. He expelled some air and held onto his line for a little while, then let go and swam around aimlessly, the weight belt and air hose still attached. Two of the crew immediately jumped into the water-and swam to assist. They thought he was already dead before they reached him and they saw some blood from his mouth but there was a determined attempt to resuscitate him after getting him back onto the lugger.

At the autopsy there was some evidence of both past and more recent pleurisy, but there were no reports that he had shown signs of any ill health. The equipment was checked and found to be in a poorly maintained condition but to function adequately. Although the hose connections were described as unsafe there is nothing to suggest they failed, and a crack in the demand valve's case which may have let in water is of uncertain significance, the victim and other pearl divers being accustomed to substandard conditions. It can never be known what prompted his tragic rush to the surface (a sudden pleuritic pain or receiving a sudden spray of water rather than the air he expected?) but the result was pulmonary barotrauma. Mediastinal emphysema was found and there was a clinical picture typical of CAGE. For safety each diver had a short rope connecting his demand valve to his weightbelt to ensure that he could easily regain it should it be pulled from his mouth, so regulator loss is unlikely to have caused panic in such an experienced diver.

UNTRAINED. EXPERIENCED. INCIDENT OCCURRED AS DESCENDING FOR FIRST WORKING DIVE OF THE DAY. UNEXPLAINED SUDDEN ASCENT FROM 16m OR 54 FSW. CLIMBED UP HIS LINE STILL WEARING WEIGHT BELT AND AIR HOSE. REGULATOR OUT OF MOUTH WHEN HE SURFACED. TYPICAL AIR EMBOLISM (CAGE). RAPID RESPONSE BY CREW. EQUIPMENT IN POOR CONDITION. EVIDENCE OLD AND RECENT PLEURISY.

DISCUSSION

Reports such as this require the involvement of the reader if they are to achieve their objective, the continuing improvement of diving safety. It is suggested that readers will obtain the greatest benefit if they imagine themselves as a member of each of the dive groups described and assess how they would have acted having regard to their usual diving practices. Naturally some of these incidents occur in circumstances foreign to the diving most recreational divers will meet, but the principles of safe diving have a common strand whatever the type of diving. By considering each case the reader can discover the features of diving training and diving equipment which, if neglected, decrease the likelihood of successful resolution of some misadventure.

The fatalities reported above have prompted the "examination paper" below. There are no prizes offered, except an inner glow of satisfaction and an increased awareness of diving safety, to those who complete the paper. However the pages of the SPUMS Journal are open to anyone who wishes to send in any of their answers (typed in double spacing with wide margins on one side of the paper only).

<u>Questions</u>

1. Identify the event which started the incident and identify in order of importance the factors which ultimately led to the fatal conclusion in each case.

2. What responsibilities rest on the person who organises a dive, and is more expected of an Instructor or a Divemaster?

3. What equipment should a dive charter boat carry so as to be prepared to adequately manage an "incident"?

4. Can dive boats be safely left unattended while divers are underwater?

5. Discuss the value of a contents gauge, a J-valve reserve, of wearing a buoyancy vest, of ascending before all air has been used, of strict buddy-diving, of allowing one of a dive group to ascend solo, and the value of buddy-breathing skills. Select evidence from the cases presented.

6. Discuss the adverse effects which may follow diving while wearing equipment having defects.

7. Discuss the possible relevance of an "asthma" history.

8. Are sea conditions given enough importance by divers?

9. Discuss the evidence for supposing that a good knowledge of resuscitation methods is valuable and illustrate from cases presented.

10. What problems may rise if buddies have air tanks of greatly differing capacities, or have equal initial air but differ significantly in rate of air use?

ACKNOWLEDGMENTS

This report would not be possible without the generous and continued support of many organisations and individuals, in particular the assistance of the Attorney General/Justice/Law Department in every State and of continued active help

of the Australian Underwater Federation. This diving safety project can achieve nothing without the interest and active involvement of many people.

PROJECT STICKYBEAK

The object of this investigation is to collect, store and, as appropriate, publish and make available for discussion, accurate information relating to all types and severities of problems encountered by divers.

CONFIDENTIALITY IS ALWAYS MAINTAINED CONCERNING THE IDENTITY OF THOSE INVOLVED IN EVENTS PUBLISHED.

The investigation is totally independent of any single diving or government organisation. Comments and reports to:

Dr DG Walker
PO Box 120
Narrabeen NSW 2101

THE INCIDENCE OF ACUTE OXYGEN TOXICITY IN A CLINICAL SETTING

Philip A Rettenmaier, Beth Gresham, Roy AM Myers.

Hyperbaric Medicine Department
Maryland Institute of Emergency Medical Services Systems
22 South Greene Street
Baltimore, Maryland 21201, USA.

This paper was presented at the 1985 Joint Conference of the Undersea Medical Society Annual Scientific Meeting and the Tenth Annual Conference on Clinical Application of Hyperbaric Oxygen, held 11-1? June 1985 at Long Beach, California, USA.

INTRODUCTION

The occurrence of oxygen toxicity is frequently described as one of the hazards of the use of hyperbaric oxygen in a clinical setting. Despite this, very few articles have been written on the incidence of acute oxygen toxicity in this setting.

A retrospective study of the occurrence of acute oxygen toxicity symptoms at the Maryland Institute for Emergency Services Systems, Hyperbaric Medicine Department (MIEMSS) from January 1978 to December 1983 was thus performed. During this period, 891 patients were treated with a total of 14,966 patient dives. All dives were performed in a multiplace chamber with the patients breathing 100% O_2 by face mask or hood and at various depths: 165 fsw, 66 fsw, 60 fsw, 48 fsw, 45 fsw and 33 fsw, depending on the condition treated.

METHODS

The patients and symptoms were identified by reviewing the chamber operators' dive logs for the time period involved and then reviewing the chamber nursing notes for the patients so identified. One problem with this method was that only patients with severe symptoms were identified, those with minor symptoms from oxygen toxicity are thus not included in this study.

A total of 137 incidents of acute oxygen toxicity symptoms in 90 patients and 11 categories of symptoms: nausea and vomiting, seizures, muscular twitching, anxiety, respiratory changes, vertigo (or dizziness), behaviour changes, visual changes, sweating, auditory changes, and altered consciousness were identified with this method.

RESULTS

The overall incidence of acute oxygen toxicity symptoms at MIEMSS during the 6 years studied is shown in Figure 1 and in Table 1.

TABLE 1
INCIDENCE OF ACUTE OXYGEN TOXICITY SYMPTOMS 1978-1983

Nausea & Vomiting	0.37%
Seizures	0.21%
Muscular Twitching	0.13%
Anxiety	0.09%
Respiratory Changes	0.05%
Vertigo	0.06%
Behaviour Changes	0.03%
Visual Changes	0.02%
Sweating	0.03%
Auditory Changes	0.02%
Altered Consciousness	0.05%

The incidence of acute oxygen toxicity symptoms was broken down further by calculating the incidence of symptoms in the treatment of the 10 categories of conditions shown in Table 2. The results are shown in Figures 1-7.

TABLE 2
CONDITIONS TREATED

Decompression Sickness
Gas Gangrene/Aerobic and Anaerobic infections
Air Embolism
Wound Healing Enhancement
Radiation Necrosis
Carbon Monoxide Poisoning/Smoke Inhalation
Osteomyelitis
Spinal Cord Injury
Head Injury
Multiple Sclerosis

We also attempted to determine whether or not there was a relationship between the duration of oxygen breathing before symptoms occurred and the number of dives (treatments) the patients have received, but there did not appear to be any significant trend other than that 73% of all incidents occurred between the first and tenth dives, with the incidence of symptoms decreasing as the number of dives increased (Table 3).

FIGURE 1

INCIDENCE OF ACUTE OXYGEN TOXICITY SYMPTOMS 1978-1983

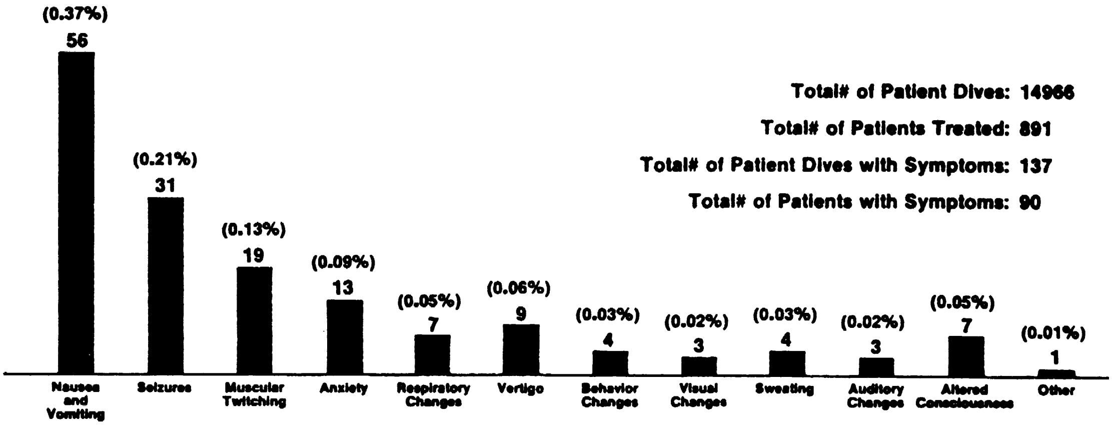


FIGURE 2

INCIDENCE OF SYMPTOMS DURING TREATMENT 1978-1983

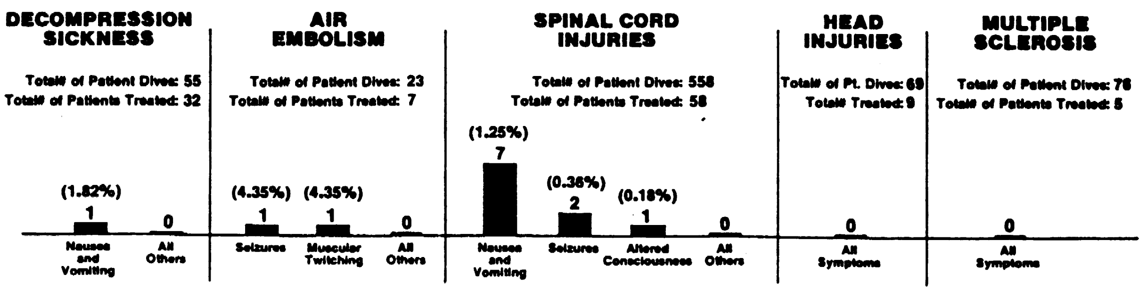


FIGURE 3

INCIDENCE OF SYMPTOMS DURING TREATMENT OF OSTEOMYELITIS 1978-1983

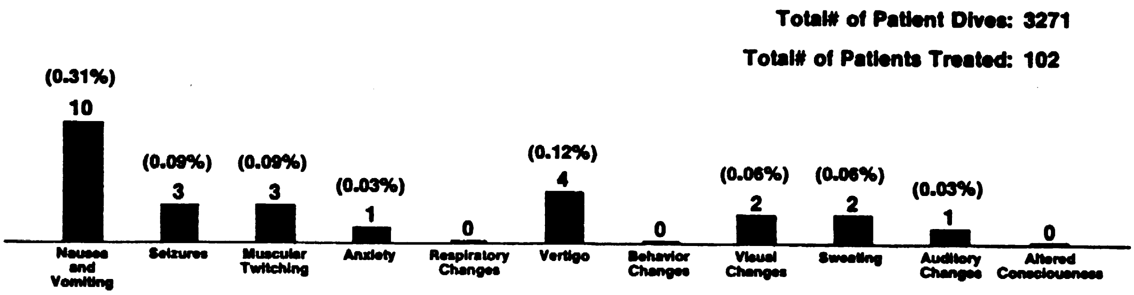


FIGURE 4

INCIDENCE OF SYMPTOMS DURING TREATMENT OF RADIATION NECROSIS 1978-1983

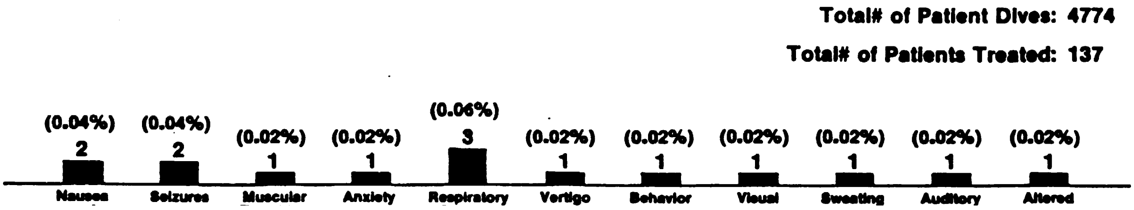


FIGURE 5

INCIDENCE OF SYMPTOMS DURING TREATMENT FOR WOUND HEALING ENHANCEMENT 1978-1983

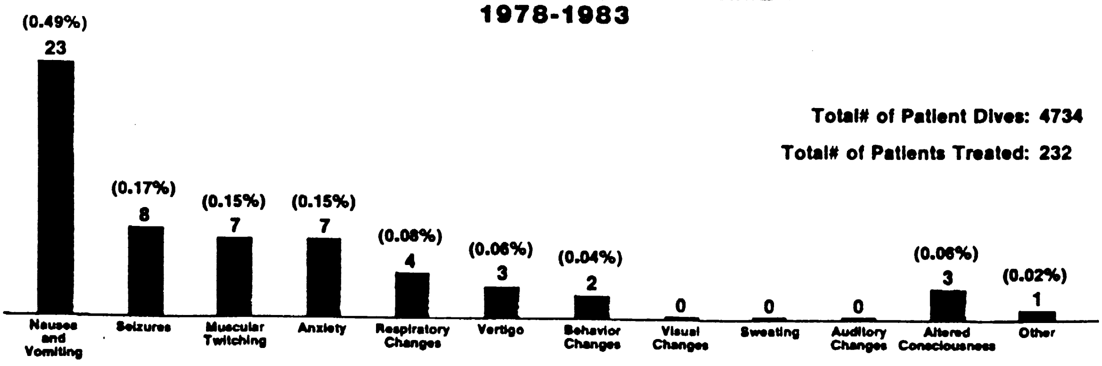


FIGURE 6

INCIDENCE OF SYMPTOMS DURING TREATMENT OF GAS GANGRENE/AEROBIC & ANAEROBIC INFECTIONS 1978-1983

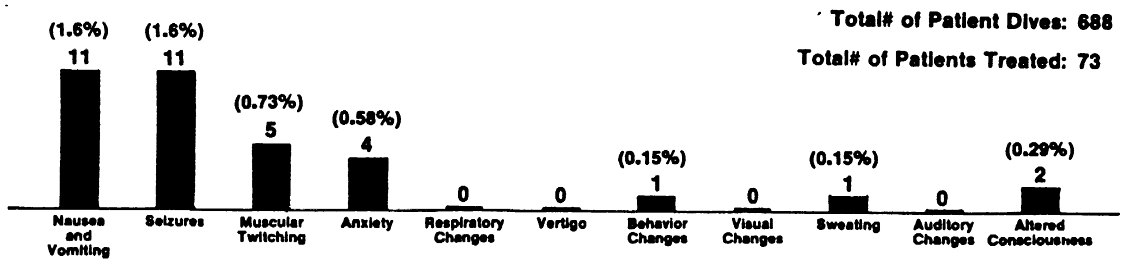


FIGURE 7

INCIDENCE OF SYMPTOMS DURING TREATMENT OF CARBON MONOXIDE POISONING/SMOKE INHALATION 1978-1983

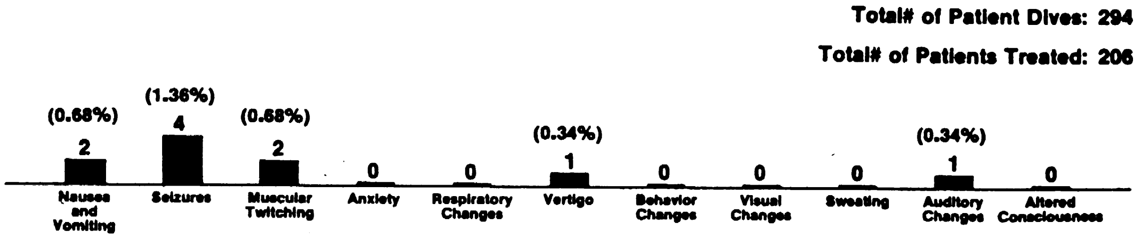
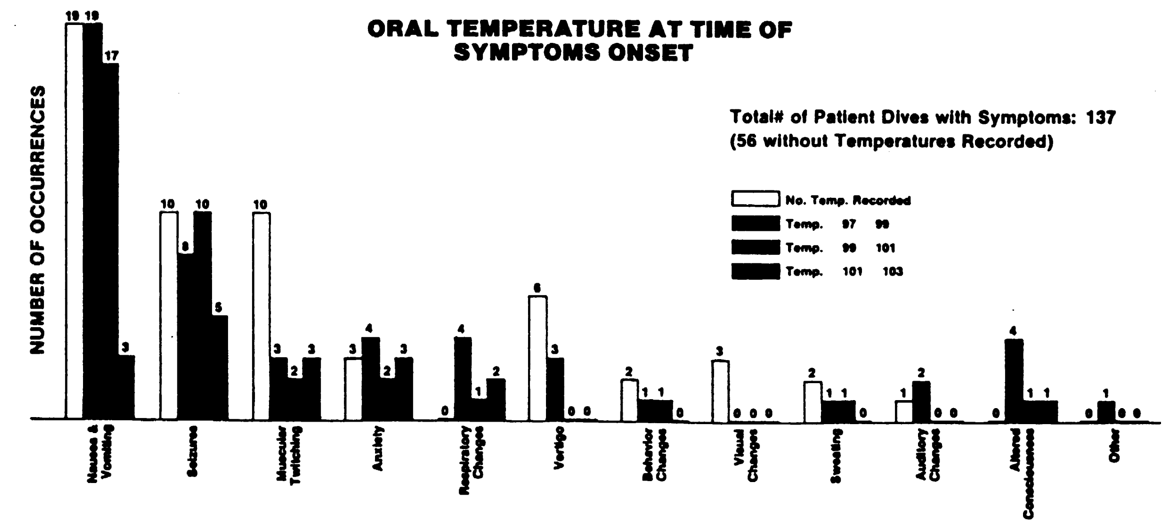


FIGURE 8

ORAL TEMPERATURE AT TIME OF SYMPTOMS ONSET



The oral temperature of the patients at the time of the onset of symptoms was looked at, but no pattern was identified (Figure 8).

TABLE 3
ONSET OF SYMPTOMS vs NUMBER OF DIVES

Number of dives	Number of incidents	Percentage
1 - 10	100	73%
11 - 20	17	12%
21 - 30	2	1.5%
31 - 40	7	5%
41 - 50	7	5%
51 & above	1	1%
No data	3	2%

DISCUSSION

Few authors have reported on the incidence of oxygen toxicity symptoms other than seizures. Ellis and Mandal (1983) in their review of 87 clinical patients, reported side effects in 18 patients: anxiety (43%), nausea/vomiting (13%), dyspnoea (12%), convulsions (5%), paraesthesiae (5%), and perspirations(30%). Donald (1947) found, in experiments with divers exposed to pressures of 3 ATA or greater, the following incidence of symptoms: convulsions (9.2%), twitching of lips (60.6%), vertigo (8.8%), nausea (8.3%), respiratory disturbances (3.8%), twitching of other parts other than lips (3.2%), sensations of abnormality (3.2%), visual disturbances (1%), acoustic hallucinations (0.6%) and paraesthesiae (0.4%). Both of these studies show far greater occurrence rates than here at MIEMSS. In the case of Ellis and Mandal, patients were treated in a monoplace chamber at 2 ATA and in Donald's study the subjects were divers breathing oxygen at depths 3 ATA or greater.

In our study all patients were treated in a multiplace chamber at depths of 6 ATA for decompression sickness (DCS) and Air Embolism, 2.8 - 3.0 ATA for Gas gangrene/Aerobic and Anaerobic infections and Carbon monoxide poisoning/ Smoke inhalation and 2.0 - 2.45 ATA for all other conditions. Thus comparisons of these studies are difficult due to the types of subjects and the different treatment protocols.

At MIEMSS the overall incidences of oxygen toxicity symptoms is much lower than in either of these studies. The highest incidence was that of seizures in patients with air embolisms (4.35%), a group that is prone to seizures just by the nature of their injury, followed by patients treated for gas gangrene or anaerobic and aerobic infections, our most septic patients, with an incidence of seizures being (1.6%) and an incidence of seizures in carbon monoxide poisoning/ smoke inhalation patients of (1.36%). In these 3 categories, patients were treated at depths ranging from 2.8 - 6.0 ATA, a range in which oxygen toxicity is a much greater problem. All other conditions were treated at lower pressures and as would be expected there was a much lower incidence of oxygen toxicity related problems (Figures 1-7 show the full details).

CONCLUSIONS

We have found that the incidence of oxygen toxicity related symptoms at MIEMSS is low, and is easily managed by removal from oxygen when symptoms occur, adjusting air break schedules and in some cases by pre-medication with Diazepam for subsequent dives.

REFERENCES

Donald KW. Oxygen Poisoning in Men. B*ritish Medical Journal*. 24 May 1947: 712-717.

Ellis ME & Mandal BK. Hyperbaric Oxygen Treatment: 10 years experience of a Regional Infectious Diseases Unit. Journa*l of Infection*. 1983; 6: 17-28.

MAMMARY IMPLANTS AND DIVING

RD Vann, GS Georgiade and RE Riefkohl

FG Hall Laboratory,
Department of Anesthesiology, and Department of Surgery
Box 3823
Duke University Medical Center
Durham, North Carolina 27710 USA.

This paper was presented at the 1985 Joint Conference of the Undersea Medical Society Annual Scientific Meeting and the Tenth Annual Conference on Clinical Application of Hyperbaric Oxygen, held 11- 1? June 1985 at Long Beach, California, USA.

The Divers' Alert Network has had several enquiries from sport divers concerning mammary implants and decompression safety. As little pertinent information could be found in the literature, an experimental study was conducted to determine if in vitro decompression of mammary implants would cause bubble formation and, if so, how extensive this bubble formation would be.

METHODS

Six mammary implants were tested in four simulated dives. Experiments were conducted with air at a temperature of 20° ± 2°C in a pressure chamber having an internal volume of about 10 cu ft. The implants were exposed to the desired pressure-time profile and then removed from the chamber for observation. The number of bubbles present and their sizes were estimated about once per hour for 5 to 8 hours and at 20 hours post decompression. The volume change of the implant was determined by submerging it in a water-filled container of known volume and measuring the change in container weight since the end of decompression. This method was accurate to a volume change of 1-2%. The maximum volume change occurred 4 t 5 hours after decompression.

RESULTS

Table 1 gives a summary of the results.

The first simulated dive was conducted at a depth of 120 feet of seawater (FSW) with a bottom time of 67 hours followed by immediate decompression to the surface. While this is an unrealistic exposure for divers, it was used because the extent to which bubbles would form was unknown.

TABLE 1
SUMMARY OF EXPERIMENTAL RESULTS

Dive Number	Dive Profile	Implant Number	Experiment Number	% Volume Change	Number of Bubbles	Bubble Sizes(cm)
1	120'/67hr	1	1	47	-	-
2	25'/65hr	2	1	7	-	-
			2	8	-	-
			3	7	-	-
		6	1	3	14	0.02-0.3
			2	1	48	0.02-1.0
			3	1	65	0.005-1.1
3	60'/60min	5	1	0	20	0.04-1.0
			2	3	60	0.02-0.8
			3	1	50	0.02-1.3
4	120'/15min	3	1	1	-	-
			2	3	17	0.2-0.5
	3 hr		3	2	15	0.02-0.6
	Surface					
	Interval	4	1	1	-	-
			2	2	170	0.02-2.5
	120'/6 min		3	4	-	-

With a severe exposure, even minimal bubble formation would be difficult to overlook. Many large bubbles developed resulting in a volume increase of 47%. No further tests of this dive were conducted.

The second simulated dive was to a depth of 25 FSW for at least 65 hours followed by immediate decompression to sea level. A marine scientist might experience such an exposure during a saturation dive in an underwater habitat. Two implants were exposed 3 times each. Upon decompression, the first implant had volume changes of 7, 8 and 7%. Fewer bubbles formed in the second implant which had volume increases of 3, 1, and 1%. As many as 65 bubbles developed in these experiments ranging from 0.005 cm to over 1 cm in diameter. The smaller bubbles were spherical while the larger ones tended to be oval or disk-like sheets of gas.

The third series of experiments tested a dive to 60 FSW for 60 minutes. This is a US Navy no-stop diving exposure limit which is routinely used by sports divers. In three exposures-of a single implant, volume increases of 0, 3, and 1% were noted. Bubbles were more numerous and larger in the second and third experiments.

The last series of experiments exposed two implants to a repetitive no-stop dive profile specified by the US Navy Repetitive Dive Tables. The first dive was to 120 FSW for 15 minutes followed by a surface interval of 3 hours. The second dive was to 120 FSW for 6 minutes. In three experiments with the first implant, volume changes of 1, 3, and 2% were observed. The second implant had volume changes of 1, 2, and 4%. After the third experiment with this repetitive dive profile sheets of gas as large as 2.5 cm were seen.

DISCUSSION

The bubble formation observed in these experiments was greater than would occur in vivo for several reasons. In the simulated dives, the implants were instantaneously exposed to the full oxygen and nitrogen partial pressures present in a diver's breathing gas. This does not occur in vivo because there is a circulatory delay in the transport of nitrogen between lungs and tissue and because metabolism reduces the oxygen tension in tissue to below the partial pressure in the lungs.

It has been demonstrated that extensive bubble formation can occur in mammary implants after severe compressed air exposure. Bubble formation leading to a volume increase of several percent might occur after shallow saturation diving. Single and repetitive no-stop dives might lead to the formation of a few bubbles but probably not to an appreciable change in implant volume.

Another significant difference between the in vitro and in vivo environments is the rate at which bubbles are absorbed. A bubble in tissue or in an implant surrounded by tissue is

SPUMS NOTICES

MINUTES OF THE ANNUAL GENERAL MEETING

held at Bandos Island, Maldives on 18 April 1985 at 1100-1125 hours.

APOLOGIES: none

ATTENDANCE: SPUMS members at the conference

MINUTES OF THE LAST AGM:

Proposed to be accepted; J Knight Seconded; P McCartney

BUSINESS FROM THE MINUTES: None

CORRESPONDENCE: None

TREASURER'S REPORT:

Submitted by Dr J Doncaster. This appears on page ... Dr C Acott moved that the Treasurer's report be accepted. Seconded J Knight.

SECRETARY'S REPORT:

Between June 1984 and March 1985 there were 40 new members, and 41 new associate members.

JOURNAL:

J Knight told those present that the function of the Journal was to:

(1) Report on the Annual General Scientific Meeting.

(2) Print original contributions.

(3) Reprint articles of interest from other journals.

(4) Report on diving deaths and accidents.

Regrettably there seemed to be little input from the membership.

The cost of the Journal had risen by 20% due to (i) changing printers and (ii) increase in postage

PRESIDENT'S REPORT

Diving Medicals do not have a Medicare number, so does not qualify for a rebate. To bill Medicare would be Medifraud.

The New Zealand members wanted to form their own sub-branch. This was agreed to. There had been a request from the AUF for a list of accredited doctors to do Medicals. A draft will appear in future Journals and comments will be appreciated.

Venue of the 1986 Conference was still undecided. But hopefully it will allow members to go on to the UMS conference in Tokyo.

Meeting was then closed.

MINUTES OF THE EXECUTIVE COMMITTEE MEETING

held at Bandos Island, Maldives on 21 April 1985 at 2100-2245 hours.

ATTENDANCE: Chris Lourey, Chris Acott, John Knight, Peter McCartney, Allan Sutherland.

APOLOGIES: None

BUSINESS FROM THE MINUTES OF THE PREVIOUS MEETING.

1. Dive Tables: Letter from the AUF
As a Society we do not recommend any particular diving tables. SPUMS recommends the use of 'fudge factors' when any dive tables are used, and recommends that the AUF teaches that none of the diving tables are 100% safe (this should be stressed to all divers). The Secretary will write to the AUF concerning this matter.

2. 1986 Scientific Meeting:

Venue - undecided. To be investigated by the Secretary.

Guest Speaker: Dr A Pilmanis. Dr C Lourey will contact him.

GENERAL BUSINESS:

1. NZ Sub-branch of SPUMS

It was agreed by the Committee that a sub-branch be formed in New Zealand. The Journal will be sent to one address in NZ and then distributed from there to the NZ members. Dr A Sutherland will write to Dr Knight to inform him to what address to send the Journals. The subscription for NZ members will still be $A30.00 (full membership) and $A20.00 (associate membership). Money will be sent to NZ to cover postage and costs.

2. Letter from ASH (Action on Smoking and Health)

Reply - As a Society we support the concept that divers should not smoke. The Secretary will notify them of our views.

3. Letter from Dr Wong requesting a list of 'diving doctors'

The Secretary will write to the SUM and hopefully obtain an up-to-date list of doctors who have completed the courses in Underwater Medicine. A notice will be put in the Journal asking people who have done a similar course with the RN or UMS, etc. to write to the Secretary so that their name can be added to the list.

4. Executive Committee elections will be held in June 1985. Nominations will be asked for in the Journal.

The Committee decided that the outgoing President should automatically have a position on the Committee. If any members have any objections to this will they please notify the Secretary by August 30. If a reasonable number of objections are obtained then a referendum will be held about it. Notification will appear in the next issue of the Journal.

5. Honorary Legal Advisor to SPUMS

The President will investigate this.

Next meeting will be held after a venue and guest speaker for the next Scientific Conference have been decided upon.

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*.

SPUMS

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 30 APRIL 1985

OPENING BALANCE			
Cash on Hand		2.00	
RESI Card		302.74	
Standard Chartered Finance Ltd		1,000.00	
RESI 30 Day Investment		3,687.47	
National Savings		3,434.76	8,426.97
ADD INCOME			
Subscriptions		13,022.61	
Interest			
- Standard Chartered Finance Ltd	113.71		
- RESI	55.44		
- RESI 30 day	339.51		
- National Savings	355.34	864.00	
		13,886.61	22,313.58
LESS EXPENDITURE			
Secretarial Service		1,872.55	
Stationery		30.00	
Journal		4,792.56	
Post		1,737.95	
Executive Travel		2,274.25	
Miscellaneous		119.00	
Cheques Dishonoured		17.21	10,943.87
(what's this??)		100.35	
			11,369.71
TOTAL FUNDS			
Represented by:			
Standard Chartered Finance Ltd	1,000.00		
RESI Card	377.80		
30 Day Account	5,384.64		
National Savings	4,607.27	11,369.71	

AUDITORS REPORT

I have examined the above statement of receipts and payments of the South Pacific Underwater Medical Society and state that the statement gives a true and fair view of the financial transactions of the Society.

LES NEWMAN
FASA, CPA

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), who will be mailing a brochure giving further details to all members in the near future.

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.

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.

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

ELECTION OF THE EXECUTIVE COMMITTEE

When nominations closed the following were elected unopposed:

President Dr Chris Acott
Secretary Dr David Davies
Treasurer Dr Graeme Barry
Editor Dr Douglas Walker

There will be an election for the three vacancies for Committee Members. The candidates are (in alphabetical order and with brief details)

Dr John Knight
Secretary of SPUMS 1976-1979, President, 1979-1983. Committee member 1983-1985. Responsible for the layout and printing of the Journal since 1980.

Dr Peter McCartney.
In charge of the Hyperbaric Unit at the Royal Hobart Hospital. Committee member 1984-1985.

Dr Ian Millar.
Senior medical officer of the Hyperbaric and Rescue Units of the National Safety Council of Australia (Victorian Division) at Morwell.

Dr Allan Sutherland.
Convenor of the recently inaugurated New Zealand Chapter of SPUMS.

Dr John Williamson.
Committee member 1984-85. Author of papers on box jellyfish *(Chironex Fleckeri)* stings.

Ballot papers will be distributed in the near future.

MEMBERSHIP OF SPUMS

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:

Dr David Davies
Secretary of SPUMS
Suite 6, Killowen House
St Anne's Hospital, Ellesmere Road
Mount Lawley WA 6050
Tel (09) 370 1711

LETTERS TO THE EDITOR

REPUBLIC OF MALDIVES

328 Wattletree Road
EAST MALVERN VIC 3144.

5th July 1985

The Editor

Dear Sir

During our 13th annual general meeting in the Maldives, I was conducted over the Male General Hospital by the Chief Medical Officer and Chief Surgeon, in an attempt to assess the theatre requirements for upgrading.

The Republic of Maldives approached the Health Commission of Victoria, I understand, to recommend the requirements for operating theatre, improvements, and, through the Alfred Hospital, to which the request was directed, I became involved.

That specific request aside, I was struck by the overall inadequacies throughout the Male Hospital, and I make a plea for our members to think before discarding any of the following:-

Journals
Suture material
Re-useable equipment such as ETTs and catheters and any equipment no longer of use such as suction equipment, instruments, drugs, etc.

Any such useable items would be gratefully accepted by the Maldivians, and can be sent to, or left at my Malvern rooms in Melbourne, 145 Wattletree Road, Malvern 3144 (Phone (03) 500 0879), or directed to Chris Lourey's rooms at 25 Hastings Road, Frankston, during office hours. Similar suggestions have been left with various hospitals I work at here in Melbourne. I look forward to an encouraging response.

DOUGLAS M DRUITT

BASSETT DECOMPRESSION TABLES

Rockhampton Base Hospital,
Rockhampton QLD 4700
Australia

30 August 1985

Dear Sir

As the Secretary of SPUMS, I feel I have to reply to Mr D Parer's letter in the last SPUMS Journal.

After long debate, the SPUMS Executive decided not to recommend any particular dive table. We approached the problem of the dive tables limitations by stressing diver education into the understanding of them, the theories behind their formation and their application. We stress that no dive table is 100% safe and all should be approached from a very conservative view point, adding various "fudge factors".

Although repetitive diving is "with us to stay", we felt as an organization, it is incorrect to recommend something that we know increases the risk of decompression sickness. I have adopted an attitude that repetitive diving is not recommended, but if it is contemplated, then a dive to no more than 9 metres should be undertaken.

I object strongly to the editor's note below Mr Parer's letter and I feel it implies that the SPUMS Executive has a slight tendency towards the Bruce Bassett tables. This is far from the case. Bassett's tables are based on the USN tables, and are just a conservative version of them, it has the so called "fudge factors" built in. The repetitive dive pattern is still based on Des Grange's concept of a tissue half life of 120 minutes.

In 1981 the SPUMS Executive published that aspirin should be used in the first aid management of decompression illness. One may now argue about this, however, it illustrates a very important point. I certainly know, and I am sure other diving doctors have had similar experiences, of divers who have taken 2 aspirin tables before a dive and then "pushing the tables" to the limit, thinking that aspirin is some magical potion to stop decompression illness. I can see the same illogical thinking occurring if we recommend any particular diving table. (The SPUMS Executive recommends them, so they must be safe!!!).

In summary therefore, the SPUMS Executive -

(i) Stresses that no dive table is 100% safe.

(ii) Stresses the importance that all divers should have a good understanding and working knowledge of the dive table that they are using.

CJ ACOTT
Secretary, SPUMS

It has always been editorial policy to encourage readers to think and the editorial comment, that Dr Acott takes exception to, was inserted to help readers find the other places in that issue where the Bassett tables were mentioned, so that they could make up their own minds about them.

Readers may think that the Editorial in the last issue displayed a critical rather than an unquestioning attitude to all Diving Tables. Those of Dr Bassett were presented at the ASM, and therefore published in the Journal, as possibly the least dangerous ones for sport divers.

With regard to Dr Acott's last paragraph, there is probably no way of making some divers act responsibly and therefore the Journal policy is to direct information to the intelligent majority.

Readers are reminded of the disclaimer printed in each issue: "All opinions expressed are given in good faith and in all cases represent the views of the writer and are not necessarily representative of the policy of SPUMS". This also applies to the Editor of the SPUMS Journal! He is in good company. On the other side of the world it has been made clear that editorials in the British Medical Journal do not necessarily represent the policies of the British Medical Association.

The Journal congratulates Dr Acott on his unopposed election to the office of President of SPUMS and looks forward to further progress of the Society under his leadership.

NEW ZEALAND CHAPTER OF SPUMS

Dr Michael Davis' letter has been shown to Allan Sutherland whose reply is printed below.

21st August 1985

Dear Sir

In the latest newsletter, I read with interest of the establishment of a New Zealand Chapter of SPUMS. There are clear practical advantages to this. However, I object to the undemocratic way in which it has become a fait-accompli without New Zealand members at large first being canvassed for their opinions nor having any say in the organization and the election of officers to the Chapter. Furthermore, information on the inaugural meeting of the Chapter has been so devoid of scientific or medical content that it has been quite impossible for myself in a salaried post to convince the University of the legitimacy of this as a post-graduate meeting or organisation.

So far it seems more like an Auckland faction than a New Zealand Chapter. As a long-standing member of UMS and SPUMS and one of the few physicians in New Zealand actively involved in hyperbaric medicine, I am not at all impressed by the way enthusiasm has so far over-ridden responsibility.

Yours sincerely

F Michael Davis
Senior Lecturer in Anaesthesia
Medical Officer-in-Charge
Hyperbaric Unit, Princess Margaret Hospital
Christchurch

"Outspan"
Bush Road, RDI
Albany
New Zealand

7 September 1985

Dear Sir

It is most unfortunate that Dr Michael Davis feels compelled to write to the SPUMS *Journal* in such terms as he has been included in, and informed of, all discussions from the beginning and was invited to the meeting on 11 December 1984 where the decision to proceed with the formation of a New Zealand sub-branch of SPUMS was taken.

He was asked for his advice about the SCUBA DIVING ACCIDENTS decal (figure l) which was produced jointly by the New Zealand Chapter and the Water Safety Council earlier this year. I am grateful to Ciba-Geigy for their generous financial support which made the production of the decal possible.

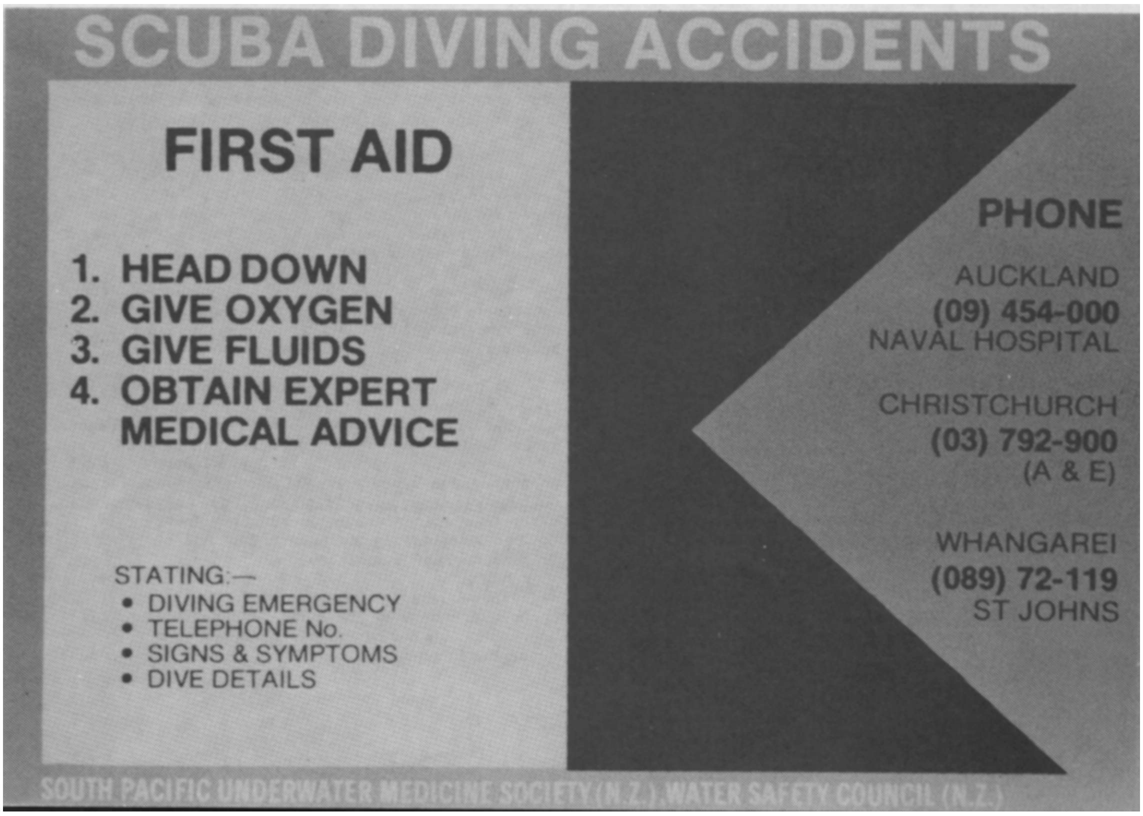
In addition he was invited to be a speaker at the forthcoming meeting on Great Barrier Island. I sympathise with him about the problems of getting money for travel expenses. We have been unable to find any money to assist our overseas speaker with travel expenses.

It is my intention to submit in the near future, for publication in the *SPUMS Journal*, the history of the formation of the New Zealand Chapter of SPUMS.

Allan FN Sutherland

FIGURE 1

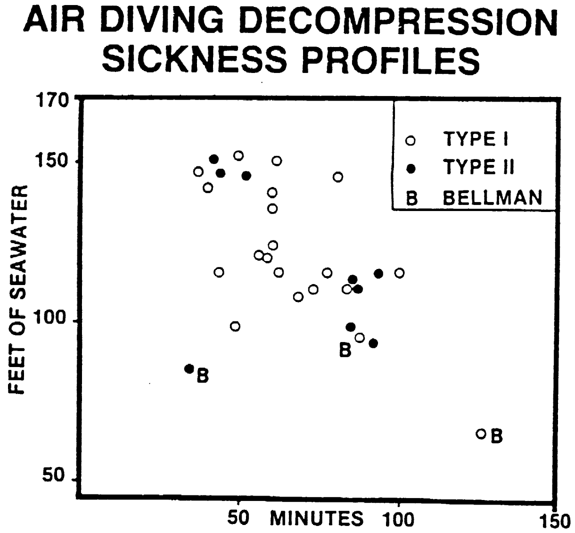
ADHESIVE LABEL FOR SCUBA TANKS, ETC., GIVING INSTRUCTIONS FOR FIRST AID FOR DIVING ACCIDENTS WITH CONTACT 'TELEPHONE NUMBERS FOR NEW ZEALAND.



FROM THE MEDIC'S LOG

Dick Clarke

Four years of surface oriented air diving from a North Sea multi-service vessel, involving 3,933 man/dives, resulted in 29 cases of decompression sickness. The accompanying figure indicates exposures that produced DCS, supporting the popular contention that USN Standard Air Decompression Tables are particularly suspect in the 120-150 foot range.



Depths ranged from the splash zone to 170 feet, with an average dive profile of 95 feet for 80 minutes. An overall incidence of 0.7% compares favourably with the US Navy figure of l.25% (Berghage 1981), particularly as the latter's average profile was a no-decompression one!

A comparison of decompression tables showed that the Standard Air Table produced 21 cases (14 Type I, 7 Type II) in 3,404 dives for 0.6%, against eight cases (6 Type I, 2 Type II) on the USN Surface Oxygen Table for 1.5%.

Reprinted by kind permission of the Editor from TRIAGE, No.7, July 198~, the Newsletter of the National Association of Diver Medical Technicians.

SWEDISH COLD SURVIVAL TEST

The Swedish Navy has reported an interesting cold survival test in a "lost bell". The survival equipment is listed as follows:

1. Water tight plastic bag, for items 2-6.
2. Thermal insulation underwater, consisting of jacket and trousers in synthetic fur. This equipment is also used in the Navy's constant volume diving suits.
3. Towels
4. Underwear, allowing for good transfer and distribution of humidity (often used as underwear for winter sports).
5. Gloves, in synthetic fur.
6. Hood, of the same material as the underwear.
7. Packaging for items 8-18 made of rubberized canvas with lacing that makes it possible to compress the equipment.
8. Survival bag (sleeping bag), with 10 cm polyester/wool insulation. The sleeping bag is provided with a zip along the length of one side and has a fixed hood with a neck seal.
9. Plastic bag, that is pulled over the sleeping bag and prevents it from becoming wet.
10. Jacket with hood, made of the same material as the sleeping bag.
11. Urine collection bags (2), in plastic with liquid absorbent material which allows the diver to urinate without having to leave the bag.
12. Socks, in the same material as the sleeping bag.
13. Alarm clock. Timekeeper with alarm bell which runs for 1 hour.
14. Diving watch, pressure tested to 300 metres.
15. Plastic flask, with 1 litre of water.
16. Torch.
17. CO_2 scrubber, gas heater type DUI Hamilton, consisting of oronasal mask, head harness, saliva collector and container for CO_2 is absorbent. The equipment is designed so that the heat and humidity in the divers' exhaled gas is accumulated in the absorbent at the same time as the CO_2 is removed from the gas.

    During inspiration this heat and humidity is reutilised, heating the inhalation gas to a comfortable level.

    A certain amount of heat is also added as a result of the chemical reaction in the absorbent when the CO_2 is absorbed.

    To prevent the absorbent canister from being cooled it is carried between the jacket and the sleeping bag which also adds a certain amount of heat in the sleeping bag.

    The size of the absorbent canister (weight of absorbent 1.8 kg) is suited to allow the container to be carried comfortably. The "dead space" is negligible for a grown person at rest, even though the inhalation and exhalation gases pass the same way through the CO_2 absorbent, a necessity in order to reutilise the heat.
18. Extra absorbent canisters (3).

    After the survival test the number of containers has been increased to 3 which gives added margin for extra time as well as variations in the capacity of the absorbent.
19. A net is stretched across the bell as an extra floor, which protects the divers from the cold diving bell walls and from wet diving gear stored under the net. The net prevents the hatch from being blocked and gives the best possible lying comfort as it is made of wide non-water absorbing straps.

20. Writing pad and pen.

21. Emergency procedure, plastic coated.

The test has confirmed that the survival systems and the modified final emergency procedure fulfil the specified survival requirement for 24 hours in water temperatures of 2°C for two divers after "lost bell" has occurred.

One condition for appropriate use, however, is sufficient training and realistic practicing.

The time period that will be the basis when planning necessary emergency resources for salvaging divers in a "lost bell" situation will consequently be 24 hours.

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MARBLES ARE NOT CHILD'S PLAY TO OILMEN

The US oil company AMOCO recently used 300,000 marbles to solve a tricky technical problem in one of their North Sea wells. The marbles were poured down the well and formed a temporary plug between two oil-bearing layers. Sand was pumped into cracks in the upper part of the well, the marbles stopping the sand at the place where it was needed. When the well was reopened the marbles were pulverised by the pressure and simply disintegrated in the gushing oil. An order for a further 500,000 marbles has been placed.

Reprinted from the Australian, 10 December 1983.

PUBLICATIONS AVAILABLE FROM THE UNDERSEA MEDICAL SOCIETY

BOOKS

US FUNDS

Barometric Pressure, Bert (1984 Reprint) $45.00
Directory of Hyperbaric Chambers: USA and Canada (1983) 40.00
Diving and Subaquatic Medicine, Edmonds, Lowry, Pennefather (1981 Revised) 40.00
Human Underwater Vision, Kinney (1985) .. 28.00
Hyperbaric and Undersea Medicine, Davis (1981) 40.00
Hyperbaric and Underwater Physiology, Shirakj & Matsuoka (1953) 30.00
Hyperbaric Medicine Procedures, Kindwall & Goldmann (1984 Revised) 25.00
Hyperbaric Oxygen Therapy, Davis & Bunt (1977) 27.50
Key Documents of the Biomedical Aspects of Deep Sea Diving (five volumes), (1983). 195.00
Living and Working in the Sea, Muller (1984) 28.00
Pathology of Oxygen Toxicity, Balentine (1982) 42.50
The Physicians' Guide to Diving Medicine (1984) 45.00
Proceedings of the 8th Annual Congress of EUBS (1982) 30.00
Proceedings of the 9th Annual Congress of EUBS (1984) 35.00
The Underwater Handbook, A Guide to Physiology and Performance for the Engineer (1976) 32.50
Underwater Medicine & Related Sciences, Vol. 2 (1975) 25.00
Underwater Medicine & Related Sciences, Vol. 3 (1977) 25.00
Underwater Medicine & Related Sciences, Vol. 4 (1979) 25.00
Underwater Medicine & Related Sciences, Vol. 5 (1981) 25.00
Underwater Medicine & Related Sciences, Vol. 6 (1983) 30.00
Underwater Physiology VII {1982) 47.50
Underwater Physiology VIII (1984) 60.00
The Use of Hyperbaric Oxygen in the Treatment of Certain Infectious Diseases ..., Bakker (1984) 25.00

WORKSHOP REPORTS

Decompression Theory (1980) 9.50
Development of Decompression Procedures for Depths In Excess of 400 Feet (1975). 8.50
Effects of Diving on Pregnancy (1978). 5.00
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Treatment Offshore of Decompression Sickness (EUBS, 1976) 1.50
Treatment of Serious Decompression Sickness and Arterial Air Embolism (1979) 3.50
The Unconscious Diver: Respiratory Control and Other Factors (1980) 6.00

ANNOTATED BIBLIOGRAPHIES

Cold and the Diver: Prevention, Protection & Performance (1985) 9.00
CO_2 Effect on Mammalian Tissue (1980). 5.50
Dysbaric Osteonecrosis (1983) 6.50
Man in the Cold Environment (1982) 12.00
Nitrogen Narcosis (1983) 8.00
Superoxide Dismutase (1981) 6.00

A bankers draft in US currency must accompany any order, which should be sent to the

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