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OBJECTS OF THE SOCIETY

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

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

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

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

Abstracts are also required for all case reports and reviews. Letters to the Editor should not exceed 400 words (including references which should be limited to 5 per letter).

References

The Journal reference style is the "Vancouver" style, printed in the Medical Journal of Australia, February 15, 1988; 148: 189-194. In this references appear in the text as superscript numbers.[1-2] The references are numbered in order of quoting. Index Medicus abbreviations for journal names are to be used. Examples of the format for quoting journals and books are given below.

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

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GLEANINGS FROM MEDICAL JOURNALS

MEETINGS AND COURSES

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PROJECT STICKYBEAK

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

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

The Editor's Offering

The Editor tenders his apologies for the late arrival of this issue of the Journal. He has been in hospital and is still on crutches which slows him down more than somewhat.

At the recent Annual General Meeting it was announced that the Committee will soon be considering the need for changes to the SPUMS policy on emergency ascent training as further data about the risks of buddy breathing ascents has surfaced.

The Annual Scientific Meeting (ASM) was successful, with many interesting contributions. The dive computer workshop was full of interest and some conflicting views were expressed. Unfortunately the participants were not provided with copies of the written submissions, sent from around the world, for them to study at their leisure. Having the shorter submissions read out is not an adequate substitute for providing each registrant with the text. One American submitted a multi-page paper, which was abridged to two pages for circulation at the meeting. Unfortunately it did not appear to be distributed, which was a pity as it was a good review of decompression theories, which are vital in assessing the merits and demerits of dive computers. It is intended, as usual, to publish the contributions to the ASM and the workshop in later issues of the Journal.

There are advantages in the new public method of coming to SPUMS policies, but unfortunately there are disadvantages. There is a need for all members and associates to consider the topic well in advance of the meeting so that they can express their ideas and opinions clearly and send them to the convener for circulation to registrants at the ASM well before the workshop, so that those who will debate the issue are fully informed before making a decision rather than being swayed by the rhetoric, and slides, of the speakers on the night. But then one has to remember that in any group of five doctors there are six opinions !

Next year's workshop will be on asthma. This is an emotional topic for many. Some are quite certain that asthma is a potent contributor to diving accidents. Others, who believe that asthmatics can do anything, recommend that asthmatics can dive safely. From personal experience the Editor does not believe this. Three cases of asthmatic divers going unconscious during their basic training has convinced him that some asthmatics are at risk. On the other hand he knows people who have dived safely for many years taking their bronchodilator medication. Asthma affects different people differently. The range is from incapacity to mild inconvenience. What is missing in the diving and asthma debate is fact. We need to find out about people who dive safely with asthma and see if there is anything about their responses to hypertonic saline and methacholine and the normality or not of their respiratory function tests. It is important to compare individual's tests with the established norms for their age, height and weight. The FEV_1/FVC result is of no significance, except for the fact that a result of below 75% was found, many years ago, in a much higher percentage of those who had received treatment for pulmonary barotrauma than that in the general diving community. But by no means is everyone with a FEV_1/FVC below 75% going to suffer pulmonary barotrauma.

The reasons advanced against letting people with asthma dive are logical and compelling. But one wonders if they apply to every asthmatic for they are based on theory rather than recorded facts. The Editor remembers very clearly the naval reservist who developed asthma in his thirties. He only got asthma when at his week-end farm and was shown to be sensitive to rye grass. This was the only allergen that he reacted to and his respiratory function tests were normal. His problem was that asthma was a disqualifying condition for naval service, yet when away from land he never wheezed as he was not exposed to rye grass !

Those asthmatics who go unconscious underwater during training present a problem in diagnosis for they never do it where people can take blood gases to establish what has happened. An attractive theory is that the regulator's inspiratory resistance and increased density of the air increases the work of breathing, which is already high because the diver is a novice and breathing deeply anyway and working hard at finning. If one adds to this the effect of cold air on the lungs and perhaps a small spray of salt water, both known to cause airway narrowing, one can postulate that they go unconscious from carbon dioxide retention. Certainly they have needed expired air resuscitation because they had stopped breathing and this had to be continued for many minutes in some cases. But did they really have hypercarbia causing their unconsciousness ? We know that this happens with commercial divers but are we right to assume that it happens to recreational divers ? Most people who suffer this fate want to have nothing to do with diving ever again, which is not surprising. But in the interests of the safety of others they need to be persuaded to cooperate with a respiratory unit to see if they retain carbon dioxide sufficiently to explain their unconsciousness or not. If not then what did they suffer from ? It is up to members of the Society to see what they can do towards finding out the facts about asthmatics and diving.

While at present asthma is a permanent contraindication to diving in Australasia it may be that we are being too cautious because we do not know what actually happens to asthmatics who dive, and they are out there getting wet every weekend.

ORIGINAL PAPERS

FITNESS TO DIVE; IMPLICATIONS OF CORNEAL SURGERY

Michal Kluger

Abstract

Corrective surgery for myopia, and the wearing of contact lenses is becoming increasingly common. Potential and established divers, who are already certified, are presenting for dive medicals following procedures such as radial keratotomy and photorefractive keratectomy. The current literature about these procedures has been reviewed and general guidelines have been drawn up to aid in decision making about fitness to dive.

Introduction

As the appeal of recreational scuba diving continues to grow, those doing diving medical examinations are being presented with potential candidates who have undergone various new surgical procedures. The impact of these on the suitability of candidates to undertake scuba diving is not always appreciated by diving physicians, dive instructors or the candidates themselves.

Approximately 25% of the western world has some degree of myopia or short-sightedness. Measures to improve eye refraction for cosmetic, work or social reasons have increased dramatically over the past 10 years. From a greater understanding of the anatomy and physiology of the cornea various strategies have been developed to correct myopic eyes. These include contact lenses, radial keratotomy (RK) and photorefractive radial keratectomy (PRK). Other techniques currently under investigation include the implantation of an adjustable ring within the cornea which could reversibly alter corneal structure and implantable hydrogel corneal implants.[1]

This paper reviews the present position of contact lenses, radial keratotomy and photorefractive keratectomy with relevance to scuba diving.

Corneal Pathophysiology

Although the lens of the eye "fine tunes" changes in light refraction, the majority of refraction occurs at the cornea. While the total power of the eye to focus a distant object on the retina is about 60 diopters, the cornea accounts for approximately 45 diopters. Hence surgical procedures which alter corneal geometry and therefore correct refractive errors are currently being evaluated.

The human cornea is divided into 5 layers. These are; epithelium, Bowman's membrane, stroma, Descemet's membrane and endothelium. The mechanical strength comes from the stroma which accounts for 90% of the thickness of the cornea along with Bowmans membrane. This stroma comprises 300-500 sheets or lamellae of collagenous material, supported in a jelly-like ground substance, which lie parallel to each other.[2] The ocular clarity of the cornea depends on these collagen fibrils being of similar diameter and equal distribution. The adult cornea has a radius of curvature of 7.86 mm (SD 0.26 mm), a horizontal diameter of 11-12 mm and corneal thickness of around 0.52 mm at the centre to 0.65 mm at the periphery.

During some refractive correction procedures (e.g. RK) incisions are made in the cornea to induce flattening of the cornea and hence a change in refraction. The healing and refractive responses are biphasic; there is an instantaneous component due to acute visco-elastic changes, usually within one hour, followed by a slower progressive healing. The surgical correction changes refraction by approximately 25% during the healing process and this may take up to 4 years to complete.[2]

Contact Lenses

Contact lenses are becoming increasingly popular to correct refractive problems, especially in the workplace, military[3] and sporting worlds. The types of lenses currently available include; traditional hard, polymethylmethacrylate (PMMA) lenses; gas permeable silicone or cellulose acetate lenses; daily wear soft hydrogel lenses and extended wear soft hydrogel lenses.[4] The traditional hard lenses are infrequently used nowadays. Despite their good visual acuity, stability and resistance to deposit formation, they are uncomfortable and unsuitable for extended wear. Hard gas permeable lenses are more comfortable and are less prone to causing corneal damage, but are more expensive, more susceptible to damage and need more maintenance and care. Soft hydrogel lenses are the most comfortable to wear for prolonged periods of time and are more closely adherent to the eye. However they fail to correct vision as effectively as hard lenses, are more expensive and are prone to a greater number of complications. These include deposit formation and bacterial contamination.

Complications of contact lenses, in general, include mechanical damage (e.g. foreign body beneath lens, lens defect or incorrect positioning of lens), corneal hypoxia, alteration of eye flora and hypersensitivity. Corneal hypoxia occurs as a consequence of impaired tear flow and oxygen exchange. Subsequent lactate accumulation and metabolic pump failure lead to corneal overhydration and oedema formation. This may in turn cause corneal neovascularisation and lead to diminished visual acuity.

Conjunctivitis may be caused by infections or be non-infectious in aetiology. Corneal damage, especially ulceration, is the most worrisome complication of contact lens wear. Infectious aetiologies include careless cleaning techniques, extended wear or use in immunocompromised patients. *Pseudomonas* is recovered in up to two thirds of all cultutre positive corneal ulcers and may lead to permanent visual loss.[4] Other commonly isolated microorganisms include; *Staphylococcus Aureus, Serratia, Bacillus, Bacteroides, Fusobacterium* along with the difficult to eradicate *Acanthamoeba*.

Radial keratotomy

Although the use of surgical incisions to alter corneal curvature and treat astigmatism began in the late 19th century, effective corneal surgery was pioneered by Sato in Japan in 1953.[5] These earlier operations using posterior incisions were complicated by corneal oedema. The technique was modified to affect the anterior stroma only by the Russian, Fyodorov, in 1974[6] and introduced into the US in 1978[7] and subsequently into Australia in the early 1980's (personal communication Dr J Glastonbury).

The technique involves incising the cornea to produce flattening and subsequent refractive changes. The actual surgical technique varies greatly among surgeons, as do the instruments used. Generally surgeons can improve outcome by minimising the central clear zone, thus increasing corneal flattening, by optimising the number of incisions to between 4 and 8 and finally making the incision as deep as possible without causing micro- or macro-corneal perforation, again to increase flattening.[8]

Complications of radial keratotomy include temporary problems e.g. pain, glare, fluctuating vision[9] diurnal variation in vision, complications which reduce visual acuity e.g. under and overcorrection, astigmatism, epithelial inclusion cysts and finally those complications that potentially reduce visual function. These include, monocular diplopia, halo and glare especially at night, disruption of binocular vision and loss of fine depth perception. Traumatic rupture of the cornea at the incision sites has been reported as a delayed sequelae of RK.[10]

Photorefractive keratectomy (PRK)

The introduction of the argon-fluoride 193nm excited dimer (excimer) laser over the past 4 years has potentially revolutionised refractive surgery. Its use was first reported in humans in 1987, with the first reported correction in a sighted eye described in 1989.[11] Whereas in RK up to 90% of the corneal depth is cut, PRK can produce changes in focal length of up to 5 diopters by ablating less than 5% of the corneal thickness. Small segments of the cornea are sculptured to remodel it so that optimal refraction is gained. The laser delivery system is computer programmed to deliver the laser energy patterns to the central corneal axis, minimising the degree of surrounding tissue destruction while optimally reshaping the cornea. This also involves destruction of Bowman's layer, as well as involving the central visual axis. This can be carried out as an outpatient procedure under topical local anaesthesia, with an operating time of approximately two minutes per eye. The advantage of using ultraviolet radiation is that it can ablate tissue with minimal damage to surrounding tissues. Longer wavelengths than 193 nm have a tendency to produce greater penetration and tissue destruction plus the added problem of potential oncogenensis,[12] although this is minimised by the short duration of exposure.

Complications of PRK include postoperative pain for a few days while the epithelium regenerates, corneal haze and transient overcorrection. While the overcorrection tends to settle within a few months, the haze appears early and peaks at between two and three months before regressing. In a small proportion of cases the corneal scarring is more pronounced leading to a reduction of visual acuity. Other problems include the complications of the topical steroid treatment along with excessive glare and halo affected vision. Glare has been reported to be a problem in up to 25% of cases after one year.

Implications for diving

CONTACT LENSES

Contact lenses of both hard and soft types have limitations in the commercial diving environment. In a study performed on two navy divers subjected to dives to 45.5 metres for 40 minutes, visible bubbles were present behind the hard polymethylmethacrylate (PMMA) lenses.[13] Slit lamp examination revealed rounded confluent areas of corneal oedema at the sites of bubble formation. This was secondary to impaired tear flow and prevention of normal metabolic exchange between corneal epithelium and precorneal tear film. These effects were not seen with soft lenses nor PMMA lenses with a 0.4 mm central hole. Infection is another important factor to consider. *Pseudomonas* ear infections (otitis externa) are common in saturation dives especially below 100 m. In such an environment where adequate cleaning of lenses may be a problem, *pseudomonas* eye infections may cause destruction of the eye. In such circumstances, contact lenses are not recommended. In contrast soft contact lenses are to be recommended for recreational scuba divers. Although bubble formation has been reported following recreational dives in divers wearing hard lenses this does not seem to be a problem with soft lenses.[14] Moreover, while hard lenses can be easily lost in a flooded face mask, soft lenses possess much more adhesion. Lovsund measured the adhesion of contact lenses by glueing a suture thread to hard and soft lenses assessing the tensile force needed to pull the lens from the eye.[15] Soft lenses required considerable force to remove them and this increased with increasing salt content of the water. In contrast, hard lenses needed little force and were unaffected by water salinity. As part of the same study volunteers snorkelled keeping their eyes open and blinking frequently using hard and soft lenses. Hard lenses fell out within 60 seconds, whereas soft lenses stayed in place.

RADIAL KERATOTOMY

While some authorities currently recommend that scuba diving is contraindicated or limited in patients with previous RK, there is limited data to support this. Although RK has been introduced only recently to Australia, thousands of patients in North America and Europe have undergone this procedure. Anecdotally many experienced and novice divers have had RK with no reported problems. It is known that any corneal incision (e.g. RK, corneal transplantation and trauma) results in a scar which has a reduced tensile strength. However reports of rupture of previous RK incisions have tended to be direct, low-area, high-pressure, axial compression directly to the globe or periorbital area. Forstot reported 8 cases of trauma in 7 patients following RK, 2 weeks to 14 months postoperatively.[10] These were due to a direct blow from a tennis ball, soft ball, war game pellet, tyre lever and unspecified "severe trauma". The only RK incisions to open were those secondary to severe trauma, with incisions of between 95 and 100% of the corneal thickness. Other case reports have described delayed rupture seven and ten years postoperatively.[16,17] These again were associated with severe direct axial pressure. Animal studies, using rabbit eyes, have demonstrated that the compressive force needed to rupture a globe 90 days post-operatively was approximately half of that of control non-operated eyes.[18] Campos and colleagues compared the ocular integrity of non-operated, RK and PRK pig eyes exposed to lateral compression.[19] While all 10 RK eyes ruptured at a pressure of 280 mm Hg at the sites of incision, none of the PRK (12.6% stromal thickness) or control eyes ruptured. When higher compressive forces were used ruptures occurred at the scleral muscle insertions in the PRK and control groups. It was not until the PRK depth was increased to 40% (not clinically used) that rupture occurred at the operative site.

The above data tends to suggest that corneal rupture is rare following RK and requires severe direct axial trauma to cause incision dehiscence. Dive instruction may need to be modified to protect such candidates from causing corneal damage when performing skills such as no-mask swimming and mask removal and replacement e.g. allowing students to swim with a completely flooded mask, and taking the snorkel off the mask for mask replacement, minimising the chance of trauma by the snorkel on the affected eye. Candidates may also be recommended to wear swimming goggles when performing watermanship skills to avoid trauma from others while swimming. Pressure changes within the mask (mask squeeze) should be minimised by emphasising the need to equalise continuously through the nose on descent.

Other potential problems include the presence of fluctuating vision (i.e. is it worse at night, or every second day) along with the presence of "haloes" or glare. These may make certain aspects of diving inappropriate e.g. night, cave or wreck diving, where reading instruments and torch light may make seeing difficult. Transient changes in visual acuity may be seen following intraocular pressure changes within the mask. It has been shown that patients who have undergone RK and who are subjected to raised intraocular pressure have improvement in their visual acuity.[20] This reversible effect may be due to transient flattening of the cornea. This has obvious implications for multiple daily dives with short surface intervals. In this case corneal curvature may not revert to pre-dive proportions immediately following the dive. This may lead to diminished and fluctuating visual acuity during a multi-day dive trip. Finally it is of great value to know the date of the operation and the type of operation. While candidates may enquire as to when is the safest time to dive following a corneal procedure, the data is unhelpful. The corneal healing process is slow and often incomplete especially when micro or macroperforation has occurred during the surgical procedure. To this end any potential or active diver should discuss their procedure with the surgeon who actually performed their operation and specifically note the number of incisions, depth and incidence of perforation.

PHOTOREFRACTIVE KERATECTOMY.

Photorefractive surgery is still at an early stage in Australasia, with relatively few centres performing PRK. Recent work from the United Kingdom[21] and Sweden,[22] reviewing up to 18 months follow up in sighted eyes, would indicate that PRK reliably corrects low myopes, with few complications. Ophthalmologists are however still awaiting the long term results (5 and 10 year) of PRK, with relevance to stromal haze, regression of correction, long term effects of laser therapy on the cornea (i.e. possible mutagenesis) along with the theoretical objection to ablating the basement membrane of the cornea i.e. Bowman's membrane. However at this time, increasing numbers of ophthalmic surgeons are undertaking PRK in Australia. Moreover diving candidates may present to diving medical centres in Australasia from the United States or Europe with a history of PRK.

From the animal data it would seem that the PRK eye is not any more structurally weakened than the normal eye at normal, clinically used excision depths.[19] This is of relevance to potential mask barotrauma, and differs from RK procedures. As with RK however the potential for glare and halo vision require increased care in those areas where limited visibility and artificial light sources are used.

The United States Air Force may be considering the use of PRK in their pilots, who are at present allowed to use contact lenses.[23] PRK offers the potential advantage of reducing spectacle and lens incompatibility with military optical and protective equipment. As with aviators, the prolonged use of contact lenses is problematic in commercial and military divers involved in prolonged operations at depth.[24] The advent of PRK may obviate the problems of bubble formation behind lenses, corneal trauma and infection. The reports of large clinical series are awaited with interest.

Conclusions

New strategies for coping with myopia are currently being developed and refined. The initial results of RK and PRK are promising, yet it is too early to say whether there may be detrimental long term sequelae. Potential and established divers who have undergone these procedures need some guidance on the possible effects of scuba diving on their vision. At present it would appear that neither RK nor PRK are absolute contraindications to scuba diving. Extreme care over equalisation techniques and avoidance of direct trauma is of paramount importance, however, in divers who have had a previous RK.

Guidelines for the management of divers who have undergone corneal surgery include;

1 There is no evidence that PRK causes significant structural corneal weakness.
2 There is a theoretical possibility that mask barotrauma may cause globe rupture after RK, however this has not been documented following scuba diving. Many people who have had RK continue to dive without problems.
3 Novice and experienced divers, who have undergone RK, and instructors need to be informed about potential problems with RK and ways of avoiding them, e.g. by emphasising the prevention of mask squeeze and the avoidance of in-water skills which may lead to face trauma.
4 Discussion of the surgery with the ophthalmologist involved to determine the type and extent of corneal surgery, depth of incision and any complications, such as perforation during the procedure is recommended.
5 Informed discussion with the diver is required. The potential risks must be made available to the diver so that he or she can make an informed judgement whether to start, or continue, diving.

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PROVISIONAL REPORT ON AUSTRALIAN DIVING-RELATED DEATHS IN 1991

Douglas Walker

Summary

In 1991 two breath-hold diving related fatalities were identified from the Great Barrier Reef area. It is possible that other deaths occurred in other areas but were recorded as drowning without full identification of the details.

Fifteen scuba diving related fatalities were identified, although details are still unavailable about one case.

Not all of the fatalities were regarded as requiring a formal inquest though all were thoroughly investigated by the police on behalf of the appropriate Coroner.

Breath-hold divers

BH 91/1

A group visiting the Barrier Reef included a business man, his son (age 14), and a new employee. After a morning of fishing, then lunch, they were offered masks and snorkels and the opportunity to swim and observe the coral. The employee, the victim, declined an offer of fins on the grounds that he was a good swimmer. The boy swam near the victim for a time and heard him say he was feeling tired. They became separated and on his return the boy thought the victim was playing a game with him as he was floating motionless, face down. He realised something was seriously wrong after there were no response when he pushed him.

The unconscious man was brought back to the boat and CPR started. He was taken by helicopter to hospital but died there later from the effects of anoxic cerebral damage. No reason can be given for his silent surface drowning in calm water close to others as no other pathology was identified.

SEPARATION/SOLO. NEAR OTHERS. RAPID SILENT SURFACE DROWNING. CALM WATER. GOOD SWIMMER. HEALTH HISTORY UNKNOWN. ASPIRATED GASTRIC CONTENTS DURING RESUSCITATION. DEATH DELAYED BY CPR.

BH 91/2

Three friends went to the beach, one remained ashore while the other two entered the water. The buddy was wearing half a wet suit, the victim a full one. Although they probably intended to spear fish this was not directly stated.

The buddy separated from his friend and returned to shore when he was feeling cold. The victim chose to remain diving over a ledge. Both the swimmer and the friend on the beach could see the victim at this time but from the beach about 20 minutes later neither could see him and they began to feel alarmed. A shore search was not successful. The body was washed ashore next morning. Possibly the victim had been held beneath a ledge by water power and freed only after the tide changed. He had not ditched his weight belt. As there is no information about his breath-hold ability it cannot be known whether this is an example of post-hyperventilation blackout.

Autopsy confirmed the cause of death was drowning but there was significant (90%) atheromatous narrowing of the left coronary artery and this may have been significant, although no evidence of myocardial infarct was noted. There was no history of ill health.

BREATH-HOLD SPEAR FISHING. SEPARATION WHEN BUDDY BECAME COLD. SKILL UN-

KNOWN. WEIGHT BELT NOT DITCHED. LEFT CORONARY ARTERY DISEASE. NO INQUEST

Scuba divers

SC 91/1

While one of their sons was having a scuba lesson from the instructor who had trained them, this couple made a separate dive. The victim had completed her training eight months previously but her husband had been trained for several years. Neither of them had dived there before.

They swam out from the beach underwater till at 12 m depth. After 35 minutes the victim showed her husband that her gauge read 50 bar (one fifth full tank). She remained where she was while he surfaced to check their position. He was not entirely sure where they were but decided to swim north in hope of finding their entry beach. After swimming about 39 m they surfaced, she near the rocky shore in moderately rough water, he 10 m further out and in calmer water. He signalled for her to join him and then lost sight of her and assumed she had dived to return to him. He dived, intending to meet her underwater but instead saw her lying on the sea bed with the regulator out of her mouth. There was no response when he replaced it in her mouth. He had not immediately realised the gravity of her condition but now he inflated both their buoyancy vests and brought her to the surface. She vomited when he performed EAR, which gave him hope, and he towed her to the rocks.

Water power foiled his attempts to pull her ashore and he lost his mask, had the regulator torn from his mouth, and lost his grip on his wife. He managed to climb the rocks and reach the beach where he told the instructor what had occurred. The instructor made an immediate search and saw her under a ledge but had to await an abatement in the water surge before he could retrieve her. There was sufficient air remaining to inflate the vest. It is possible she hit her head when tossed about in turbulent water and lost her grip on the regulator, but no significant head injury was found.

TRAINED. SURFACING SEPARATION. HELD UNDER LEDGE BY WATER POWER. POSSIBLY HIT HEAD ON ROCKS. WEIGHT BELT NOT DITCHED.

SC 91/2

This man had been certificated but was thought to be unco-ordinated and rather slow in grasping what was required. For this reason that he was buddied with his former instructor on this boat dive. The conditions were ideal, with good visibility and no current. The depth was 24 m. After reaching the sea floor his buddy (the instructor) helped him adjust his buoyancy as buoyancy management was one of his poor skills, then looked away for a moment to watch another diver feed a sea urchin to some fish. When he looked back he saw that the victim was lying in a balanced, relaxed posture quite unlike his usual appearance. This worried the buddy who swam over to find that he was unconscious with the regulator out his mouth.

The buddy immediately replaced the regulator and inflated the victim's buoyancy vest. He ditched the weight belt after reaching the surface and towed the victim to the boat. Resuscitation attempts were hindered by mucus coming up. The victim failed to respond. The equipment was correct and the only autopsy findings were those of drowning. The pathologist offered no reason for his loss of consciousness. His wife later revealed that he "was not asthmatic but used "Ventolin" for a similar condition" (sic) and was surprised he had been assessed as Medically Fit to Dive. No cardiac pathology was noted but he may have suffered a cardiac arrhythmia. He would not have reported symptoms of ill health to others.

TRAINED. LACKED CONFIDENCE. DETERMINED PERSONALITY. HID ASTHMA HISTORY. SLOW LEARNER. SUDDEN SILENT DEATH CLOSE TO BUDDY. IMMEDIATE CORRECT RESCUE. RESUSCITATION EFFORTS UNSUCCESSFUL. POSSIBLE CARDIAC DEATH

SC 91/3

This 67 year old man, whose usual exercise pattern is unknown, died from natural causes during a dive in a basic scuba course. There was no history of any ill health and he had passed a Fit to Dive medical check.

It was a boat dive to accustom the pupils to the underwater situation, planned to conclude with a practice "emergency controlled ascent" from 10 m. The victim accompanied by the instructor, was the first to ascend. They ascended the anchor line and at the surface the instructor left the victim close to the boat. The victim told the coxswain that he was feeling tired and that his gear was heavy. His tank was taken into the boat, then he swam from the bow to the stern platform. Two divers saw him lean forward on the platform, then topple into the water. He was two feet under water when reached and his arms were limp. He was recovered into the boat but failed to respond to resuscitation efforts. Autopsy revealed a thrombus completely occluding the right coronary artery. There was no evidence of any air embolism. This was an "unavoidable" death.

PUPIL IN CLASS. SUDDEN DEATH WHEN ABOUT TO BOARD BOAT. FATIGUE AS ONLY SYMPTOM. PRACTICE EMERGENCY ASCENT **NOT** THE CAUSE OF DEATH. DIED FROM CORONARY ARTERY THROMBUS.

PROVISIONAL REPORT ON AUSTRALIAN

Case	Age	Training and experience Victim	Training and experience Buddy	Dive group	Dive purpose	Depth m (ft) Dive	Depth m (ft) Incident	Weights On	Weights kg (lb)
BH 91/1	33	No training or experience	Not stated Not stated	Group Separation before incident	Recreation	Not stated	Surface	None	Not applicable
BH 91/2	40	No training Experienced	Training not stated Experience not stated	Buddy Separation before incident	Spear fishing	Not stated	Not stated	Not stated	Not stated
SC 91/1	42	Trained 8 months	Trained Experienced	Buddy Separation before incident	Recreation	11 (36)	Surface	On	11.4 (25)
SC 91/2	49	Trained some experience	Trained experienced	Buddy not separated	Recreation	25 (86)	25 (86)	On	Not stated
SC 91/3	67	Pupil Inexperienced	Trained Experienced	Group Separation before incident	Class	18 (60)	Surface	Off	Not stated
SC 91/4	52	Trained 2 years	Trained Experience not stated	Buddy Separation before incident	Recreation	16 (53)	Ascent	Off	Not stated
SC 91/5	19	Trained Experienced	Trained Experienced	Buddy No separation	Recreation	8 (27)	8 (27)	On	Not stated
SC 91/6	64	No training No experience	Trained Experienced	Group Separation before incident	Recreation	3 (10)	Surface	On	Not stated
SC 91/7	58	No training No experience	Trained Experienced	Group Separation before incident	Recreation	4 (13)	4 (13)	On	6.4 (14)
SC 91/8 +	33	Trained Experienced	Trained Experienced	Buddy Not separated	Recreation	50 (165)	50 (165)	On	Not stated
SC 91/9	30	Trained Experienced	Trained Experienced	Buddy Not separated	Recreation	50m	50m	On	Not stated
SC 91/10	44	Trained Some experience	Trained Experienced	Group Separation before incident	Recreation	4 (13)	4 (13)	On	Not stated
SC 91/11	34	Trained Inexperienced	Trained Experienced	Buddy Separation during incident	Recreation	24 (80)	24 (80)	On	12 (28)
SC 91/12	51	Just trained Inexperienced	Trained Inexperienced	Buddy Separation before incident	Recreation	4 (13)	Surface	On	16 (35)

DIVING-RELATED DEATHS IN 1991

Buoyancy vest	Contents gauge	Remaining air	Equipment Tested	Equipment Owner	Comments
None	Not applicable	Not applicable	Not applicable	Hired	Separation. No fins. Silent surface death. Found floating face down. Delayed death.
None	Not applicable	Not applicable	Not applicable	Own	Separation after buddy became cold. Some coronary disease. Possible water power factor.
Not inflated	Yes	Low	No fault	Own	Water power at rocks. Trauma to head ?
Not inflated	Yes	Yes	No fault	Dive shop	Sudden death. Cardiac death. Wife thought he was unfit.
Inflated	Yes	Low	No fault	Dive shop	Sudden death while boarding dive boat. Cardiac death.
Inflated	Yes	Low	No fault	Own	Separation. Solo ascent. Collapse at surface. Air shown on X-Ray. CAGE
Not inflated	Yes	Yes	No fault	Own	Shark attack. Body never recovered
Not inflated	Yes	Yes	No fault	Dive shop	Resort dive. Loose dental plate "Follow the leader". Rock weight in vest.
Not inflated	Yes	Yes	No fault	Dive shop	Resort dive. "Follow the leader" Separation. Solo ascent. Drowned
Not inflated	Yes	None	No fault	Own	{Trained wreck divers. Each with life line {which he did not use. {Went into crew compartment of wreck.
Inflated	Yes	None	No fault	Own	{ "Silt out". {Unable to find exit.
Not inflated Hose not connected	Yes	None	Significant fault	Own	Night dive in line ahead. Separation. Out of air. Tangled in bucket chain. Lost fin and torch. Ear drum lacerated. Air shown on X-Ray. CAGE.
Not inflated	Yes	None	No fault	Own	Third dive after course. Out of air. Failure of octopus breathing when buddy ran out of air. Middle ear bleed. CAGE.
Partly inflated	Yes	Yes	No fault	Dive shop	Sudden death. Snorkelling on surface. First dive after course. First night dive. Cardiac death ?

PROVISIONAL REPORT ON AUSTRALIAN

Case	Age	Training and experience Victim	Buddy	Dive group	Dive purpose	Depth m (ft) Dive	Incident	Weights On	kg (lb)
SC 91/13	64	Trained Experienced	Not applicable	Solo	Recreation	Shallow	Shallow	Off Tangled	Not stated
SC 91/14	41	Trained Experienced	Trained Experienced	Group Separation before incident	Recreation	Great depths	Great depths	On	Not stated

SC 91/4

The charter boat carried five divers and the dive boat operator, an instructor, who also intended to dive leaving the boat unattended. Conditions were excellent with no current and good visibility. The divers were assigned as a buddy pair and a trio, with the instructor watching in mid water above them. He was very visible in his bright suit. Water depth was 14-16 m.

The victim had been trained for two years and had made 14 logged dives, one deeper than the present one. Two of these dives were recent, following a 9 months break from diving. His buddy was trained but her experience is not recorded. After about 30 minutes he signalled that he was low on air and intended to ascend. She was aware that his use of air was greater than hers (she still had between 50 and 100 bar) so she decided to continue diving but watched as he made an unhurried and apparently normal ascent. Later she could not recall whether she saw bubbles coming from his regulator. The instructor noticed that she was alone and joined her to find the cause, and when he was unable to see any diver at the surface they ascended together.

The instructor saw the victim trying to climb from the water onto an islet whose steep rocks appeared a poor alternative to returning to the boat. He was alarmed by the risk of an accident although the diver did not appear to be in any danger at that time. He decided to take the boat across to the diver, a short delay occurring as he assisted the buddy aboard after himself. When 50 m from the rocks he stopped the boat and shouted to the victim to swim out to him. The victim seemed to fall into the water and lie face up and motionless, so the instructor jumped in and swam to him. The victim's buoyancy vest was inflated and weight belt missing when he was reached.

The victim was got aboard with difficulty and the boat taken to a safe distance from the rocks. With the help of one of the other divers the victim was placed on the engine cover, the only available flat surface, and CPR commenced, but this produced no response.

The autopsy was performed by a pathologist fully aware of the procedure for diving-related deaths. An X-Ray examination showed the presence of air in the aorta and both ventricles, the middle cerebral and the basilar arteries. The coronary arteries also contained air. There was a patent foramen ovale, which allowed a 5 x 2 mm probe to be passed, but it had an intact valve flap with 6 mm of overlap and there was no evidence of it having caused previous morbidity.

It is noteworthy that the victim made an apparently calm and correct solo ascent and was actively attempting to climb up the rocks before his collapse and death.

TRAINED. RECENT LIMITED EXPERIENCE AFTER NINE MONTHS WITHOUT DIVING. BUDDY'S SKILLS NOT STATED. SEPARATION AFTER LOW AIR. APPARENTLY NORMAL ASCENT. DITCHED WEIGHT BELT AND INFLATED BUOYANCY VEST. SURFACE SWIM. ATTEMPTED TO CLIMB ROCKS BEFORE COLLAPSE. BOAT UNATTENDED. X-RAY EVIDENCE OF MASSIVE AIR EMBOLISM. PATENT FORAMEN OVALE.

SC 91/5

The sudden attack by this shark was completely unexpected. Two divers were close to the sea floor, at about 8 m, the buddy leading but looking back from time to time to check they did not become too separated. They were swimming near to a drop-off (to unstated depth) and getting near to their dive boat when the buddy stopped to examine a brightly coloured rock growth. He heard "a roaring sound like a motor boat" and a large shark rushed past, stirring up sand. Blood was coming from his companion, who was in its mouth. The sound was due to air escaping from the severed air hose as the tank emptied itself. There had been no sightings of sharks in this area by any of the many divers there that day. The buddy hurried back to the boat and reported the attack. There was no doubt in his mind that it was a large white pointer of possibly 3-4 m length, but in the circumstances estimates

DIVING-RELATED FATALITIES 1991 (CONTINUED)

Buoyancy vest	Contents gauge	Remaining air	Equipment Tested	Equipment Owner	Comments
Not inflated Hose not connected	Yes fault	Yes	Significant faults	Own	Crutch strap over weight belt. Inflator hose not connected. Leaky regulator case. Duodenal ulcer history. Acute gastric bleed.
Not inflated	Yes	None	Not applicable	Own	Left others filming. Solo. Deep dive. Nitrogen narcosis. Body never found.

cannot be expected to be exact. The time was about 1500 to 1530.

An immediate search was made of the area but the only portion of the body recovered was part of one lung. His tank, fins, portion of his weight belt (buckle area), the severed air hose without the regulator, and torn wet suit hood were also found. The autopsy was limited to confirming that the lung was human tissue and the Inquest to confirmation that the missing diver had indeed been taken by a shark.

SHARK ATTACK. BODY NOT RECOVERED. SOME SEPARATION FROM BUDDY AS RETURNING FROM DIVE. DEPTH 8 m. NEAR EDGE REEF DROP-OFF. POOR VISIBILITY. DAMAGED EQUIPMENT PROOF OF ATTACK.

SC 91/6

Day trips to the Barrier Reef often offer a scuba dive under the supervision of a diving instructor to passengers. They have to declare their medical history and are given a short introductory talk on diving and the equipment while the boat is sailing to its destination. To reduce the risk of such novices making a sudden uncontrolled ascent, with the danger of air embolism, they were not told how to use the buoyancy vest or to ditch the weight belt. They were to rely on the instructor for this service.

Seven people took up the dive option on this trip. One was a trained diver who commented that the talk, though necessarily brief, was informative. The victim forgot to mention in his health profile that he had a past cardiac problem.

The novices and all their equipment were taken ashore before the other passengers They were given an introduction in shallow water and then divided into two groups, the victim and three others being in the first group. He was initially underweighted but this was corrected by placing a coral rock in his buoyancy vest.

They swam out from the beach, the instructor leading, reaching a depth of 3-4 m when 50 m from the beach. Here the instructor, looking back, noticed one novice was missing. He signalled to the others to remain where they were and then surfaced. He saw the victim and noted that he was having great difficulty remaining at the surface, so inflated his buoyancy vest. The victim's primary problem was his difficulty in retaining the demand valve because his lower dental plate was loose, but he agreed to try to dive again. However he only reached half a metre before giving up and surfacing again. He said he wished to return to the beach. He was puffing a little and appeared tired so the instructor reinflated his vest, then turned the air off, and told him to swim on his back for the return. He seemed to be a little disorientated and distressed so the instructor decided to remain at the surface to watch his progress.

After the victim had swum 5-10 m he started to cough and splutter profusely, then his head fell back and he appeared to be lifeless. The instructor called to him and got no response so quickly swam to him. The instructor called for help and the dinghy soon reached him from the beach. The victim's equipment was ditched and EAR was commenced immediately in the dinghy, CPR was started after reaching the boat. He failed to respond. The lack of support for the face after removal of the lower denture made it difficult to obtain a good mask seal. There was also some problems caused by gastric reflux or vomiting.

The outcome could have been worse because the other three divers were left unsupervised and ascended by themselves. Luckily a windsurfer soon arrived and supported two with his board. The third, the trained diver, took care of himself and retrieved the equipment.

There were significant faults with the equipment but these were not critical to the fatal outcome. The regulator supplied an inadequate air at 6 m depth and allowed the entry of some water, in particular if under a heavy demand (as when a diver was stressed and air hungry). The secondary (octopus) regulator was similarly hard to breath. There was also a small tear in the buoyancy vest.

The autopsy indicated that the cause of death was ischaemic heart disease.

RESORT DIVE. NOT TOLD HOW TO INFLATE BUOYANCY VEST OR DITCH WEIGHTS. INSTRUCTOR AHEAD OF GROUP OF FOUR DIVERS. SEPARATION NOT NOTICED. PROBLEM RETAINING REGULATOR. LOOSE LOWER DENTURE. REGULATOR GAVE INADEQUATE AIR AND ALLOWED WATER ENTRY. BUOYANCY VEST IMPERFECT. SURFACE CARDIAC DEATH. DIFFICULTY WITH FACE SEAL WITHOUT DENTURES. VOMITING A PROBLEM DURING RESUSCITATION.

SC 91/7

The basic facts are as for case SC 91/6 except that there was a greater stress on the previous health questionnaire. Again the instructor was leading, frequently turning to check that he was being followed. Again one novice ascended without warning and was found at the surface as they were beginning to return to shallower water as one of the group was having ear equalisation problems.

When the instructor surfaced a witness, a windsurfer, told him of seeing a diver surface and call out, though not appearing to be in distress as he was not waving his arms. The diver had submerged but surfaced again calling for assistance. However he sank before the windsurfer, hampered by a surface current, could reach him. A search, using the dinghy, was made for bubbles. The victim was soon seen lying unconscious on the sea bed with the regulator out of his mouth. The instructor retrieved him and ditched his equipment at the surface. Resuscitation produced some apparent response but death was certified soon after he reached hospital. The cause of death was drowning.

Again the unsupervised novices were of necessity placed in potential danger. They ignored orders to remain underwater but ascended successfully. The instructor inflated their vests as soon the victim was on his way back to the boat, then directed them to swim back to the beach while he returned to the boat to help with the resuscitation efforts.

RESORT DIVE. NO INSTRUCTION IN INFLATING BUOYANCY VEST OR DITCHING WEIGHT BELT. INSTRUCTOR AHEAD OF NOVICES. NO BUDDY CONTACT BETWEEN THE DIVERS. SEPARATION UNOBSERVED. DID NOT INFLATE VEST OR DITCH HIS WEIGHT BELT. SOME SURFACE CURRENT. SURFACE PROBLEM. DROWNED

SC 91/8 and SC 91/9

This double tragedy illustrates the truism that training and knowledge require experience before they are likely to be applied correctly. Both these divers held divemaster certification, had taken a wreck diving course, were regarded as careful divers, and had made several previous dives on this wreck.

In this instance they ventured into an enclosed area of the wreck and omitted to tie off the lines they carried before entering.

The dive trip was carefully conducted and when they failed to surface at the expected time it was thought that two divers of their experience could not have died but must have surfaced without being observed and drifted out to sea. Unfortunately this was not the case. None of the other divers who had been on the wreck had seen them at any time. A check of the wreck by the police and other divers found no trace of them, no significance being paid to silty water seen coming from the opening in the floor of the deck cabin, which led to the crew quarters, a space made dangerous by loosely hanging cables.

Some friends of the missing divers refused to believe that both would die without ditching their weights and inflating their buoyancy vests so assumed the bodies must be trapped within the wreck. They prepared carefully as the depth was 51 m and the compartment was dangerously cluttered and they expected to encounter nil visibility. The team of six divers had strong lights and the diver who was to make the search was on a line and supplied by hose from a tank placed close to the hatchway. They retrieved one body but left the other for the police as they were risking decompression sickness if they remained longer.

The victims presumably entered the compartment while there was satisfactory visibility, but became totally disorientated when stirred silt produced nil visibility. Lacking accurate knowledge of the compartment they were unable to relocate the hatchway. Nitrogen narcosis would have reduced their ability to reason out the position of the only exit.

DOUBLE FATALITY. TRAINED. EXPERIENCED. QUALIFIED WRECK DIVERS. FAILED TO USE LINES WHEN THEY ENTERED WRECK. STIRRED SILT. NIL VISIBILITY. DEEP DIVE. LIGHTS USELESS IN SILT OUT. NITROGEN NARCOSIS A FACTOR.

SC 91/10

Five divers were making a night dive after swimming 20 m from shore. They had dived together before, including night dives here. The victim had taken his basic course seven months before, dived regularly since, and was regarded as a competent diver by the others. They all carried torches but his was the brightest. They descended to 3.5 m and swam for about 45-50 m along a rock face, then two divers decided to return while the other three continued a further 10 m before starting their return. The victim at this time had 50 bar, his buddies 70 and 90 bar respectively, and he was in the rear as they swam in line ahead, the leader looking back every 30 seconds or so. After swimming about 10 m the absence of the victim was noticed.

They retraced their way but did not see him or his torch so they surfaced. After a surface search they saw his torch and found it and one fin but not their friend. Further surface searching was fruitless so they returned to shore and notified the police. A formal search was made and the victim located, mask off and regulator lying loose, minus one fin and wearing only one glove. There was a chain, connected to a bucket, round his upper body and arms. Attempts to ditch his weight belt found the chain was tangled with the quick release and prevented it opening. As the inflator hose was not connected the searchers were unable to inflate his buoyancy vest. However they had no difficulty in bringing the victim to the surface. It was thought he had intended to collect mussels in the bucket. When tested, his tank was empty and contained some water.

The local pathologist recognised that the autopsy should be conducted by someone well informed in diving-related problems, and arranged this. A pre-autopsy X-Ray showed there was air in both anterior cerebral and middle cerebral arteries, the common carotid arteries, left vertebral artery, and the neck vessels bilaterally. The chest films showed air at the left hilum and small bubbles in the rest of the lung fields (thought to be intravascular rather than interstitial). Air was also seen in the liver. There was also (surprisingly) air in the internal jugular veins. He had suffered a massive air embolisation. An ill defined history of his suffering a recent fit was never resolved as he had not attended any doctor to report such an occurrence.

TRAINED. SOME EXPERIENCE. NIGHT DIVE. HAD BRIGHT TORCH. LAST IN LINE OF TRIO. SEPARATION. THEN LOST FIN AND TORCH. OUT-OF-AIR (PROBABLY). INFLATOR HOSE NOT CONNECTED. WEIGHT BELT QUICK RELEASE FOULED BY CHAIN WHICH ENTANGLED ARMS. POSSIBLE HISTORY RECENT FIT. PRE AUTOPSY X-RAY. CEREBRAL ARTERIAL GAS EMBOLISM.

SC 94/11

This club dive had no appointed dive master controlling the fifteen divers present but there was a de facto acceptance that the experienced diver who owned the boat in which the victim travelled was in charge. The apparent purpose of the dive was to strip the small reef of every fish and crayfish of value. This was only the third dive, and the deepest, the victim had made since completing his club training three months previously.

Dive conditions on the wreck, depth 24 m, were described as ideal. Someone saw and speared a Port Jackson shark. The victim took part in its subjugation and then put it in the catch bag he had attached to his belt. Soon after this a witness saw he was looking agitated and appeared to be asking for air, so gave him his regulator and used his own octopus rig, though they soon changed. They established direct contact before starting their ascent. Their rate was reduced by the weight of the shark.

When they reached about 16.5 m the donor’s tank became empty and they broke contact. The witness made a rapid ascent but the victim never surfaced. It is possible that he attempted, in panic, to find another air donor rather than attempting to ascend. After he reached the surface the witness attempted, without success, to attract the attention of some divers in one of the boats, but had to swim to their boat before they noticed him. They described seeing a diver surface but a head count revealed the victim was indeed missing.

The “dive master” descended and soon located the victim, who was obviously dead and wearing all his equipment. A brief attempt at resuscitation was soon abandoned. The autopsy revealed middle ear haemorrhages and no clear lung pathology but the histology showed widespread interstitial congestion and occasional marked intraalveolar haemorrhage with focal oedema, and some areas where ruptured alveolar walls “seemed consistent with barotrauma”. No X-Ray check was performed in this case.

TRAINED. INEXPERIENCED. 3rd POST TRAINING DIVE. NO BUDDY DIVE DISCIPLINE. EXERTION GRAPPLING WITH SPEARED SHARK CAUSED RAPID USE OF AIR. FAILED TO MONITOR OWN AIR. SUCCESSFUL OCTOPUS BREATHING ASCENT UNTIL BUDDY RAN OUT-OF-AIR. THEN SEPARATION. DID NOT DITCH WEIGHT BELT OR SHARK. PULMONARY BAROTRAUMA. RUPTURED EAR DRUMS. PROBABLE CEREBRAL ARTERIAL GAS EMBOLISM.

SC 91/12

This was not only his first scuba dive since his just completed course but was his first night dive, so he was naturally a bit tense and worried although he was determined to undertake the dive. His buddy was similarly inexperienced, having been on the same course with him. This had involved six dives, two in a pool and the remainder during a single day. As he was aged 51 an ECG had been suggested as part of his Diving Medical and was to be performed two days after this dive.

The dive was organised by the course instructor and was on a wreck lying 200 m from the point of entry, a yacht club pier. The sea was calm and they were to snorkel out in their buddy pairs after they had made their mutual equipment checks. All had their air turned on and some air in their tanks, each carried a torch. The buddy was a little ahead of the victim and when he looked back on one occasion the latter seemed to be fiddling with his mask and snorkel. He heard a sound like someone clearing a snorkel and the next time he looked there was no sign of the victim and none of the others knew where he was. The instructor made an immediate unsuccessful underwater search then brought them all back to shore and organised a systematic search of the area, which was successful. The body was found drifting a little above the sea bed, all equipment present and the regulator hanging loose.

Autopsy revealed severe but patchy coronary atherosclerosis, the left anterior descending artery being 90% narrowed some 4 cm from its origin and other vessels less narrowed. There was no evidence of any past or recent thrombosis. Pre-autopsy X-Ray films showed no evidence of air embolism. Death was silent, at the surface, and he had made no attempt to call out, ditch his weights or fully inflate his buoyancy vest. It is possible he inhaled cold water and suffered a sudden fatal cardiac arrhythmia. There was no history of angina.

JUST TRAINED. FIRST NIGHT DIVE. "5th" OPEN WATER DIVE. CALM COLD WATER. SURFACE SEPARATION. SILENT DEATH. FAILED TO DITCH WEIGHT BELT OR FURTHER INFLATE BUOYANCY VEST. DELAY IN FINDING DESPITE HAVING A TORCH. MEDICAL CHECK FAILED TO REVEAL SIGNIFICANT CORONARY ARTERY DISEASE. CARDIAC DEATH. NO KNOWN PREVIOUS ILL HEALTH.

SC 91/13

Although he had been trained for 10 years and was an experienced diver he had not dived for 12 months or so. He was on holiday with his wife and after lunch by a lake he spent some time tidying his boat to pass the time till he thought it was safe to dive. His wife went for a walk then settled down to sunbathe. The only thing out of character was that although he had noticed he had forgotten to bring his radio and watch he uncharacteristically did not return for them.

His wife saw him surface about 20 m out, then submerge again in an apparently normal manner. Eventually she realised he should have completed his dive long ago and decided to walk along the beach to meet him, assuming that he had come ashore some distance away. When dusk began to fall and he had not returned she decided to seek help and was fortunate to meet some campers who drove her to the nearest house with a phone. Only a helicopter search was made till next day as nobody was able to start the victim's boat. The body was found by police divers. He had ditched his weight belt but it was caught on the crutch strap of his BCD as he had not donned the weight belt after all other equipment.

The autopsy showed he had been a healthy man with a healthy heart but he had suffered extensive bleeding from multiple gastric erosions. He had a duodenal ulcer in 1986 and six months before his death had a dilation of a stenosis of the gastro-duodenal junction. He was taking anti-ulcer medications.

Examination of the equipment showed the tank was nearly half full but he would have been unable to inflate his buoyancy vest as the inflation hose did not fit the connection on his vest. In his time of need he was unable to discard his weight belt or inflate his buoyancy vest, so he drowned.

SOLO. TRAINED. EXPERIENCED. NO DIVES IN THE PREVIOUS YEAR. SHALLOW WATER. DITCHED WEIGHT BELT TRAPPED BY CRUTCH STRAP OF BUOYANCY VEST. INFLATOR HOSE DID NOT FIT, SO NOT CONNECTED. DEMAND VALVE ALLOWED WATER ENTRY. MEDICAL HISTORY OF DUODENAL ULCER. ACUTE GASTRIC BLEEDING FROM EROSIONS WITH NO APPARENT WARNING.

SC 91/14

A film on crocodiles and sharks required some additional shots of sharks feeding. The film maker was an underwater photographer and he took with him on this trip two experienced divers as his team and another diver, the victim (V), of reputed experience more as a friend rather than a member of the film crew. The water was calm and visibility excellent for filming.

The boat was anchored over a reef in10 m close to a drop off where the depth exceeded 400 m. They let down a shark cage and bait and hoped for sharks to appear. The dive plan required that they remain beneath the boat and not exceed 10 m depth.

While one diver was in the shark cage with the camera the other two took turns "on guard" with a hand spear, with V nearby. One of them noticed V leave the cage area and swim towards the drop off and swam after him, but returned to the cage when he saw two of the crew descending for a private dive as it seemed that V was going to join them. He was seen to cross the reef edge and start descending in what appeared to be a completely normal manner, looking at the fish and corals, and he was seen to look at his gauges. The two crew members were surprised to see one of the film group diving solo here but they assumed it was with the knowledge and approval of the group's leader. Nevertheless they were concerned and said so on their return but was only after the film group completed their task and surfaced that it was realised one person was missing, probably dead.

A search was organised, indeed two divers descended to 53 and 62 m respectively while a surface search was made. These divers later required recompression therapy. No trace of the missing man or of any of his equipment was ever found.

While it can never be known why he disregarded the dive plan and made a solo excursion over the reef edge it can be supposed he did not regard himself as part of the film team and could therefore leave them. It is possible the clear water made him unaware of his true depth and that he misunderstood the digital display of the borrowed depth gauge he was using, believing it to record feet rather than metres. Being an experienced, confident diver, a flying instructor, and SAS trained, he would have thought a solo dive in such ideal water conditions to be completely safe. Nitrogen narcosis was probably the factor which negated this assumption.

TRAINED. EXPERIENCED. EXCELLENT DIVING CONDITIONS. DISOBEYED DIVE PLAN. SEPARATION/SOLO. OBSERVED GOING TOO DEEP FOR WITNESSES TO FOLLOW. DELAY BEFORE ABSENCE NOTED. NITROGEN NARCOSIS. SEARCHERS SUFFERED DCS. BODY NEVER RECOVERED. POSSIBLY MISREAD DEPTH GAUGE UNITS.

Discussion

Both the breath-hold divers died after separation from others, one at the surface, inexplicably drowning in calm water, while the other may have suffered a post hyperventilation blackout or been held under a ledge by water power. The failure of the pathologist to comment on the significance of the severe coronary artery disease in case BH 91/2 is surprising.

The scuba fatalities illustrate the wide variety of routes to disaster. Diving instructors will undoubtedly empathise with the instructor in cases SC 91/6 and SC 91/7 concerning the impossibility of providing a "safety guarantee" even with a group of four (or one, as in case SC 91/2). There appears to be a need to review the rules governing the running of Resort Dives before further tragedies occur.

This series includes examples of most of the significant causes of scuba diving related fatalities, including a shark attack. There were four deaths where it is probable that a cardiac factor was the critical element which decided the outcome. These cases (SC 91/2, 91/3, 91/6 and 91/12) were all in the age bracket 49-64 years. There is no certainty that even direct questioning of these divers before they entered the water would have revealed any cardiac risk factors, and certainly the possibility of gastric haemorrhage in case SC 91/13 would not have occurred to most people.

While some of the pathologists have followed correct "diving deaths" autopsy protocols, others have signally failed to provide as full and helpful assessment of their findings to the Coroners. This is in marked contrast to pathologists' evidence in criminal cases.

In three cases (SC 91/4, 91/10 and 91/11) there was evidence that air embolism had occurred. In one the ascent had appeared to be normal in rate and manner but in the other two an element of panic was almost certainly present. This was due in one instance to night time separation complicated by entanglement in a chain, in the other to failure of an octopus breathing ascent when the donor's tank ran out of air. Low air states probably initiated both these fatal incidents.

Several equipment factors were involved, including the failure to connect the inflation hose to the buoyancy vest and wearing the weight belt under other equipment. Not informing the Resort Divers about managing buoyancy vests and weight belts had adverse consequences. The rationale for turning off the air before initiating the surface swim return to the beach in SC 91/6 is difficult to understand. Whether the absence of an indication of the measurement units in the depth gauge lead to the death of case SC 91/14 cannot be known, but this is a potential danger to anyone using unfamiliar equipment.

In case SC 91/6 there was not only poor regulator function but also a spray of water with inhalation. This man had a loose lower dental plate and in consequence was unable to retain the regulator adequately.

Inexperience was probably a very significant factor in five of these deaths (the two Resort Divers and cases SC 91/3, 91/11 and 91/13) though was it far from being the only adverse factor in any case. The tragic double fatality is a reminder that knowledge which is not applied has no value.

Many of the victims failed to use their equipment properly. Weight belts were retained when buoyancy was required and only two (SC 91/3 and 91/4) inflated their vests.

Water power, the flow of water off rocks, was undoubtedly the reason for the death in case SC 91/l, while that silent enemy, silt out, again showed its lethal capability by claiming two lives.

Regurgitation of gastric contents has again been noted as a problem during resuscitation and the problems which can arise from having loose dentures played a significant role in both the causation and management in case SC 91/6.

It is striking that, apart from the shark attack, there was a number of avoidable factors present in each of the fatal scuba diving incidents. This indicates that it should be possible to reduce even further the number of divers who die each year. So dive carefully at all times.

Acknowledgments

This report could not have been prepared without the generous help and forbearance of those charged with the management of the documentation concerning such fatalities. This is true of every State and includes the Police services in some States in reference to cases where no inquest was considered necessary. Others who have identified cases or supplied information are also thanked. It is hoped that one day there will be wider involvement in this project by members of the diving community.

PROJECT STICKYBEAK

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

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

NITROUS OXIDE INDUCED DECOMPRESSION SICKNESS FOLLOWING SHOULDER CAPSULE BAROTRAUMA

Carl Edmonds

Abstract

A shoulder dislocation in a diver was complicated by her continuing the dive and developing barotrauma of ascent in the shoulder. Reduction under general anaesthesia, using nitrous oxide, was followed by clinical decompression sickness.

Case report

An experienced female diver, taking an advanced diving course in Northern Australia in June 1993, had the following dive profiles:

Day 1 3 m for 56 minutes.
Day 2 18 m for 33 minutes.
Day 3 (i) 21 m for 33 minutes, followed by a long surface interval, which left her with 4 minutes residual nitrogen time, and then
(ii) 21 m for 29 minutes .

She had logged approximately 60 dives, and was diving with two physicians when she dislocated her right shoulder. This followed a backward roll entry with heavy equipment held in her right hand. At the time she was aware of a sharp pain, but it caused little difficulty during the remainder of the 29 minute dive, with the arm splinted by the wet suit and held immobile.

She was unable to use the arm or hand throughout the dive, but the shoulder pain increased significantly during the actual ascent. She was unable to hold onto a line with that hand, and the pain caused her great discomfort and difficulty. The increasing pain forced her to slow her ascent and the shoulder was extremely painful by the time she reached the surface.

Immediate attempted reduction by the companion diver physicians failed and she was transported to hospital.

Pethidine was given for pain and metoclopramide for nausea. An X-ray confirmed the dislocation and an attempted reduction again failed.

The shoulder dislocation was successfully reduced under anaesthesia, using nitrous oxide, some two and a half hours after the dive.

The following day she was aware of lethargy, sleepiness, distortion of vision, paraesthesia and numbness of the extremities. There was a sense of disorientation and dizziness (she felt that the car in front of them was moving backwards onto their car). At that stage she was also feeling nauseated.

On examination she failed the sharpened Romberg test.

Hyperbaric oxygen therapy commenced on the second day after her anaesthetic and resulted in a prompt resolution of most of the symptoms, with a dramatic improvement in the general status. She felt well, with no more numbness or paraesthesia and regained the ability to perform the sharpened Romberg test.

She said that with recompression “I began to feel much better and afterwards appreciated how wonky I must have been. I felt as if an unrecognised woolly feeling had been lifted. My fingers and toes were no longer tingling and my perceptions had returned to normal".

Diagnosis: (i) Dislocated shoulder, with barotrauma of ascent.
(ii) Decompression sickness, aggravated by nitrous oxide administration.

Discussion

An explanation for her symptoms, according to our current knowledge, is as follows.

Shoulder

Enclosed gas spaces in the body can produce barotrauma in diving[1].

The shoulder joint is a ball and socket arrangement partly lined by a synovial membrane. The membrane secretions permit excellent lubrication as the surfaces are apposed. There is little or no gas space, as such, between the ball and the socket. When the head of the humerus is removed from the glenoid cavity the surface tension between the two membranes must be broken and fluid or air must enter.

During dislocation and subluxation, there is probably a greater negative pressure in the joint space (relative to ambient), and therefore gas and possibly some fluid, is likely to be "sucked into" the new space, from the membrane and surrounding tissues. Tearing of the capsular membranes would also result in additional fluid accumulating in the joint.

The production of gas (>90% nitrogen) with joint traction[2,3] is well recorded in degenerative joints . When apposed joint surfaces are distracted, a partial vacuum is created and its volume must be filled. Gas, in solution in the surrounding tissues, passes into the space and occupies it as a gaseous phase. This is referred to as the "vacuum phenomenon" and is detectable by CT scan and sometimes plain X-ray. It is especially found in the intervertebral discs, where it is produced by enlarging the disc space in extension (distraction) and reduced with flexion (compression). Otherwise, the commonest joint affected is the shoulder.

Whether this newly acquired air space in the joint, following the dislocation, contributes to the sensation of pain is not known. Often air in the joint is painless. This air space would diminish with descent. However, while the subject is diving, there would be a significant nitrogen pressure gradient between the arterial supply to the tissues (including the synovial membrane) and the joint space. Nitrogen would then move into the shoulder joint, partly restoring the volume of the gas space. It is likely that the number of gas molecules in the shoulder joint capsular space would have increased during the considerable exposure to pressure.

During ascent, this gas space would then expand, producing a sensation of pressure and then pain if the capsule is distended.

After surfacing, the pressure in the shoulder joint space would reduce to approximately one atmosphere, as do all distensible gas spaces. Gas molecules would continue to move from the hyperbaric exposed "slower" tissues surrounding the joint, into this capsular space, expanding it further.

Gas in the joint spaces of aviators[4] and divers[5] exposed to decompression, have been described previously. Barotrauma has been described in bone cysts.[6] It is believed that this is the first reported case of barotrauma associated with a shoulder joint.

Decompression Sickness

Nitrous oxide (N_2O) is a fast moving gas (a diffusing capacity 35 times that of nitrogen, 0.46 compared with 0.013). Most senior anaesthetists are aware of this, and therefore know that if there are any air spaces in the body and if the subject breathes nitrous oxide, those gas spaces will expand as nitrous oxide flows into them much more rapidly than nitrogen will flow out.

The basic pathology of decompression sickness involves the development of gas bubbles in tissue and blood.

Books on diving medicine,[1] and the occasional article[7] have warned of the danger of giving N_2O, and advised therapists not to administer nitrous oxide while under pressure, or to divers after a dive, when it is thought to "precipitate decompression sickness". Some of us have even used it to aggravate subclinical decompression sickness in experimental conditions (naughty!).

When breathing N_2O, middle ear pressures rise because N_2O diffuses from the blood to the middle ear. If the Eustachian tube opens, the pressures return to normal. During middle ear surgery a rise in pressure can "pop off" the recently replaced tympanic membrane. Most anaesthetists either turn off the nitrous oxide well before the surgeon closes the tympanic membrane or use some other carrier gas.

In 1973, Professor Ralph Braur and I, at the Veterans Administration hospital near San Diego, measured middle ear pressures increasing when normal subjects breathed Heliox (80% He/20%O_2) and reducing when they breathed oxygen, if they did not open their Eustachian tubes. We even titrated the various He/O_2 mixtures against the middle ear pressures, but the results were never published.

It is likely that nitrous oxide administered to a diver who already had sub-clinical bubble development from a considerable hyperbaric exposure, would aggravate the bubbles present.

Of interest to diving physicians, but not relevant to this case, is the analogous change of pneumothorax volume. A pneumothorax will double its size within 10 to 15 minutes if 70% nitrous oxide 30% oxygen, a common anaesthetic mixture, is breathed instead of air.

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Acknowledgment

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** *The patient's story appeared in Divelog (Australia) February 1994 issue.*

THE WORLD AS IT IS

OUT OF COURT, OUT OF SIGHT, OUT OF MIND

Douglas Walker

There are many, often compelling, reasons why a case which has been entered into with vigour by the parties involved can end, as far as outsiders can ascertain, in a conspiracy of silence. The practice of Law frequently involves the quoting of precedents and where cases are settled out-of-court no precedents are established. It is this fact, combined with limiting the vast expense of litigation, which encourages settlements. Naturally there are losers as well as winners. Public good seems to be the loser in some out-of-court settlements as the opportunity to learn of problems and plan to avoid their repetition is lost.

This may seem an irrelevance to most divers but they would be wrong. In a hypothetical claim for damages after a diving incident which resulted in morbidity, the people sued, be they persons or organisations, will have a real interest in avoiding both publicity and cost, and hope to prove no blame should attach to their actions. Their insurer will want to minimise the expense, even if this means that the insured has to accept an implied blame which may not be deserved. The lawyers of both parties have a financial benefit from a prolonged battle, but the plaintiff can avoid the uncertainty of outcome which is always present with even the most apparently cast iron of cases.

Without going to the extremes of the claims which are rumoured to be made in America, where such cases are often taken on a no-win no-pay (contingency) basis (for a proportion of the award) it is possible to suggest some scenarios which could arise in New Zealand or Australia. Litigation could result from defective hired equipment or injury during a Resort Course Dive or a dive from a commercial dive boat. It is possible that an injured party could claim that an inadequate or incorrect course content provided less skill than the pupil required and expected. This is a veritable minefield, with present and potential risks to all levels of the diving industry.

At this time (February 1994) there have been no reports of anyone making a claim on the grounds that they have suffered pain and morbidity following dives made during a training course, or by an instructor claiming his duties have resulted in an episode of decompression illness. However, this situation will not continue indefinitely. There are records of such cases which have required recompression treatment. There is no guarantee that all patients in the future will have complete resolution of their problems, nor that they will meekly accept such discomfort as unavoidable. One day they will demand a cash recompense.

In the analysis of scuba diving-related fatalities it is not unusual to find some adverse comments made about the function of the equipment, though it is unusual for such problems to be critical. If the equipment was hired or had been checked by the dive master there could be a duty of care case launched. Unless there is very careful and frequent checking of dive shop equipment there always will be a risk of a claim if the wet suit was too loose or tight, the regulator incorrectly set or letting in water, or the buoyancy vest had some fault. A claim could arise from those whose holidays are spoilt or who feel they have suffered in some way from such problems, even when they had suffered no actual harm. Failure to isolate, for examination, the equipment worn by a diver who suffers a significant problem could be taken to indicate poor attention to safety factors. Keeping meticulous records is a great legal protection.

A dive master (or equivalent) now faces responsibilities which have increased greatly in recent years, and probably include matters which are the responsibility of the dive shop when taking the diver's booking for the trip. The diver should have proof not only of training but also of experience adequate for the planned dive. The dive master must ensure that those who enter the water are aware of the depth and other basic details of the locality, have the correct equipment and are suitably buddied. The adequacy of the surface, and possibly underwater, care provided will be dictated by the circumstances. Proper contemporaneous documentation often appears to be a bureaucratic chore but can save one much grief if an accident occurs and one is cross examined in court later on.

The de facto situation nowadays is that all scuba divers must initially obtain a basic training before being permitted any access to air refills or acceptance on any commercial dive, except for the special situation of a Resort Dive Experience.

While this rule may protect the dive operator from the untrained there is, as a corollary, the implied contract that the training given is fully adequate for the skill level the pupil believes he or she was trying to attain. They should be fully aware of any limitations in their grade of training and not misled by certification cards stating they are "Advanced", when this term is not given the meaning which it has in everyday life. Misapprehensions on such matters can be, and indeed have been, fatal.

Quoting the official manual of the diving organisation is often relied upon as a defence against negligence claims, based on a belief that a divergence from the manual implies improper behaviour. This is probably an unwise assumption for manuals are rarely critically revised and updated to take into account the lessons of incident analysis. Judges may choose to require greater or different skills to those stated in a manual. Any organisation which fails to seek actively to revise and improve its procedures, through the analysis of data obtained by a continuous collection of "incident" reports, may be found to be irresponsible and liable for the consequences of failing to apply information it should possess. The diving organisations should act before legislation forces harsh obligations upon them. It may be cheaper, as well as better business morality, to maintain a critical review of all the customers' expectations and rights. The Diving Incident Monitoring Study (DIMS) and Project Stickybeak continue to offer a confidential resource for data exchange and collection.

There is little available data on claims and their outcome so little is known concerning either the problems which give rise to litigation or about the outcomes. However they will certainly become both increasingly frequent (and costly) and harder to defend in the future, unless those with power to make the necessary changes recognise the need for changes to take account of available information. The requirement to show an ongoing upgrading of procedures in response to any new information is a reasonable requirement to which coroners and all who represent litigants will increasingly draw attention.

Before this is disregarded as mere theory take note of what has been stated in connection to fatal incidents in the worlds of commerce, shipping and aviation. Taking the theme of accountability, Mr Joe Catanzariti has commented[1] that corporate crimes in the USA were usually a consequence of company inadequacies. He said that, in addition to charging the primary criminal, the prosecution should also pursue the company and place appropriate conditions on it. These would include requiring the introduction of strict auditing controls, increased internal accountability, and provision of regular and detailed reports on the progress it was making. In relation to the Zeebrugge car ferry disaster he drew attention to the finding that it was the ferry company rather than individuals which was held responsible "because it was found to be infected with the disease of sloppiness". He summarised his views by stating "regardless of who is finally convicted (of some crime) management can rarely claim to be free from blame". Recently at the inquest into the crash of a RAAF Boeing 707, while making an emergency-management training manoeuvre, the coroner was told that RAAF operational publications were deficient, that there was an erosion of corporate knowledge as pilots left for civilian life, that RAAF officers knew little of other incidents involving Boeing 707s, and that there was inadequate collection and dissemination of information about accidents involving RAAF aircraft.[2] There was a comment by the coroner that "in a sense this (crash) was due to a systemic failure, responsibility for which could be said to rest with the entire chain of command of the Air Force".

In Australia the Bureau of Air Safety Investigation (BASI) runs a confidential non-punitive reporting service and many airlines are now developing similar reporting schemes. The idea is to identify how mistakes are made and rectify any systemic factors which play a part in causing them. Prof Jim Reason, University of Manchester, has defined two types, active and latent, of failure in complex systems,[3] and his model is now used by human factors psychologists. The traditional focus of (the aviation) industry has been on active failures involving front-line operational staff. Latent failures are accidents looking for a "window of opportunity", one created by systemic deficiencies.

The Australian Incident Monitoring Study was started in 1987. It is a confidential collection of anonymous reports of incidents from anaesthetists. The information is published from time to time, the latest being a symposium issue of Anaesthesia and Intensive Care,[4] when the data base was over 2,000 reports. These publications have been acted upon by the Faculty of Anaesthetists of the Royal Australasian College of Surgeons and its successor, the Australian and New Zealand College of Anaesthetists, to change their recommendations about anaesthetic practice.

The relevance of the coroner's remarks on the crash of the RAAF's Boeing 707 should be clear to the diving community, and especially to those running the instructors' organisations. While this may be taken as a plea for the more active involvement of such individuals and groups in the Dive Safe/Project Stickybeak projects (which it indeed is) it can also be regarded as an advanced warning of looming problems which can either be minimised by decisions taken now or allowed to grow to become devastatingly (and deservedly) costly in impact.

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PAPUA NEW GUINEA
ST. MARY'S HOSPITAL VUNAPOPE

St. Mary's Hospital Vunapope (PNG) is a 270 bed Catholic Hospital close to Rabaul. The Hospital provides Medical, Surgical, Obstetric and Paediatric services to the people of East New Britain Province. A nurse training school is attached for both general and post certificate students.

The following positions will become available during the coming 12 months;

l) Anaesthetist.
Short term; 6-8 months from June 1995. Commencement time flexible. Open to Registrars, Specialists, or GP. Anaesthetist.

2) Obstetrician.
Long term; 2 year position becomes vacant November 94. Supervise Obstetrics and Gynaecology services. Involved in Post-basic Midwifery Course 1996.

3) General Practitioner.
Long term; 2 year position becomes vacant April 1995. Responsible for management of medical patients.

4) Specialist Physician.
Term negotiable, preferably 2 years. A seconded Government position with Pay and Conditions in line with PNG Government Employment.
AVAILABLE IMMEDIATELY.

The mission provides accommodation (family) plus shared use of a vehicle. A stipend and family allowance is paid fortnightly.

Recreational activities include, fishing sailing, scuba diving, snorkelling, golf, squash, tennis.

An excellent mission primary school is located on the station.

Rabaul shopping is good. Most needs can be met. The markets provide fresh vegetables and fruit.

A chance to practice challenging medicine while living in another culture in a tropical paradise.

For more information and role descriptions contact;
Daphne White
Health Secretary, St. Mary's Hospital
P.O. Box 58 Kokopo
East New Britain Province
PNG.
Fax 0015-675-92-8246.
Phone 0011-675-92-8355

SPUMS NOTICES

S0UTH PACIFIC UNDERWATER MEDICINE SOCIETY DIPLOMA OF DIVING AND HYPERBARIC MEDICINE.

Requirements for candidates

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

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

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

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

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

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

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

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

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

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

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

MINUTES OF THE EXECUTIVE COMMITTEE MEETING TELECONFERENCE

held on Sunday 13/2/94
at 0900 Eastern Summer Time

Present

Drs D Gorman (President), S Paton (Treasurer), C Meehan (Secretary), J Knight (Editor), D Davies (Education Officer), C Acott, G Williams and J Williamson.

1 Minutes of the previous meeting.

Accepted as a true record, proposed by Dr Knight, seconded by Dr Williams.

2 Business arising from the minutes.

2.1 Conveners for future meetings

Convener for the 1995 Scientific Conference to be Dr David Davies, with Drs Paton and Williams as co-conveners.

Convener for the 1996 Scientific Conference to be Dr Guy Williams.

2.2 Rabaul ASM

2.2.1 Monies left over from the registration fee to be used to absorb extra expenses which should be itemised. A decision as to what to do with the remaining amount can be left to the committee meeting in Rabaul.

2.2.2 Safety sausages and DCIEM tables to be organised by Dr Acott.

2.3 Accreditation of courses

To be decided by sub committee of the Censors, Drs Gorman, Davies and Williamson, and to be discussed at a later date.

2.4 International Diving Health and Safety Symposium

This will be held in October 1994 in Cairns, to be followed by a Dive Festival, which will include a diving medical seminar. Proposed to be held annually.

2.5 1996 ASM

To be in Fiji. Dr Williams to research venues, using Mana Island as a yardstick

2.6 1995 Speakers

It was suggested first approach Drs Nick Mclver (England) and then Fred Bove (U.S.A.). Dr Davies to write to them.

Other suggestions were Drs Andy Veale (New Zealand) and Sandra Anderson (Sydney) for Asthma Workshop.

2.7 Timing of tenders for future ASMs

To be discussed at the next meeting.

2.8 Medical examinations

The AMA have agreed that "medical practitioners who intend to examine and certify the fitness of candidates for recreational scuba training should ensure that they possess the appropriate expertise and carry out such examinations in accordance with the recommendations concerning these medical examinations, as published by the Standard Association of Australia from time to time".

3 Rabaul ASM

3.1 Papers

Drs Williams and Knight to present papers on the benefits of diving with computers.

1993 figures from the various recompression units to be presented.

3.2 Malaria

Malaria prophylaxis and current immunity to tetanus is essential. Hepatitis A and B immunisation is also recommended. Dr Acott will formulate official recommendations for prophylaxis and immunisations, which is then to be sent to Allways Travel.

3.3 Medical equipment

Any spare medical equipment would be welcomed by the hospital.

4. Tender for the 1995 ASM

Notice made of the work put in by Drs Paton and Meehan in co-ordinating the above tenders received from Allways and Dive Adventures.

4.1 Both tenderers to be invited to give a presentation at the next committee meeting in Sydney on 23/4/94.

4.2 That the tenderers be asked to make their final quotations to the Treasurer before this meeting.

4.3 The decision as to the successful tender will be announced after the ASM in Rabaul

5 Treasurer's report

$42,000 in the bank accounts. Report accepted moved by Dr Knight, seconded by Dr Davies.

6 Correspondence

6.1 Letter from Dr Whaites, dated 7/1/94

Dr Meehan to address this.

6.2 Letters re Emergency ascent training workshop and SPUMS policy

To be published in an edited form in the Journal. Dr Gorman to write a reply which will be published in the same issue.

Journal editorial will give notice to all members of the society that they are invited to participate in the workshops and if they are not going to be present at the workshop they are invited to express their views beforehand and to register an absentee vote.

6.3 Letter from Standards Australia

A query about the question about high risk groups for Aids/HIV in AS 4005. 1 medical. Dr Gorman to write to Standards Australia giving SPUMS opinion. This letter to be published in the Journal.

7 Other business

7.1 IDAN

Due to some difficulties with DAN USA, DAN in Australia will be identified as DAN Australia. Oxygen courses will be identified as in-house Australia.

Meeting closed at 1220 EST.

SAFE LIMITS

AN INTERNATIONAL DIVING HEALTH AND SAFETY SYMPOSIUM

to be held at the

Radisson Plaza Hotel

Pierpoint Road,
Cairns
Queensland 4870
Australia
from
October 21st to 23rd 1994

The symposium is being organised by
The Queensland Government
Division of Workplace Health and Safety
Department of Employment, Vocational Education, Training and Industrial Relations
with
Dive Queensland
and
The Queensland Tourist and Travel Corporation.

The symposium is endorsed by

SPUMS

Registration fee $Aust 350.00

For further details, program and registration form contact

Total Control Conference Management
P.O. Box 101, Burleigh Heads
Queensland 4200, Australia.

Closing date for registration 29th August 1994
Book early as places are limited

A brochure about this symposium with the program and application form are included with this Journal.

LETTERS TO THE EDITOR

PERILS OF PELILEU

CORRECTION

Owing to an editorial error the date of the incident, given as 20th March 93, in Dr William Douglas' letter "Perils of Pelileu" (*SPUMS J* 1994; 24 (1): 25) was wrong. The correct date was the 20th of **May** 93.

FURTHER PERILS AT PELILEU.

Some time in 1994 a party of five divers, four Japanese tourists and a dive guide, were swept away by the current at Pelileu Point. They were missed and searched for without success at the time of their disappearance.

Five days later some of the bodies were found floating. From the entries on a diving slate it seems that at least one young woman survived for three days. She recorded seeing boats close by, but the boats missed them, and seeing aeroplanes which did not spot them.

With the present surface cover, diving at Palau, where ocean currents occur, can only be described as a hazardous occupation.

THANK YOU SPUMS

The Committee of SPUMS at the AGM announced that all the diving safety equipment, oxygen regulators and masks, intravenous fluids and giving sets, as well as other gifts from members would be given to St Mary's Hospital Vunapope as the Medical Superintendant at the Government Hospital had,on a number of occasions, refused to meet a SPUMS delegation. Furthermore the profit from the registration fee, due to the overseas guest speaker having had to withdraw, would be spent on a robuts oximeter and spare parts for St Mary' Hospital. A letter from the hospital's Medical Director appears below.

St. Mary's Hospital Vunapope
PO Box 58, Kokopo
P.N.G.
21/5/94

The President,
SPUMS.

Dear Des,

On behalf of St. Mary's Hospital Vunapope, I would like to express our appreciation for your generous donations, especially the pulse oximeter.

Without donations like yours, it would be difficult to provide the level of care we currently offer to the people of East New Britain.

G.A Davies

THE EMERGENCY ASCENT TRAINING DEBATE

32 Pleasant Drive
Mt Pleasant
Waterford
Ireland

Dear Editor

I have read with interest the articles and letters in the last two issues of the SPUMS Journal. I would like to comment again. I will start with Dr Douglas Walker's article *The no air problem in scuba diving*. This is a very good, informative article. One point that also runs through statements made in other articles and letters is that "Nearly half of the diving deaths in Australia occurred in grossly inexperienced divers". This statement is to me the key to the debate. Dr Walker makes the point, but I fear not strongly enough when he refers to G K Chesterton's words through his creation Fr Brown "it is that they can't see the problem". The problem that is being presented is that "Inexperienced divers run out of air at depth and die trying to get back to the surface". To rectify the situation the factors involved must be looked at

1 The training and experience of the individual.
2 The diving environment/buddies, that is who he goes diving with.
3 Is he a recreational diver ?
4 Is he a sports diver ?

These four factors are very closely interlinked and it must be accepted that there is a difference between "Recreational Diver" and "Sports diver" and also a difference between the diving environments of the two groups.

The recreational diver

This is a person who learns about diving through a training agency or holiday dive shop. He or she learns the bare essentials to get into the water with the group. His mentality is that "I'm paying my money, it's up to my Instructor to make sure nothing happens to me." This attitude would also prevail on dive boats, taking into consideration the experience such divers say they have had where the dives are lead by company employees. These divers believe, because they know no better, that they have enough knowledge to dive safely. The dangers of diving are never really stressed enough in their training. How many agencies tell their customers "If you make a mistake you can die" ? The need for experience (i.e. time underwater in various conditions) is not emphasised enough, so one cannot blame these people for going through their course and thinking at the end of it that they know enough about diving.

The sports diver

This is a person that learns about diving either from a club or dive shop or training agency but will always join a club afterwards. This person is interested in learning about diving and in wanting to be in a safe diving environment. This is the way we operate in Ireland and also in the BS-AC. These people learn slowly and are bound by the club's rules (which are common sense rules for safety). Everyone gets to know everyone else, at least within the group frequented, and they are only allowed to dive within their experience by club rules.

I believe the club diving environment is very important to safety. After a short time everyone's capabilities become known to everyone within the group. There are always experienced people to look after the inexperienced. I do concede that there are adventurers in every organisation and some people exceed their capabilities and worst of all bring others well beyond theirs and into difficulties.

The records show that the club environment is a safe place to dive. Dr Walker again points out that the training given to novices by dive shops is critically inadequate for the diving they think they can do. The standard for training of recreational divers is controlled by finance, how much is the market prepared to pay, how quickly can they be taught and how fast can the customer get into the water.

Anyone who is involved in Instruction will tell you that one can talk for days on a subject and get people to practise techniques in the classroom until they are very proficient, but dress them up in diving equipment and put them in the sea and you find that they have got to learn all over again. It is here in, this environment, that they need to practise and lots of it. This definitely is not achieved in 4 or 5 dives. It takes time to acclimatise to the diving environment, both physically and mentally. Remember when something goes wrong at depth you cannot call out for help, you cannot ask your buddy what should you do, you literally have seconds to assess the situation, decide on a course of action and ascend, all while the ravages of panic are rampant in your mind.

The SPUMS workshop on Emergency Ascent Training (EAT) was designed to develop a policy on EAT. Contrary to Dr Walker's belief, I believe that the objective was achieved and it went a stage further. It put forward a number of solutions. The gap that is between the two beliefs is where the starting point is. You cannot have various standards of safety for EAT. You set the standards, as this workshop has done, then it is up to the instructors to train their students to achieve the level of competency necessary to be able to perform the tasks required, regardless of the time and effort it takes. Which option is best ? That is the decision of the instructor, agency or club. One thing is certain, every diver must have some knowledge and experience of EAT. You cannot say to a novice that you must not get into a difficult situation where an emergency ascent is required until you have trained for it. That is ridiculous. Every diver going under water must be given the option of a way out if his air fails. I refer now to Dr Bill Douglas' remarks about my statement " divers should not run out of air". I say it again, they should not. If they were instructed properly they would not. The exception is mechanical failure. I am most surprised at his comments about divers swimming around each other checking gauges instead of enjoying the scenery. This seems to imply that its "un-diver-like" to check gauges. Should they guess when the air is low ? Or wait until it is gone ? In fact this is what is happening and this is why the problem is there. To say that the underwater scenery is more important than your air supply is not acceptable at all. Is this debate taking place because its "un-macho" to check gauges?

Another theme that seems to be suggested is that independent organisations that set standards of safety should drop their standards to cover the practices of the foolhardy or novice adventurers, who that do not bother to learn about what they are getting into, or because it is too expensive to train people properly to that level. All this is totally wrong. A common standard of safe diving should be set because anything below that level is unsafe.

I would like to question some statistics. The article in the December issue of the SPUMS Journal written by D Richardson and T Cummins stating that all the dives done during instruction had a very low level of injury reported. These are controlled conditions under strict supervision, laboratory conditions one might say. One would expect nothing less from competent instructors. BUT when they leave this sheltered environment they enter the statistics mentioned in Dr Walker's article in the March issue. That the provisional report on diving-related deaths show nearly half of these deaths in Australia occurred in grossly inexperienced divers. We are back to "what" or "who" is an "experienced diver". This seems to be the real core of the problem. It seems that there is not a common base line of instruction and experience that everyone is starting from together. Each agency and organisation seems to be starting from their own start point and not from a common one. With the result that there is no common ladder of progress with which to slot in experience or at which level everyone agrees that a diver is trained.

The workshop on EAT was acceptably conclusive in highlighting the main cause of the problem and in suggesting a number of options for both the diver and the instructor. The workshop also had a very real informative periphery i.e. all the well informed articles in December and March issues. This amount of attention given to the topic should and must make people think about the importance of the subject. This was a very worth while workshop. In comparison the UHMS Workshop did not produce this amount of detailed printed material.

I would like to suggest for future workshops that the chairperson(s) should write an article outlining their thinking and current thinking on the subject. Then invite written submissions. The workshop now has a large base of material to discuss. All the submissions together with the workshop report could then be published. In turn this would generate further discussion. This is the way this one basically worked and it worked well in my opinion.

Gerry Stokes

52 Albert Road
Devonport
Auckland
New Zealand
27/4/94

Dear Editor,

The discussion of out-of-air situations in diving by Dr Walker (SPUMS Journal 1994; 24(1): 2-5) is a good demonstration of the limitations of numerator research and a great advertisement for alternative methods of assessing diving safety to analyses of deaths and accidents. Both of the latter are numerator research models and the conclusions made by Dr Walker on the basis of such data are in my opinion untenable.

Dr Walker states that because nearly half of the diving deaths in Australia occurred in "grossly inexperienced divers", that an acceptable level of training is not being achieved "by a proportion of those certified." Further, he argues that running out of air is "a serious indictment of the training they have received." Both these statements have to be considered in context; that is the absence of data about the number of dives being made without incident and the percentage of the total dives that were made by grossly inexperienced divers. These data are needed as they are the denominators to Dr Walker's numerators. Market diving surveys show that most divers stop diving within a few years of being trained. It follows that most dives then will be made by novice or inexperienced divers. At face value, from Dr Walker's mortality data, inexperienced divers would appear to be under-represented among the diving fatalities.

Data from numerator research should be treated cautiously and any conclusions be made in this context. Measurement of diving exposure is urgently needed and numerator research should be attributed a relatively low priority in assessments of diving safety.

Des Gorman

This letter was shown to Dr Walker and he has submitted the following reply.

1423 Pittwater Road
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New South Wales 2101
20/5/94

Dear Editor

I would like to thank Dr Gorman for his critical attention to my paper,[1] although I find it rather strange that he has presented a longer criticism in Dive Log Australia.[2] Dr Gorman has raised fundamental concerns, the basics of any scientific or medical investigation. He appears to have forgotten Paracelsius' axiom, that the first step to cure is to know the disease. Nobody can investigate a problem until it has been shown to exist. The investigations which he deprecates act as an early warning system.

Dr Gorman disputes the significance of the proportion of deaths which occur in trained but grossly inexperienced scuba divers. He disagrees with my opinion that running out of air, which is in most cases due to the diver failing to monitor his or her air supply, casts doubt on the adequacy of training received. He casts doubt on the value of treating incidents reports as a significant element in attempts to improve the awareness of problems which are associated with dives where functional impairment, morbidity or even death has occurred.

I find his stance surprising as no diving problems have ever been predicted by researchers or medical specialists. Such people operate in the secondary, but highly important, phase by working on the problems after they have been identified.

Dr Gorman deserves a reasoned response to the critical points he has raised, particularly as he has brought the matter to the attention of the general diving public.

The dangers of gross inexperience

My paper did not provide full details of the training of the grossly inexperienced scuba divers (those who have made less than 6 dives since finishing their training) who died. As since 1980 divers usually have had to show evidence of formal training to get air fills, I have used the cases from 1980-1991 to produce the table.

SCUBA FATALITIES 1980-1990

Total deaths		94
Grossly inexperienced scuba divers		36
No formal training	10	
Some training	4	
In class (cardiac death)	1	
Resort dive (1 cardiac death)	2	
Recently trained	19	

While newly trained divers are "only" a little over 50% of the grossly inexperienced, this is a significant finding as they represent 20% of the mortality for the 12 years. If it was discovered that 20% of drivers killed in road traffic accidents had driven less than six times since passing their driving test, most people would demand that testing standards be raised. There would be investigations into the training they had received. Unfortunately the facts concerning divers, readily available to anyone with an interest in diver safety, have produced no response from either the instructor organisations or anyone else in the diving community.

Perhaps Dr Gorman can inform us how many deaths in the grossly inexperienced, as a percentage of the total scuba diving deaths, can be considered acceptable and how many diving deaths a year must be accepted as inevitable. It might assist if Dr Gorman stated the numbers of diving deaths a year which he would accept as inevitable and requiring no search for causal factors. My approach to diving fatalities is not to accept even a low mortality if this could be further reduced, so my failure to calculate risk rates per 100,000 dives does not appear to me to constitute a research error. He talks of a diving population while I consider divers as individuals. There is a place for both approaches, with each having its value and neither being exclusive.

The out-of-air problem

The single most important factor for surviving in the underwater environment is to have available an adequate supply of air (or a suitable alternative gas mix). It is therefore the primary and essential responsibility of each and every diver to ensure their remaining air is adequate at all times. To both assume and accept that every diver will fall into this error is to admit that their training was possibly inadequate, in that they have failed to understand this basic safety rule. Anyone who is unable to follow this simple rule should not be certified as adequately trained. The only acceptable reason for any out-of-air situation should be equipment failure or becoming trapped.

Surely basic training should ensure the diver "over learns" this behaviour, rather than inculcate a belief that there is no real necessity to avoid running out of air because the emergency ascent training included in the course has made the diver able to perform this in a stress situation. No evidence has ever been presented to back this belief, indeed BS-AC divers survive without this training element, indicating that it may be irrelevant. As I have noted elsewhere, there have been no investigations by any of the Instructor organisations into the causes, frequency and management of "low/no air" emergencies. Both UMS and SPUMS have run "Workshops" in which responses to emergency situations were discussed from a training viewpoint but neither considered why such situations arose, how they could be avoided, nor evidence that the proposed remedy was effective. This I regard as reprehensible.

Incident reports and denominator or numerator in research

The base on which our knowledge of diving problems has been developed has been incident reporting and analysis, which can be seen from any consideration of diving history. I do not believe that Dr Gorman would write critically of "the intrinsically limited nature of almost all the published assessments of diving safety"[2] when he rereads Paul Bert's book.[3] This is full of such reports, including the first reports of Caisson Disease, by an engineer (Triger), and the later report from the two general practitioners (Drs Pol and Watelle) who cared for the health of his workers. Paul Bert also reported on the medical problems of sponge divers (Dr Alphonse Gal) and those working on digging the foundations of bridges (engineer Eads and others). Dr Gorman will be aware of the papers by Drs Babington and Cuthbert,[4] Dr A.H.Smith,[5] Dr Corning,[6] Dr Van Rensselaer[7] and many others. None of these can claim any valid statistical basis but all made very significant contributions to our understanding of pressure related problems.

There has been no possibility of calculating risk factors in relation to the number at risk, for many reasons. There is no source of accurate information concerning the number of divers active on any day, let alone in any year, the training they have received is unknown, as is their true experience, the type and frequency of the dives they perform, and the frequency and types of the problems they encounter but survive. It is surely unacceptable to accept complacently the death of any healthy person, particularly one who has just completed training and been certified as competent to perform safely in the environment responsible for his or her death.

It is my belief that to dismiss morbidity and fatality reports because there is no statistical data base to define the population at risk is an improper response. A single paper by Craig[8] altered for ever our thoughts on the dangers of hyperventilation before making a breath-hold dive. A paper by Polak and Adams[9] defined the distinction between decompression sickness and air embolism. Unfortunately the new nomenclature, introduced because of the occasional clinical difficulty of the differential diagnosis, is blurring the difference. It was only the persistent complaints of recreational divers which finally persuaded Naval Authorities to question their belief that decompression sickness was always the fault of the diver and to recognise that the Tables were not a perfect protection.

There are many paths to enlightenment, or so it is claimed, and certainly more than one way to uncover truths. To the Chinese is ascribed the belief in Yin and Yan, the complimentary elements which are present in problems. As Samuel Butler said, "Life is the Art of drawing sufficient conclusions from insufficient evidence". This may not be statistically satisfying but it is the way of the world which we inhabit.

I thank the Editor for this opportunity to respond to a criticism from an Authority in the field of Diving Medicine.

Douglas Walker

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DIVING DIABETICS

Operating Theatre Laboratory
Department of Anaesthesia and Perfusion
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Victoria 3084

18 April 1994

Dear Editor

I concur with many of the sentiments expressed by Bryson, Edge, Lindsay and Wilmshurst in the March journal.[1] I was surprised to see this as an original paper, because there really is nothing new in most of the comments and recommendations they made. In particular, I would stress the entire basis of diabetes management in the 1990's is prevention and not cure. The mention of oral glucose tablets or glucose paste seems a little bit dated in this day and age. Much more effective is a small bottle of 50% glucose which can be drunk if required. I was also trying to envisage how to administer glucagon intramuscularly to a diver in a 5 mm wetsuit. I am not quite sure where one would start. The authors apparently have not heard of the use of intra-nasal glucagon.[2-4] Nor am I sure what a diabetologist is; perhaps I will ask some of my diabetic friends if they have ever met one.

It may interest readers that Dr Douglas Walker, the coordinator of Project Sticky-Beak, has asked me to assist him in setting up a confidential register of diabetic divers who for the first time ever, now feel they are able to "come out" and be accepted within the recreational scuba diving community.

Mark J. Sullivan

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8807 Wildridge Drive, Austin
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7/5/94

Dear Editor,

Although my practice involves commercial divers, I noted with some agreement the two articles in the March issue concerning diabetic divers. Dr Sullivan's mention of Dr Ken Kizer deserves further comment.

Dr Kizer is a former US Navy diving medical officer; we received our training together. Ten years ago, in a Canadian scuba magazine, he discussed the medical evaluation of diabetics for diving. Kizer outlined six criteria which he believed should make the diabetic acceptable:

- a mature individual who accepts his condition and the need for special care; no evidence of denial or self-destructive tendencies; able to plan and foresee;
- good understanding of diabetes in general and his own case in particular; the interactions of diet, exercise, and insulin;
- physically fit and regularly participating in exercise or athletics without difficulty;
- no evidence of chronic nervous or cardiovascular impairment;
- willing to follow conservative bottom times and diving in general, avoiding tricky or challenging diving;
- finally, a dive buddy who knows and is comfortable with the diver's diabetes and knows how to help if there is an insulin reaction.

As Kizer's writer-successor, I was so impressed with this article that I wrote a follow-up in 1988, adding a few thoughts of my own. Shortly after, I was contacted by a Canadian university diving officer concerning a diabetic marine biologist from Ireland who wanted to come for a year's post-doctoral work. Letters from his general practitioner, diving club, and former university indicated he met the criteria outlined above and had been diving many years with no unusual difficulty.

Assuming the diving officer had firm administrative support, I recommended he allow the scientist to dive. During his time in Canada, there were no problems (with all the diving done in cold water).

Clearly, many diabetics cannot meet these criteria, perhaps most; those who do could be the safest folk in the water. While I do agree with the general prohibition or scepticism regarding diabetics, Kizer's criteria make good sense and can help dissect out those diabetics who are the exception to a sound general rule. As he said himself "Many of these diabetics are active and athletic people who suffer no functional impairment .... not surprisingly, a number are interested in scuba diving".

Gordon Daugherty

ASTHMA AND DIVING

1423 Pittwater Road
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15/5/94

Dear Editor,

It is with some reluctance that I venture to comment on statements made in the recent Journal (March 1994). However, in the interests of accuracy the following points should be discussed as they bear directly on the reputation of the Society.

1 **Asthma**

It is stated that "Asthmatics are over represented in diving fatalities".[1] This appears to be untrue in relation to Australia and New Zealand. I have copies of the Coronial records of 201 Australian and 120 New Zealand scuba diving related fatalities. In only four of the deaths (Aust SC 81/1, Aust SC 84/5, NZ SC 81/2 and NZ SC84/1) could asthma have been a possible cause of death. In these cases there were significant additional factors present capable of causing the fatal outcome. There were six deaths in Australia and three in New Zealand where there was a definite, or possible, history of asthma but asthma played no part in the incident (see table on pages 29 and 30). These facts should be remembered in any discussion of the fatality rate in asthmatic divers. Naturally there is no information about the participation rate of asthmatics in scuba diving because all such divers are reluctant to reveal their condition to doctors.

2 **Data reliability**

The statement[2] that "Data can never be true or false and are always subject to criticism and analysis" cannot be allowed to remain unchallenged. Unless it is deliberately false or inaccurately collected, data should be accepted as "true". However it may be incomplete, selectively reported, or wrongly focused, and is always at risk of having invalid conclusions drawn from it.

3 **Democratic decision making**[2]

The statement that to have a post-workshop vote "would also not favourably weigh informed opinion and be subject to the bias of the writers of the draft, the reviewers of the literature (for the benefit of those not well informed about the subject matter) and the analysers of the consequent correspondence" is a clear declaration that careful discussion of "Workshop" decisions is thought undesirable as different conclusions might be reached. To say that critics have misinterpreted the Policy and to disagree with the findings "is not particularly complimentary to the participants" is to personalise a discussion which should be dealing with facts.

4 **Decisions cannot be criticised later**

The statement[3] that the majority decisions of the next "Workshop" cannot be subject to the critical examina-

ASTHMA HISTORY IN 321 SCUBA DIVING FATALITIES IN AUSTRALIA AND NEW ZEALAND

No history of recent asthma

Aust SC 79/2

Trained but inexperienced, good visibility so diving as a group, separation, swimming strongly when last seen. Body never recovered.

Mild asthmatic, only details "there had been no attacks for a number of years"

Aust SC 84/1

No training, possibly some experience. Buddy untrained but experienced. Separation, sat on a rock then found floating. Cardiac death

Single episode of "wheezy bronchitis" in 1983 when he used Ventolin.

Aust SC 90/6

Young boy, trained but inexperienced, contents gauge caught between rocks while in rough water over a reef.

No history asthma "but pathology suggested this".

NZ SC 87/1

Training and experience not stated, separated during dive, found on sea bed clutching catch bag, tank free from backpack, wights on and BC not inflated. Inadequate data to state why he died.

Histology showed "mucus plugs in some bronchi and tissue changes suggestive of acute asthma".

No history of recent asthma but evidence of drug usage

Aust 84/5

Trained diver. Separated as started ascent "nearly low air", surfaced with mask off, vest inflated, weight belt on. Floated unconscious (CAGE). Died in RCC after initial response to treatment.

Ventolin containers found in his room. Sister, who had asthma, admitted that "he had asthma until age 8" and that he was a heavy smoker at times.

Asthma may have contributed to this death.

History of recent asthma drug usage unknown

NZ SC 81/2

No training, no experience, borrowed hired equipment from friend who warned that the contents gauge had error and not to loan equipment to anyone. Left alone in 4.5 m deep rock pool, found dead floating face up, vest inflated, weights off and tank empty.

Reportedly "only two or three asthma attacks a year, not severe." Lung histology "severe mucus plugging of some small bronchi".

Asthma might have contributed to this death.

NZ SC 84/6

No training, first use scuba, separation from buddy for solo surface swim to boat, called for help, drowned.

Said to be a "controlled asthmatic". Buddy was unaware of this. No histological evidence of asthma.

History of asthma and using drugs

Aust SC 77/3

No training, first open water dive after single pool dive, water cold and choppy, attempted exit on to rocks, washed off.

Four year history of asthma and nasal allergy, smoking 15-30 cigarettes a day and using a bronchodilator.

Aust SC 81/1

Impulsive nature, asthma symptom onset caused surfacing then surface separation. He swam to rocks where he ditched his back pack buoyancy instead of his weights, drowned.

Severe asthma history, recent near fatal dive incident.

Asthma was involved in this death

Aust SC 86/4

Blind, obese, hypertension, asthma, severe head injury from road traffic accident. Closely monitored dive, surface death from cardiac disease.

Allergic wheeze to redwood in 1984. In 1985 asthma attacks March and November (requiring hospitalisation), then put on steroids. December 1985 his doctor described his asthma as "mild" and no contraindication to diving.

Aust SC 91/2

Trained but poor ability as a diver. Sudden silently unconscious as watching fish close to buddy (instructor). Cardiac death.

Family admitted that he used Ventolin but claimed that "he was not an asthmatic, had a similar condition". Described as having "borderline respiratory function" at diving medical. Failed to reveal asthma history.

NZ SC 84/1

No training, third use of scuba, snorkeler who admitted habit of breath holding during ascent. Seen to use inhaler before dive. Ascended slower than buddy, gave surface OK then collapsed. Clinical CAGE but no evidence of this at autopsy or that asthma affected outcome.

Reportedly a severe asthmatic he used 1 Ventolin pack a month. Lung histology "small airway obstruction consistent with asthma".

***Asthma might have contributed to this death*.**

NZ SC 84/4

No training, first use of scuba, hired equipment, poor visibility, cold, so separated and sat on rock. Started return underwater. Buddy, who had no training and was using scuba for the third time, was at surface, saw the victim surface, call for help and sink. Death due to drowning.

Said to be liable to asthma attacks. Used Ventolin and Becotide and took Nuelin. "No evidence of active asthma."

tion of anyone not represented at the "Workshop" is ludicrous. Facts cannot legitimately be ignored in either scientific or medical discussions merely because they were not formally presented at some set time and place. Truth does not depend on a show of hands but is reached by establishing a fit between theory and the available facts. And before any problem can be solved it must first be correctly identified.

5 **Inevitability of running out of air**

It is defeatist to hold that running out of air should be accepted as inevitable,[4] as can be shown by the results of training cave divers to avoid any such situations. To reduce the frequency of low/no-air situations by scuba divers will require the introduction of a far stricter training protocol with greater stress on the dangers of running out of air under water and explaining that trying to breathe water leads to drowning.

6 **SPUMS Policy making**

That the SPUMS Committee decided to elevate the findings of a "Workshop" discussion into a declaration that emergency ascent training was necessary was an unnecessary and unwise decision. At no time was the available scuba fatality data considered to assess the relative importance of the adverse factors which have been identified in scuba diving fatalities nor was there consideration of the relative value of the options which are available to mitigate adverse factors.

Douglas Walker

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DIVER EMERGENCY SERVICE (DES)

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27/4/94

Dear Editor

During April 1994 a meeting was convened, in Durham, North Carolina, by the Divers Alert Network (DAN USA) to discuss the future collaboration of countries providing, or wishing to provide, a 24 hour emergency service to divers in need.

Represented at this meeting were DAN America (President Dr Peter Bennett, with many other members of DAN USA's Board of Directors and staff), DAN Japan (Professor Yoshhiro Mano), DAN Europe (Dr Alessandro Marroni), DES Australia (Dr John Williamson) and DES New Zealand (Dr Des Gorman). DAN Europe, co-ordinated through a central emergency telephone location in Switzerland, is co-operation between many, but not all, European nations. The administrative headquarters of DAN Europe is with Dr Marroni, who also provides an Italian divers' emergency hotline, in Roseto, Italy.

After considerable discussion Australia and New Zealand resolved to remain respectively DES Australia and DES New Zealand, identifying the emergency telephone services of those two countries. However full and harmonious co-operation will continue with international activities (formerly IDAN) such as data sharing and joint collaborative research efforts towards improving the safety of diving worldwide. Indeed, Australia's Project Stickybeak, and the Diving Incident Monitoring Study (DIMS) are in some ways international role models of such data gathering.

DES is an established and well recognised emergency telephone consultation service for divers in our two countries. The service is maintained by, at present five, specialist anaesthesia and diving medicine consultants on a totally voluntary basis, and somewhat uniquely, provides a diving medical physician as a first response. It is clear that the DES services in Australia and New Zealand compare more then favourably with existing national services in other countries. The existing DES Australia Oxygen Courses will remain under that identity, and the DES logo will remain the international flag alpha, bearing a white cross, signifying medical and first aid activities, and a kangaroo. The DES Australia telephone numbers remain unchanged. Within Australia, (user free) 1-800-088 200, and from outside Australia (user pays) 61-8-223 2855.

DAN USA will promote its Australian equivalent, DAN Australia, inside Australian diving ranks. DAN USA's logo, which may already be familiar to some, is the red flag with a white stripe running from top left to bottom right, used as a dive flag by United States divers, with a white cross on the right of the fly and the letters DAN below. The future DAN Australia will focus upon diver membership, with an accompanying insurance package, and marketplace fundraising on a predominantly non-profit basis, including sale of decals, T-shirts, accident reporting data publications, etc. Hopefully regular financial contributions towards the costs of the quite separate DES Australia telephone will be made.

There does seem reasonable certainty however that Dive Master Insurance Consultants Limited will market a diver insurance package tailored to Australian needs, wherever the Australian diver may travel and dive. This package has, as part of each contract sold, the payment of a small donation to DES Australia. Thus in the future Australian divers can know that their dollars which purchase certain diver insurance, such as Dive Master, are making a direct contribution towards the support of their own national emergency diver telephone. DES Australia will also generate funds from the DES Australia (flag alpha) Oxygen Courses.

DES Australia will continue to provide its 24 hour services to any diver in need, nationally or internationally, regardless of the nationality or whereabouts of the caller or the diver. Currently DES Australia handles about 500 calls a year and these are increasing steadily. Following previous publications[1-3] this accumulating data base will be published regularly the SPUMS Journal. The DES Australia team looks forward to harmonious collaboration with the future DAN Australia and with the diving emergency services of all other countries in the mutual interests of increased diver safety and enjoyment.

Chris Acott
Des Gorman
John Williamson

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BOOK REVIEWS

THE SPORTS DIVING MEDICAL
A guide to medical conditions relevant to scuba diving
John Parker.
ISBN 0 9590306 8 9.
J.L. Publications, P.O.Box 381, Carnegie, Victoria 3163, Australia.
RPP $Aust 29.95 (includes postage within Australia) postage and packing for overseas orders $Aust 10.00.

The cover sets the tone of this book as it shows a pair of divers diving as buddies, that is within touching distance so that they can observe and assist each other at all times. Too often buddies are metres apart, far too far away to be a source of succour. This emphasis on safety permeates the text.

This not a look-up-and-there-is-the-answer cookbook approach. The author has chosen a thinking person's approach to the problems of the diving medical. First he lists the things that make recreational scuba diving different from other sports. Then there is a quick summary of basic diving physics followed by a list of good reasons for having a diving medical, one of the most important of which is the opportunity to be given medical advice on how to dive safely. This is followed by a simple questionnaire used by the author and advice about the questions to ask after the form has been filled in.

Throughout the book topics are listed in the left hand margin in bold type with comments as the main text. There are subheadings such as "Points to ponder" and "Points to consider" and "Points to consider very seriously". Each statement is short and to the point. The author's conclusions, which might not be the reader's, follow in italics. These are conservative recommendations based on the general Antipodean approach to controversial subjects such as asthma and diabetes. In the disclaimer underneath the preface the author is at pains to point out that the recommendations are only his views, which may well be changed as further knowledge is obtained.

Clinical cases appear at the bottom of many pages illustrating the opinions expressed about the topics on that page. It is an excellent book for finding out about sensible options for various conditions as it has a good index.

There are a few things to disagree with, two minor errors in English usage (but then the author is a Scot), one misprint and a surprising, unreferenced, statement that asthma is responsible for 8% of scuba diving deaths. Only for two of 100 consecutive Australasian diving deaths[1] was asthma the recorded cause of death. In seven, who had a history of asthma, the official cause of death was drowning, usually combined with compromised air supply (6), salt water aspiration (5) and fatigue/panic (5). This suggests that perhaps asthma is not as dangerous for a scuba diver as the accepted logic dictates and that it is the multiple problems of running low on air that overwhelm divers rather than their asthma.

In the ENT section there is no mention of the effect on ear clearing ability, 90% success, of a SMR (submucous resection, or septoplasty) when inability to clear ones ears is combined with a deviated septum.[2] This is not surprising as the reference was published in 1975, in the limited circulation "Guffers' Gazette". Photocopies of the paper are available from the Editor.

The page about diving emergency facilities around the world is hampered by giving the wrong ISD number for Australia (66 should be 61) and failing to give the number for the other countries mentioned. In the list of diving medical organisations SPUMS is credited with the Australian and New Zealand College of Anaesthetists' old address rather than new one of 630 St Kilda Road, Melbourne, Victoria 3004.

I recommend this book very highly for everyone who does diving medicals as it requires thought (Points to ponder) and clear deductions. It will be of use to all divers interested in medical fitness as an excellent summary of current ideas in diving medicine and the logic behind the recommendations.

John Knight

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UNDERWATER EAR AND NOSE CARE
(2nd Edition 1993)
Noel Roydhouse

Best Publishing Company
P.O.Box 30100, Flagstaff, Arizona 86003-0100, U.S.A.
Price from the publishers $US 25.00. Postage and packing extra.
Also from
Medical Books New Zealand Ltd.
P.O.Box 8565, Auckland, New Zealand
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The current text by Noel Roydhouse, is an up to date summary of "state of the art" scuba diving for novice divers, instructors and dive masters, regarding ear, nose and throat problems.

The author succinctly describes the problems encountered by pressure changes in Eustachian tubes, outer, middle and inner ears. He deals with problems found in these areas with basic anatomy and modes of management in simple and explanatory terms. Case histories add interest and focus on common problems often misdiagnosed by doctors in the non-diving fraternity.

The section on sinus problems has practical demonstrations for nasal "soak" and sinus "squeeze" with key point summaries on treatment and prevention, all in simple language and explanations suitable for lay persons.

Dizziness is compared with vertigo, which, although synonymous, has different meanings for the average diver. Diagrams of the mechanism associated with nystagmus, nausea and vomiting, explain clearly eye and ear incoordination and control by central processes.

The latter part of the book deals with the temporomandibular joint and jaw complaints from case histories of ninety divers, including stress-caused jaw muscle spasms associated with clenching and grinding of the teeth.

A gentle "rap on the knuckles" is thrown in by the author for misdiagnosis of sinus and ear problems and "fear of God" statements by non-diving medicos.

Management of middle ear barotrauma and diagnosis by three step examination, commencing with the Toynbee Manoeuvre, ending with counselling and watching the movements of tongue and soft palate in a mirror, is a practical mode of teaching basic anatomy to divers. No difficult gas pressure levels in cavities of nose, ear and sinuses are included in this text.

Encouragement is the heart of the book and is well illustrated in the opening chapter on "Fitness for Diving". Serious diseases and chronic disorders disbar those divers who would be hazardous under water. Folk medicine and tales of woe are rebuked. The author should be complimented when he states "any ear can be made fit for diving".

Charles Finlay-Jones

SPUMS ANNUAL SCIENTIFIC MEETING 1993

WHAT ARE THE LONG-TERM SEQUELAE OF DIVING?

David Elliott

Abstract

The effects of hydrostatic pressure and of the raised partial pressures of the respiratory gases are exerted on every cell in the body. Man at pressure is physiologically not the same animal that he is at the surface. With the additional hazards of decompression it seems rather surprising that, for many years, the only well recognised long-term sequelae of diving were those associated with neurological residua after an acute episode of decompression illness. Subsequently, bone necrosis was recognised as a hazard of raised environmental pressure. An assumption that this condition was also decompression-related was not supported by the lack of a one-to-one relationship with limb bends and a wealth of hypotheses remain, each trying to account for it. As new investigative techniques, with greater powers of resolution, became available for hospital use, they were applied by occupational physicians to apparently healthy workers. The presence of new "abnormalities" were detected and the absence of adequate control studies led to a number of erroneous conclusions.

Changes in lymphocytic chromosomes have been reported in divers but without significant sequelae. Changes of lung volumes and of carbon dioxide sensitivity have been recognised for some years, but, more recently, a reduction in pulmonary diffusion capacity (TLCO), with functional consequences, has been reported. With each new allegation of adverse diving sequelae, the implications to be considered include the validity of the diagnostic procedure used and the likely impact on the long-term quality of life for that individual.

Introduction

The person who takes up diving takes up a hazardous activity. Diving will always be hazardous and so the future level of activity for man in the sea will depend upon the balance between the benefits and the perceived risks. Any perception of risk is usually different from the actual risk and it seems important to estimate the actual costs, in terms of health and safety, of each type of activity underwater. The sea makes no distinction between the recreational diver and the professional, but the balance point between apparent benefit and perceived cost is not the same. In each diving group the benefits are relatively clear: pleasure for the sports diver and, for the employed diver, payment. Other than the consequences of a diving accident or of decompression illness, the perception of the recreational diver is probably that the risk of long-term health effects due to diving is around zero. This may not be quite so true for the professional air diver but, because his instruction has been confined to diving emergencies and his only knowledge about long-term risks may come from other divers and the media, he is not necessarily fully aware of the occupational hazards to his health.

It is the purpose of this review to look at some hazards of air diving and to assess the risks that these imply for the diver's continued good health.

The first part of this review will be devoted to hazards which may be at the cellular level, rather than the more obvious acute hazards to health, such as "running out of air". Bone necrosis has been described as a condition which, thanks to the standardisation of diagnostic techniques, is capable of being largely controlled by the adoption of appropriate decompression procedures and which can, for the individual diver, be monitored during his career. Other long-term effects for instance, of hearing, pulmonary function and chromosomes also provide important methodological background to a consideration of neurological deficits.

The Hazards

While at depth, every cell and each molecular process is subject to increased hydrostatic pressure. At great depths the molecular and cellular effects of hydrostatic pressure are relatively easy to demonstrate and some may have long-term consequences.

The effects of increased environmental pressure on the gas-containing spaces of the body are not confined to the various forms of acute barotrauma but may have other effects, for instance upon the pulmonary system.

The increased partial pressure of oxygen is perhaps the most prominent toxic agent in diving and its effects are not confined to the brain and the lungs.

Perhaps the most potent hazard to which the diver is exposed is that of the "silent bubble". The bubble can arise during accepted safe decompression procedures and is a powerful biological agent within the bloodstream.

Each of these four primary hazards is well known but the threshold of safe exposure to them is unknown because we have no means of defining "safe" in this context. Indeed, is there a "zero-threshold" effect?

HYDROSTATIC PRESSURE EFFECTS

While the vast majority of studies in hydrostatic pressure upon living cells and organisms have been conducted at extreme pressures,[1] the mechanism of these effects are simply related to changes of molecular volume and such changes need not be extreme. For instance the squid giant axon shows a reduction of threshold current and potential at a pressure of 7 bar.[2]

Under some circumstances dissolved gas can induce an osmotic effect, causing tissue water to be redistributed.[3] This is considered to be important pathologically only within a rigid structure such as bone and may lead to changes in intra-medullary pressure which may, or may not, be associated with dysbaric osteonecrosis.

Alterations of the stiffness of blood cell membranes have been described[4] as another possible cause of osteonecrosis and other diving-related conditions.

Increased pressure prior to decompression also induces platelet aggregation[5] and the effect upon platelet density of compression is related to the level of pressure achieved.[6]

There seems to be no evidence that the high pressure nervous syndrome (HPNS) is *per se* anything but a transient phenomenon although post-dive effects have been ascribed to it.

GAS-CONTAINING SPACES

In many cases, barotrauma is acute and any effect can be dated from a particular incident. But the effects of minor but multiple compression barotrauma upon the middle and inner ear can be responsible for changes which may well become long-term.

Decompression barotrauma can lead to arterial gas embolism. The acute effects are well recognised but in some the effects can be sub-clinical. Extra-alveolar air was found in a number of submarine escape trainees after apparently successful ascents[7] and EEG changes found after successful ascents by submarine escape trainees implies the probability of some "silent" arterial embolism.[8]

Increased gas density may be related to some of the long-term pulmonary effects.

PARTIAL PRESSURE EFFECTS

The literature on oxygen toxicity is vast but has the threshold for relatively minor effects of long-term exposure yet been defined? Oxygen is well known to have effects throughout the body ranging from the endocrine system[9] to bone marrow in which Walder[10] proposed that a raised partial pressure of oxygen would enlarge the volume of fat cells.

The raised partial pressures of the other respiratory gases, such as carbon dioxide, also have possible long-term effects. There can be other gases in the breathing mixture. For the recreational diver failure of adequate air filtration can lead to contamination by oil and particulate matter, which may have health consequences, but for the commercial diver the list is long, and includes such factors as fumes in welding habitats.

DECOMPRESSION EFFECTS

The blood-gas interface induces a wide range of haematological and endothelial effects. The effects upon platelet aggregation, Hageman Factor activation, the clumping of blood cells, the release of lipid emboli, the activation of complement systems and kinins, the increased and decreased activity of some enzymes and other effects have been reviewed elsewhere.[11]

Respiratory function

One effect of diving is an increase in vital capacity with age in young professional divers, who then have difficulty in passing the FEV_1/FVC pulmonary function test at annual medical examinations.[12] The arbitrary minimum value of 75% should not be accepted without consideration of the implications of this long term effect. The general conclusion that divers tend to have larger vital capacities than non-divers was not confirmed by a study of 126 saturation divers by Thorsen[13] who suggests that there is a greater, belated, diminution. Any change of vital capacity probably has little effect upon the diver's general health though recent studies have shown that divers do develop some degree of air flow obstruction due to airway narrowing.[14]

Perhaps a more significant long term change among divers is demonstrated by a minority of divers who can be identified as "carbon dioxide retainers".[15] While it might seem an advantage for a diver to be able to tolerate a greater level of carbon dioxide, the synergistic effect of increased carbon dioxide, oxygen and nitrogen is considered to make it more of a hazard than an advantage. The group can be identified by their inadequate increase in ventilation to a raised inspiratory carbon dioxide level.[16] Steady-state studies of end-tidal carbon dioxide levels showed that those divers who have high values continue to do so after they have finished diving.[17]

Pulmonary diffusion capacity is another physiological function which appears to deteriorate in divers with age. At the present time the work to assess this is incomplete, particularly in air divers. The early reports have all been confined to mixed gas divers,[18] which is in part due to the fact that divers are exhaustively examined before and after every deep dive, much more so than at the annual medical examination. The diminution of pulmonary diffusion post-dive may not be clinically significant and tends to improve during the next few weeks, but it is also associated with a diminution in exercise tolerance.[13] A number of explanations can be offered, the most favoured being an association with the possible cumulative dose of oxygen at tensions greater than 0.3 bar. In contrast, a study of 8 divers in a German deep dive showed no significant diminution of pulmonary carbon monoxide transfer capacity (TLCO),[19] though there were other variables. The study is now being repeated with a 450 m dive at the National Hyperbaric Centre in Aberdeen. The significance to recreational divers of findings after 28-day saturation exposures to maximum depths of 450 m may seem remote but, if the hypothesis of a lower threshold for pulmonary oxygen effects is correct, then one would expect to find this long-term effect in all saturation divers. It could also become a matter of concern for those who dive extensively each day at shallower depths.

Genetic Effects?

It would be difficult to think of a topic more likely to attract the spotlight of media attention than that of the possible genetic effects of diving. Although there may seem no reason why there should be any genetic changes, once such a question is raised it will not go away.

The discovery of triploid zygotes in the child of a diver was sufficient to initiate a pilot study in Aberdeen on chromosome aberrations in the cultured T-lymphocytes of divers. The results of that pilot study were sufficient to justify an enlarged study which was funded by the UK Department of Energy.[20] There are some positive features of this investigation which provide a useful lesson to other investigators.

Because of the emotive nature of this project, all who were concerned in it agreed to maintain strict confidentiality until it was complete. Blood was taken from more than 150 divers and an equal number of control subjects. Each person was fully informed about the purpose of this study and would be counselled in the event that any abnormalities were found.

Of 77 compressed air divers and 76 mixed gas divers, 6 had a few heavily damaged cells. The health risks imposed by these abnormal cells is unknown but the damage they contain is, in most cases, so extreme that they are likely to die at mitosis. No such cells were found in the controls.

This type of finding was unexpected and, because of such low numbers, no correlation was possible with the many associated occupational factors that were also studied.[20] The aberrations observed were typical of those induced by ionising radiation and were present in air divers as well as mixed gas divers. None of the affected divers admitted to using gamma-sources for examining welds at depth, whereas some of the divers who had normal chromosomes did use isotopes.

At this stage it was necessary to release the results. Before publication, a letter was written by doctors associated with the project to each participant and to each diving company, explaining the significance of the findings. In spite of the uncertainties of the study and of the concerns that could easily have been created, this briefing was sufficient to assure the diving population that the problem had been investigated meticulously and that, although the cells studied were only lymphocytes, there was no evidence that would indicate a significant effect in the germ line. This extensive briefing meant that when the newspapers became aware of this project, there was no angle to the story which they wanted to print. All occupational health surveys should be confidential to the investigators until the results are known. This shows that it can be done.

Hearing Loss

It is well known that old divers are deaf. Indeed a number of audiometric studies have shown that a population of divers demonstrate hearing losses greater than in age-matched controls.[22, 23] If the deafness is insidious and without obvious cause then it falls within the remit of "long-term effect".

Noise-induced hearing loss is a likely cause for deafness in professional divers. A temporary threshold shift can occur whenever one is exposed to a loud noise. In professional divers these hazards are more common and include the rush of gas entering a chamber during compression, the circulation of gas in diving helmets, the use of noisy underwater tools and the occasional underwater explosion. Repeated exposures will cause a permanent threshold shift in both ears.

There are many other causes of hearing loss in divers. Even if those for which there are obvious acute causes, such as decompression sickness or inner ear barotrauma, are excluded, repetitive sub-clinical episodes of these same conditions must be considered.

Susbielle[24] suggested that repetitive minor barotrauma to the middle ear can lead to changes of pressure within the inner ear. He also suggested that inert gas dynamics could lead to osmotic dysbarism in the endolymph and perilymph. In a study of 116 divers, Molvær and Albrektsen[22] concluded that much of the loss of hearing acuity in these men was due to high noise levels at work but, in addition, residual damage from acute inner ear injury caused by barotrauma was also found. In a study of the effects of compression and decompression upon a small series of mini-pigs[25] it was shown that inner ear changes occurred in these animals on a pressure schedule that is usually regarded as safe for man but, of course, the mini-pig may not be very good at ear-clearing. An important feature of this study was the loss of hair cells throughout the cochlear in all the compressed animals.

Conclusion

This review is far from comprehensive but each of these long-term health effects has been well documented and is of potential concern to air divers. A wide range of possible pathogenetic pathways has been mentioned, some of them specific to one condition, others common to several. There are also many other possible long-term effects such as subfertility in animals[26] and in man effects on such organs as the liver,[27] the heart[28] and even the hand.[29] We have a random collection of observations in which no common thread can be discerned. How is one to assess the clinical significance of these conditions? An effect upon the quality of life is probably the ultimate test, but is not one that can be quantified.

One way forward was demonstrated in the MRC study of bone necrosis in tunnellers and divers by the creation of the Decompression Sickness Registry in Newcastle. The collection of thousands of individual X-rays, annual medical examinations and, for the tunnel workers, the depth time profile of each shift's exposure, was a monumental piece of work. From it has emerged many invaluable observations encapsulated in a number of papers. Even so, many questions about bone necrosis remain unanswered. That the research is incomplete can be attributed to the failure of national funding authorities to recognise the importance of a central registry to the health surveillance of a relatively small numbe of high-risk workers, who are travelling the world in search of employment. A broad data base was established before the Health and Safety Executive (H&SE) withdrew funding nearly 10 years ago. Since then no further data has been collected.

Cross-sectional studies may be useful in the definition of an occupational problem but longitudinal studies provide much better scope for analysis. In the 1960's and early 1970's many supported the concept of a central European diving registry, not only for the collection of data related to occupational health but also because of a need for centralised medical records internationally for the North Sea.

Perhaps a breakthrough could still happen. For commercial divers in the UK, at least, it has now been agreed between the oil industry, the diving companies and the Offshore Division of the Health & Safety Executive that all air-range dives will be monitored on-line. The pressure profile, together with breathing gas composition and thermal status, will provide a complete diving record for each diver. One immediate benefit of on-line dive data recording is for the retrospective analysis of any diving accident. A second benefit is not merely relating a bend to the causative dive but in time, by providing tens of thousands of such dive records, providing the opportunity for precise statistical analysis. This would lead to the generation of safer decompression tables. Now (May 1993) start-up funding seems assured. Given the co-operation of those responsible for recording annual diver fitness, one can begin to appreciate the great potential of a new preferably international registry, in which each diver's lifetime diving history is recorded and retrievable.

Such registry could allow identification of the contributory factors that may lead to long-term health effects, particularly in those who never have been recompressed for decompression illness. The data are now being recorded on each and every dive. The divers are examined medically each year. To turn this process into a reliable epidemiological survey of the relatively limited population of occupational divers worldwide no longer seems to be a dream. If bureaucratic hurdles can be removed, it might become possible not only to recognise any potential harmful effects at the earliest stage, but also perhaps to prevent them.

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The above paper is an edited transcript of a lecture delivered to the 1993 Annual Scientific Meeting of SPUMS. It was delivered, as an introduction to Professor Elliott's paper "Neurological deficits after diving" which was published last year in the SPUMS Journal (1993; 23 (3): 160-165).

UNDERWATER ESCAPE FROM DITCHED HELICOPTERS

David Elliott and Michael Tipton

Abstract

Some people fail to escape when a helicopter ditches into the sea. Protective clothing has for years focussed on hypothermia whereas almost no attention has been given to the immediate effects of cold immersion. Sudden immersion in water as warm as 15°C causes physiological effects which may jeopardise through-water egress from an in-

verted helicopter. A significant reduction of breath-hold duration occurs even when wearing a full dry suit.

A 5 year program developed a simple underwater breathing aid suitable for passengers which avoids the hazards of pulmonary barotrauma and air embolism that can occur when providing compressed gas to a submerged survivor. A counter-lung designed to meet international standards for underwater breathing apparatus (UBA) performance can more than double underwater survival time in 10°C water when compared with maximum breath holding. After operational evaluation in a helicopter dunker, it was concluded that this survival aid can only enhance safety and for some, could be life-saving.

Introduction

A forced landing on the sea is a foreseeable hazard for helicopters but one that, for most passengers, seems reasonably remote. Where the water is cold, wearing an immersion suit has become accepted practice within the oil industry. Though expensive to purchase and maintain such suits have been accepted, together with the costs of practical training, as necessary in the interests of health and safety. In spite of this some persons fail to escape when a helicopter ditches in the sea.

Recognition of the problem

Sudden immersion in very cold water has long been recognised as a cause of almost immediate death among personnel shipwrecked or lost overboard. The provision of survival suits did much to minimise the loss of body heat from survivors and, when oil and gas exploration was extended to the North Sea in the 1970's, the industry provided suitable protective clothing for its helicopter passengers based largely on military experience.

At that time the uninsulated dry suit over suitable heavy clothing was considered an adequate protection against hypothermia due to slow body cooling. Shell's policy in 1980 was that immersion suits were needed only for rescue times greater than 1 hour if the sea temperature was less than 15°C. For lesser durations, heavy winter clothing alone was regarded as adequate.

The perception that hypothermia is the principal hazard to a survivor on immersion in cold water has dominated the protective clothing policies for helicopter passengers in the offshore industry for more than 15 years. However these policies have not yet acknowledged that some people do not survive long enough to reach the phase of slow body cooling and hypothermia.

Among the open water drownings that occur each year, some two thirds happen within 3 m of a safe refuge and among those who disappear in these circumstances, some 60% were stated to have been good swimmers.[1,2] This supports the view that, long before there can be any significant whole body cooling, there are other hazards that must be overcome. These may be considered as the initial and short-term responses to immersion (0-3 and 3-15 minutes[3]) known colloquially as cold shock. This causes an immediate rise of blood pressure and a temporary inability to control ones breathing rate. Characteristically, there may be a sudden inspiratory gasp after which the survivor may not be able to avoid taking a breath even when a wave is passing over his head.

Which is first?

A second misleading perception arises from the use of the term cold shock. This implies that this can only occur in cold water but, because of its large thermal capacity, sea water must be considered cold in most locations including some that are considered to be sub-tropical. An uninsulated person cannot maintain thermal balance when immersed in water below 35°C and the effects of cold shock can be significant below 15°C.

Following the loss of a Bell 212 helicopter in the North Sea in 1981 when one person died after about 40 minutes in the water, a shuttle jacket was introduced for use in flights in which rescue times were expected to be less than 60 minutes. This was a neoprene jacket, with a beaver-tail like the top of a diver's wet suit, but worn over normal clothing and was an improvement thermally on the previous practice of wearing just heavy winter clothing (Figures 1 and 2).

However, it was then shown that even a full immersion suit fails to provide adequate protection against cold shock.[4] The potentially lethal consequences of this are serious for those trapped underwater, as most persons can hold their breath for some 50 seconds on dry land but less than one quarter can remain under water for that time, even when wearing an effective survival suit.

The significance of this observation should be considered in the context of work that was already in hand by the US Coastguard (USCG) following two helicopter ditchings in 1979 when the water temperature was around 14°C. Of nine crewmen, all trained in helicopter escape and all wearing immersion dry-suits, only three survived.[5] None of those who perished had significant injuries but all had drowned. Following this, an emergency underwater breathing device was developed by the USCG and evaluated by the US Navy Experimental Diving Unit in 1981.[6] The device (HEED-1) was a 12 litre rebreathing bag on the air-crew life jacket, filled from cylinders of oxygen but with no carbon dioxide scrubber. Maintenance costs are high, training is not without risk and the apparatus is not made available for use by passengers.

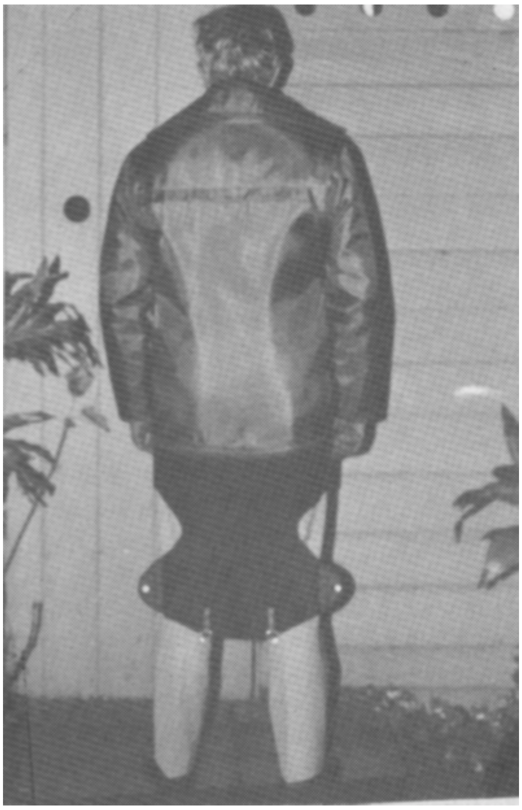

Figure 1. This jacket, similar in design to the one mentioned in the text, but designed for sailing, was available in Australia in the 1970s. The beaver tail clipped up inside the back until required.

Figure 2. The front of the jacket showing the beaver tail fixed in position.

Concurrent with the subsequent development of the Shell counter-lung rebreather, the US Navy (USN) introduced the Helicopter Emergency Egress Device (HEED-2). In the years 1981 to 1983 there had been 29 Navy and Marine Corps helicopter accidents in which the fuselage inverted or sank.[5,7] Twenty seven air crew drowned thus providing the stimulus for this alternative underwater breathing aid. The USN device is essentially the same as the miniature bottle of compressed air (Air 11) carried by some scuba divers in case their primary gas cylinder runs out of air. HEED-2 is a 5 x 25 cm aluminium cylinder charged with air to about 13 bar and it has a single-stage regulator. It was adopted for official use in 1986 but, like HEED-1, purchase and maintenance costs are high, and there is the serious hazard of pulmonary barotrauma with the risk of gas embolism both in training and when used in an emergency. There have been reports that the bottles have been found to be empty when needed and also it can be difficult to purge the mouthpiece of sea-water before breathing from it, particularly when upside down. The USN device is also only available to air-crew.

The underlying problem

How long is needed for trained and uninjured passengers to escape from a helicopter which suddenly rolls and sinks? Consider that, from the moment of the last breath before submersion, during the period of inversion and re-orientation, removing a window or following another survivor out, to arrival at the surface, the total duration underwater needed by a survivor is likely to be longer than the time taken in the ideal circumstances of a helicopter underwater escape trainer (HUET). The US Navy, the US Coast Guard, the RAF, the Institute of Aviation Medicine and the Royal Navy have all suggested, informally, times of around 45 to 60 seconds.

Breath-hold duration underwater in some persons can be a matter of only 10 to 20 seconds. In a recent trial using a realistic helicopter mock-up, 30% of trained undergraduate volunteers were not able to complete a simulated escape on breath-hold alone.

The two existing underwater breathing aids, HEED-1 and HEED-2, are both available commercially but each introduces the potential survivor to additional hazards, requires considerable training and is considered to be suitable only for air-crew.

The alternative of re-breathing one's expired air from a simple counter-lung is not an original concept. However, a simple bag is, of itself, inadequate to meet the need.

"Air pocket" counter-lung development

The question to be answered was whether or not the use of a counter-lung, without a supplementary supply of compressed gas from a cylinder, would prolong underwater time. An associated question was whether the gas available by exhalation from a full vital capacity after breath-hold would be sufficient or whether it would be necessary first to partially fill the counter-lung with some air, preferably also from the lungs, before submersion.

Manned trials with several prototypes were undertaken at the National Hyperbaric Centre, Aberdeen. From these a number of conclusions emerged but many were true only for the prototype which has since been changed. However, the use of oxygen to pre-fill the counter-lung provided no significant advantage. These trials did reveal some problems with counter-lungs. An important one was "shut off" of the bag while much of the gas needed was still captive in a distant part of the re-breathing bag.

Static and dynamic unmanned trials on five prototype designs of counter-lung were undertaken using a head and torso breathing-manikin. This was mounted in a tank of water so that it could be rotated into each possible orientation of the user: vertical upright; vertical head-down; horizontal face-down; horizontal face-up; horizontal 90° lateral rotation left, and right. The breathing characteristics of the counter-lungs were examined using the physiological acceptance criteria for underwater breathing apparatus.[8] Subsequent unmanned trials of 6 litre and 10 litre triangular counter-lungs indicated that the position and attachments of the bag were critical to its performance. The best results were obtained with the bag close to the torso but without compressing it. The turning moment induced by the larger counter-lung was high. On the basis of these results the 6 litre bag was selected and the project moved to the next phase which was to determine the optimum procedure for the use of the counter-lung.

The first tests were conducted in the dry environment with various subjects taking in a deep breath, holding it to their maximal breath-hold duration and then, at the break-point, rebreathing with the counter-lung to the maximum duration. This was compared with persons who, after taking a maximal breath, rebreathed immediately without any prior breath-holding. This was done at rest and at two levels of exercise. The results indicated that it was possible to adopt the style which would also be the safest.

By first holding one's breath as long as possible and not rebreathing, the subject might be able to make a successful escape. By using the counter-lung only after the breath-hold, the use of an counter-lung becomes the alternative to drowning. Tests were continued in warm water and confirmed the ability of persons to use an air pocket in all orientations and to remain submerged for some 60 seconds.

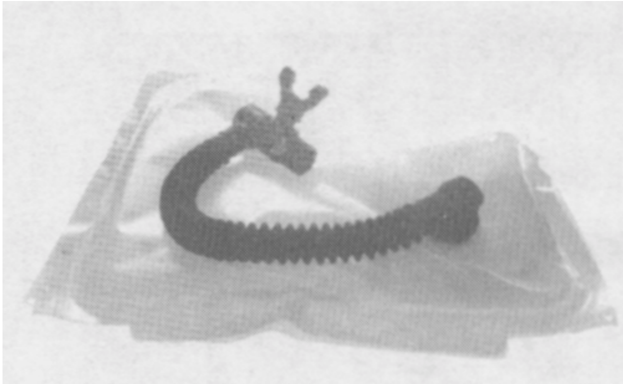

Figure 3. The final counter-lung. The most important tubing, that within the counter-lung, is not visible.

At this stage the counter-lung was fitted with an internal manifold to ensure a better distribution and enhanced emptying. In this way a counter-lung was developed which could be breathed from in any orientation underwater, which would not be subjected to "shut off", which was sized to keep breathing resistance to a minimum and which did not need to be filled with additional gas but could be used with the subject's own maximal breath (Fig. 3).

The next objective was to confirm the breathing characteristics of the counter-lung when the subject was dressed in an immersion suit (Fig.4) with a life jacket. The total underwater duration was limited to 70 seconds by the experimental design and so the maximum times for the potential use of the counter-lung were not determined. Each individual was subject to two testing immersions: one in 25°C and the other in 10°C water, chosen to represent the average temperature in the UK sector of the North Sea. It was apparent from these results that the counter-lung significantly extended the time that all subjects could spend at rest and under cold water when compared with their maximum breath-hold time.

Trials were then carried out with moderate exercise to test the effectiveness of the counter-lung procedure during a simulated helicopter underwater escape in warm and cold water. The maximum duration for this test was limited by the experimental design to 60 seconds. The results show that to rebreathe with the counter-lung could extend underwater duration by a factor of not less than 2.5. The results suggest that if 30 seconds were needed for a successful escape in these particular conditions, with breath-hold all would fail but with the counter-lung all might succeed (Fig. 5).

Having demonstrated the potential value of the counter-lung the final phase of the trials program was to confirm that it had no adverse effect on manoeuvrability and

Figure 4. Survival suit with built in counter-lung with the mouthpiece displayed.

the ability to escape from a HUET. A group of six experienced instructors and six naive subjects volunteered to take part in these trials. The training process included first simple submersion while breathing from the counter-lung after a maximal breath-hold and then on a shallow water escape trainer (SWET) chair in which the subject could be inverted before switching to the counter-lung. Each subject then pushed out a side window and egressed using the counter-lung towards the surface.

The instructors then made 4 exits underwater from the HUET using the counter-lung: position 1 a simple exit starboard through an open window; position 1 an exit port side after releasing the life raft; position 2 turning 180 degrees to release the life raft; position 3 moving aft through the cabin to release the life raft (Fig. 6). Having successfully completed this phase the instructors made an exit from the pilot seat by the bulkhead door and then out of the main cabin through a type 4 window, at 0.47 by 0.65 m the smallest in commercial helicopters. This proved to be easy even for one instructor at 1.85 m tall and weighing 105 kg.

The naive subjects (4 males, 2 females) followed a similar training plan but omitting the relatively difficult seats 2 and 4. One subject failed to egress the HUET within 60 seconds, which was the pre-agreed ethical limit to underwater duration and the counter-lung was required by the subjects in 30% of exits. There were no problems

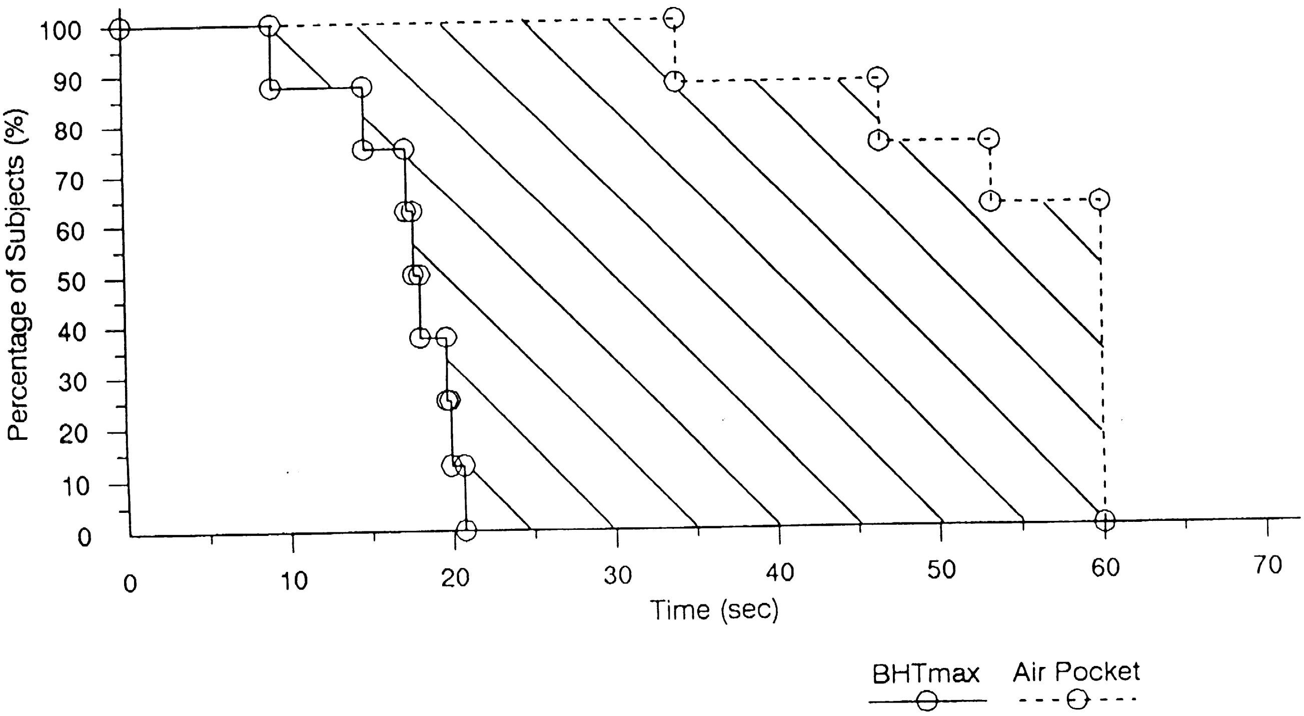

Figure 5.

The percentage of subjects able to remain submerged for any given time when breath-holding (BHT max) or when using the counter lung.

Exercising submersions. Water temperature 10° C. Counterlung worn with a "dry" survival suit. Test subjects were not exposed for more than 60 seconds.

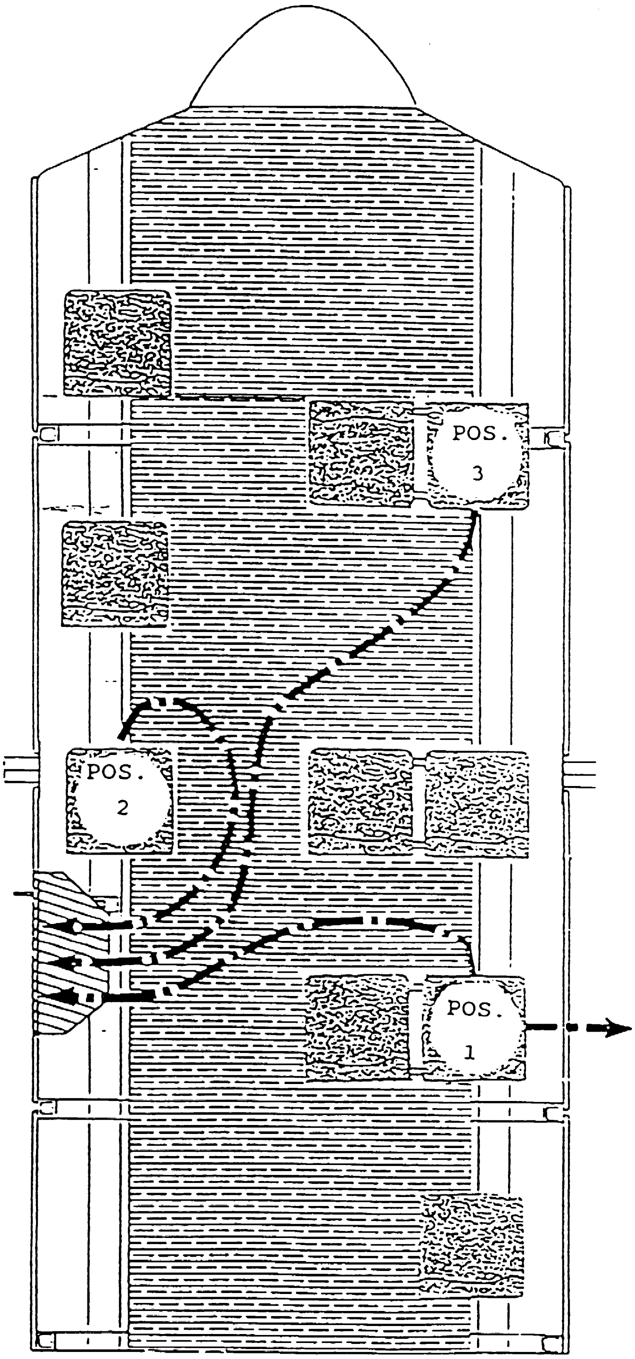

Figure 6. The S-61 METS configuration with starting positions 1, 2 and 3 marked. The arrows show the route to the liferaft encasement and exit point.

associated with snagging or buoyancy and all found it easy to use.

Test criteria

Performance objectives have been set for the use of a counter-lung with no supplementary compressed-gas cylinder. Other breathing aids and procedures may introduce the hazard of lung over-pressure during ascent with a consequent risk of serious medical complications due to gas embolism. It is important to emphasise that the counter-lung which has no supplementary compressed-gas cylinder, should also **not** be "primed" by filling it with air before submersion.

The performance objectives, test procedures and past criteria cover many non-physiological aspects such as fire protection and durability. The recommended acceptable program includes unmanned testing on a breathing machine which can model the human pulmonary system in selected orientations upright, head-down and forward at 90° and 270°. The results should be reviewed using the standards of the "Guidelines for the Minimum Performance Requirements and Standard Unmanned Procedures for Underwater Breathing Apparatus" (1984) Department of Energy and Norwegian Petroleum Directorate. The counter-lung is then tested in warm (25°C) and cold (10°C) water at rest and with moderate exercise to ensure that, when used as recommended, it provides the healthy subject wearing an approved immersion suit with a significantly prolonged duration underwater when compared to simple breath-holding.

The manned tests need to be repeated every time that the counter-lung is fixed to any new type of survival suit with which it has not been used previously. For instance, it may not be compatible with a relatively tight fitting design if it is to be worn between the suit and the individual's clothing. In this circumstance it would need to be fitted to the outside of the suit and in some other conditions it may need to be fitted to the life jacket.

Conclusions

The "Air pocket" counter-lung:
is relatively inexpensive;
provides no special difficulties for training;
is simple to use;
is compatible with any position in the water;
does not introduce the additional hazard of pulmonary barotrauma and gas embolism;
can be validated for use with other survival suits;
can enhance safety to an extent which may be life-saving for a proportion of passengers.

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ARTICLES OF INTEREST REPRINTED FROM OTHER JOURNALS

WHY US DIVERS DIED IN 1990

In the past, Undercurrent's annual series, "Why Divers Die", has been based on studies performed by John McAniff at the National Underwater Accident Data Center (NUADC).

Recently, McAniff merged his effort with the Divers Alert Network (DAN), which has for four years been reporting on recreational scuba accidents. This expanded DAN report is based on information from more than 130 treatment facilities in the United States, the Caribbean and Pacific territories.

Undercurrent is pleased to bring you the DAN 1990 Report on Diving Accidents and Fatalities with the belief that by reading these accounts, we will become safer divers.

Undercurrent takes all responsibility for editorial changes and errors.

NUADC has been collecting scuba fatality information for the past twenty years. Since 1989 DAN and NUADC have been collaborating in this effort. This report covers those fatalities which occurred to United States citizens who were recreational divers throughout the world in 1990.

NUADC has reviewed studies of diver population and estimates the active diver population in the US to be 2.45 to 3.1 million at the end of 1990. The difficulty of comparing these studies was the lack of a consistent definition for an active diver. Divers may be excluded in one study because they were under 18 years of age or included in another study if they dived more than twice a year. Certification was not necessarily a criterion for being an active diver.

All figures include individuals engaged in training for entry level certification while excluding those taking resort sessions. Technical diving is included in the active diver population, but is not considered recreational and is discussed separately. Technical diving can be loosely defined as an avocation which uses specialized techniques, equipment, training and skills to advance beyond the present limits of recreational diving.

There are several reasons why a range is used when describing the number of active divers. No reliable numbers are available to determine how many new divers are certified each year. NUADC estimates there could be 550,000 newly certified divers yearly. Not all will remain active after the first year of diving. Drop out continues for several years adding to an unknown cumulative drop out rate. Although 550,000 individuals may have received a first time certification, the total active diver increase in 1990 was between 100-150,000 certified divers due to the overall drop out rate, and that some people re-enter after dropping out.

Deaths

For 1990, 95 recreational scuba diving fatalities were reported. Four of these deaths were foreign nationals and 91 were US citizens. Eleven victims had not been certified. The fatality rate for 1990 is 2.93 to 3.71 fatalities per 100,000 active divers. Although this an estimated rate, it suffices to say the rate is very low.

A review of the scuba fatalities since 1970 reveals a decreasing trend in yearly scuba fatalities. The 1970s were far the worst years for fatalities in recreational scuba diving. Increased training standards and diver awareness are believed to have led to a decrease in fatalities in the 1980s.

The 1970s averaged 130 deaths per year, compared with an average of 90 deaths per year in the 1980s. The first two years of the 1990s have produced an average of 78.5 fatal dive accidents per year. The peak year for scuba fatatilities was in 1976 when there were 147 deaths and there was a recent peak in 1989 with 114 deaths. There was record low of 66 scuba deaths in 1998 and 67 in 1991.

According to our estimates, the number of active certified divers is increasing each year, and the number of fatalities is decreasing, representing a dramatic decrease in the fatality rate since the 1970s.

Location of diving fatalities

The state of Florida recorded 22 scuba fatalities during 1990, seven in caves. This is a considerable reduction from the 1989 which showed 29 deaths with nine deaths in caves. California had 14 deaths compared to 21 in 1989. Washington state reported four deaths for 1990, while Hawaii, Maine and New York had three fatalities each. Several states recorded two fatalities: Massachusetts, New Jersey, Pennsylvania, Rhode Island and Wisconsin. Nine states recorded one scuba fatality each: Connecticut, Illinois, Louisiana, Montana, Ohio, Oregon, South Dakota, Texas and Utah. In addition, one death each was noted for Puerto Rico and the US Virgin Islands during 1990.

Twenty three deaths of US citizens occurred in foreign countries or US territories. There were four such deaths in Mexico. Two occurred in the Gulf of California, one off Cozumel and the fourth in a cave system near the Yucatan Peninsula. The three deaths in the Bahamas occurred at different locations.

Triple fatalities occurred at two foreign locations. The first occurred on the French Windward Island of Martinique in January, 1990. The victims included two French citizens and a 24 year old American. All three were certified instructors who attempted a dive together on compressed air that was to exceed 300 feet (90 m). None of the divers returned.

In Jamaica, two US citizens died while scuba diving with their Jamaican divemaster and six other Americans. The group intended to go no deeper than 70 feet on a drift dive. Missing the intended ledge, the entire dive party reached a depth of 160 feet (48 m). Inexperience and nitrogen narcosis resulted in three divers continuing to well over 200 feet (60 m). An experienced member of the dive group rescued one diver who had lost consciousness. The other two divers apparently continued to sink and were never recovered. The Jamaican divemaster died as well.

One double fatality at Lake Garda near Verona, Italy involved two US servicemen doing a recreational scuba dive.

Nine other foreign countries also recorded the deaths of US citizens during 1990. These include Belize, Bermuda, Bequia, Cayman Islands, Egypt (the Red Sea), Honduras, Japan (Okinawa), Micronesia and Panama.

Seventeen of the 80 certified diver fatalities in 1990 were female (21 percent), the largest number of female deaths since 1986 when there were 19. The record year for female deaths was 1978 when there were 21 female deaths in a total of 144 scuba fatalities.

Forty-six percent of the fatalities held basic certification or were taking their initial training. Lack of experience most likely played some role in individuals with entry level training only. Divers who complete an open water certification are not complete divers. Accidents can occur when individual or group diving skill levels and ability to respond to underwater situations do not match dive conditions and the skill required to successfully complete a dive.

Thirty-eight percent of all divers had dived twenty times or less since certification; 33 percent were very experienced with a minimum of 61 dives. Fifteen of the experienced divers died of drowning, three of cardiovascular disease, three of embolism, two were diving without a buddy, one trauma case and two unknown cases.

Fatalities that occurred during pleasure dives were often the result of the individual being unable to control some aspect of the dive.

Struggling with a speared fish can add stress to the already physically challenging environment. The same can be said of task oriented diving such as collecting golf balls or retrieving lost articles. Even photography can divert a diver's attention from keeping an open airway, maintaining proper buoyancy control and monitoring air pressure and depth gauges.

Open water dive scenarios

A 23 year old man, certified for three years, lost his life in Seneca Lake in New York. He had logged about ten dives in the previous year, none deeper than 50 feet (15 m). He and his two companions had planned to dive down the steep slope of the lake to explore three sunken barges that rested in a line on the slope at depths of 30 ft (9 m), 60 ft (18 m) and 90 ft (27 m), then bounce to 140 ft (42 m). At about 135 ft (40.5 m), the victim's regulator began to free-flow, causing panic and a rapid ascent. He suffered a massive air embolism.

The wreck of the Ida, ten miles off Monmouth, New Jersey, was the site of the death of a 49 year old male, certified with several years of diving experience. He was in the water with six other divers at depths between 85 and 115 ft (25.5 to 34.5 m). His body was located on the surface about two hours after the start of the dive and his tanks were out of air. None of his companions was aware of any problem that might have caused him to drown.

A 35 year old man certified as an open water diver died on the USS San Diego. He was found lying on the hull of the wreck 70 ft (21 m) deep. Separated from his buddy, he became entangled in his ascent line and ran out of air.

A 50 year old man died off Honduras while on his first open water dive to a wreck 100 ft (30 m) deep. he signalled out-of-air and buddy-breathed to about 30 ft (9 m), then broke away and made a rapid ascent.

In the U.S. Virgin Islands, a 50 year old man completed a 60 ft (18 m) dive and returned to the boat. With the help of the captain he was taken on board and began vomiting. He collapsed and despite resuscitation efforts died of a myocardial infarction, basically a heart attack.

Another case attributed to a myocardial infarction took the life of a 56 year old certified diver who was exploring an 80 ft (23 m) deep shipwreck in Bermuda with his son as a buddy.

Training case scenarios

Divers under instruction accounted for nine deaths. Six were taking their initial training, while the remaining three were taking advanced level classes. Alcohol or drugs contributed to several of the deaths.

An advanced open water training night dive off California resulted in the death of a 49 year old woman. She had completed three dives that day. On the last dive, she apparently became entangled in heavy kelp but was rescued. Initial CPR was successful, but she died four days later.

At a reservoir in Utah, a 29 year old woman was making a dive planned for 80 ft (23 m). The instructor allegedly lost sight of the victim and her buddy in the silt disturbed from the bottom. He found the buddy in distress and assisted him to the surface, then had to make two more dives before finding the victim on the bottom. Extensive efforts at resuscitation were unsuccessful and the death was attributed to drowning. She had 1,500 psi remaining her tank.

The third fatality during advanced training was that of a 54 year old man who developed distress during the ascent from his second dive off the coast of Puerto Rico. The autopsy report indicated he was intoxicated.

During 1990, six fatalities were recorded while the victims were undergoing entry level training. Two occurred in Florida and involved a 50 year old man and 62 year old woman, both of whom died from myocardial infarction.

A 39 year old man drowned off Jamestown, Rhode Island. This 280 pound (127 kg) victim was wearing 37 pounds (17 kg) of weight attached with a jury-rigged suspender-type harness (under his buoyancy compensator) which could not be removed during the emergency.

A 32 year old, 275 pound (125 kg) man died during his first open water dive near Nubble Light, Maine. While on the bottom in 25 ft (7.5 m) of water and having completed an escorted bottom swim with his instructor, this victim signaled "out of air" to his student-buddy partner who assisted him with an alternative regulator part way to the surface. He then panicked and made a rapid ascent. On the surface, he stated that he could not breathe and continued in a panic state until he lost consciousness and was towed to shore. Despite extensive resuscitation efforts he drowned.

A deep pond behind a dive shop in Ohio was the location of the drowning of a 35 year old man. This victim indicated that he had only 500 psi of air just before making a descent to 35 ft (10.5 m). An immediate head count on the bottom discovered him missing. A recovery team located his body three hours later.

After surfacing from an uneventful fourth certification dive, a 65 year old female complained of being tired. The instructor towed her to shore during which time she lost consciousness. The autopsy listed her cause of death as drowning.

Saving lives

Due to the remoteness of dive locations, recreational divers often do not have immediate access to emergency medical services. Having to use secondary roads reduces response time. Air evacuation assistance is widely available but may involve long flights. Furthermore, only U.S. Coast Guard and military helicopters have crews capable of making open ocean sea to air rescue. The U.S. Coast Guard provided search or rescue assistance in 33 %

of the certified diver fatalities in 1990. There were only nine air medical evacuations.

Surviving an unexpected underwater event may depend on timely and effective CPR. The shorter the non-breathing time interval, the better the chance of survival.

Effective CPR in diving accidents is hindered because the underwater event goes unnoticed or there is buddy team separation, prolonging initial rescue. Once located, the victim must be removed from the water and placed on a hard surface capable of supporting a CPR effort. Finally, many of these individuals require a level of care found only in hospital emergency departments. The diver who has had a myocardial infarction, near drowning or suffered some other serious medical condition is not likely to survive with the limited medical skill and resources available at a dive site.

The delivery of oxygen is important in the treatment of near drowning and myocardial infarction. Oxygen should be given during CPR as soon as it becomes available, but it is still not widely available for emergency use by divers.

Drowning deaths

The majority of the drowning cases were associated with running out of air, due sometimes to entrapment in a cave, a wreck, under ice or being lost. Many divers ran out of air unexpectedly and were unable to rescue themselves. Some drowning victims had air available in their cylinders, but did not use it.

Several drowning incidents involved a mismatched buddy pair consisting of an experienced diver with a novice. A father dived with his daughter on her first open ocean dive. While he was spearfishing, she disappeared and her body was never found. A similar incident occurred with a buddy team of father, son and mother. The mother was inexperienced and became separated from the other two, ran out of air and drowned.

An experienced diver was diving with fiancee who had been certified for four months. They surfaced 200 ft or more from the boat and resubmerged to swim to the boat. They became separated, and she was discovered later on the bottom at 73 ft with an empty tank.

A 14 year old boy was untrained and diving with his stepfather. The child developed an unknown problem that was followed by panic, unconsciousness and drowning.

Embolism

In deaths stemming from cerebral embolism, rapid ascent was the cause in three cases. In one case, a panicked diver struggled against rescue assistance. Another panicked diver struggled against buddy breathing and rescue. One diver attempted to assist another diver who was out of air. The diver in trouble survived, and the rescuer died.

Alcohol and drugs

Alcohol or other drugs contributed to eight deaths. One individual was discovered at 110 ft with a fully inflated BC and empty air tank. He was wearing a 35 pound weight belt. Blood alcohol level was 0.19.

While a friend observed from shore, a 32 year old male made a 10-15 ft dive alone. He was using borrowed equipment. Although instructed only to use the equipment in his backyard pool, the victim went diving in a river. The witness on shore saw the diver in distress at the surface and then sink. It took twelve hours to locate him at which time he was found to have 1,500 psi in his tank. He was not using a BC, and his tank and backpack were found away from his body. His mask and fins were not located. His urine was positive for methamphetamines and cannabinoids.

A 35 year old uncertified male was collecting artifacts around a pier at a depth of about 10-20 ft with 5 ft visibility. He was diving with a friend, but there were not diving as buddies. He surfaced and yelled for help. A surface observer threw a float to him that he was unable to reach. he did not release his weight belt and submerged again. His body was located 14 days later. Upon inspection, his regulator free flowed and needed repair. He was intoxicated.

Four young men had been drinking and diving. After the diver, a 20 year old man, developed distress at the surface, his friends on the boat could not pull him in due to a strong four knot current. He also could not inflate his BC with a power inflator or CO_2 cartridge. There was air left in his tank. He had 14.5 pounds (6.6 kg) of lead weight and was not wearing a wetsuit. His body was found four days later. The autopsy indicated the diver was intoxicated.

One of the unqualified cave diver fatalities occurred in an individual with a history of depression who was on benozodiazepine and fluoxetine. The blood of a 34 year old drowned female was contained two prescribed addictive psychotropic drugs and two prescribed analgesic medications.

A 35 year old male had dived 20-30 times. He had been drinking and made a shore entry with a certified diver. He signalled to his buddy that he was returning to shore. When his buddy returned, he found a law officer performing CPR. The regulator was hard breathing, the diver was overweight, not wearing a wetsuit and wearing 18 pounds of lead weight. His blood was positive for alcohol, and urine was positive for cannabinoids.

Accident scenarios for non-certified divers

An uncertified 22 year old male made a shore entry dive with a certified dive buddy. The uncertified diver was missing ten minutes into the second dive. The dive profiles were 25 ft for 10 minutes with a 2 hour surface interval followed by a 25 ft dive. He was found on the bottom with 2,000 psi left in his tank.

An uncertified 62 year old male with two years of diving experience and about 40-50 dives was an active individual with a history of heart disease. He made a 60 ft dive for about 5 minutes with his son, came back to the surface and lost consciousness. His son reported that he had not made a rapid ascent. The autopsy reported hypertensive cardiovascular disease was present.

An uncertified 39 year old male was collecting artifacts off the Florida Keys when he came up to tell the people on the boat that he found something. They next noticed him floating face down at the surface. He had a medical history of chest trauma with a punctured lung.

Two certified adults were diving with a 14 year old male in 10-15 ft of water. The youth was using a horse collar BC but no power inflator. The regulator mechanism that holds the diaphragm down was bent, possibly allowing water to enter. His buddy saw the diver panicking with his regulator out of his mouth trying to get to the surface. The dive buddy's attempt to assist the diver was unsuccessful.

A 21 year old male was diving with a certified friend. His friend set up the equipment with the BC backwards. They were gathering golf balls from a course pond and were not using fins or a depth gauge. The visibility was poor, and they were not using the buddy system. A topside witness saw the diver, take off his mask and go back under. The witness also saw that the rope that secured the bag of golf balls was wrapped around the victim's neck. He had air left in his tank.

A 20 year old male, who had made about six dives, made a shore entry with two certified divers in a calm cove. They swam toward the opening of the cove and surfaced because of increasingly rough water. The waves knocked the victim into rocks causing him to lose his regulator. He drowned.

Generally, there is more than one catalyst to a fatal dive accident. For example, ten divers first became lost in caves, wrecks, or under the ice, then ran out of air and drowned. Running out of air contributed to the fatality, but the initial cause was getting lost. All phases of a dive require attention. Not being prepared to enter the water can lead to immediate and early dive problems. Late dive difficulties often evolve from low or out-of-air situations.

If a diver develops a primary problem at depth or on the surface, he may have to overcome negative buoyancy. Failure to release the weight belt contributed to three fatalities; one diver was at the surface. Failing to drop a weight belt complicated eight out-of-air ascents.

Three divers suffered injuries at the surface and drowned. Two were struck by boats in separate incidents, and one struck his head on rocks near shore in rough seas.

At least 16 victims with cardiovascular disease severe enough to have disqualified them as divers, knew about their disease. A problem may have started at depth, forcing the individual to the surface early. Cardiovascular disease can usually be diagnosed, so divers older than 40 should be carefully evaluated before participating in a strenuous activity such as diving.

Overhead environments

In 1990, eight people dies in caves, four under the ice, two penetrating a wreck and one while cavern diving. Three of these were double fatalities

Thirteen of the fifteen failed to follow standard procedures. Six of these failed to maintain a continuous guideline to the surface. Two used homemade reels and became entangled in them. Two became entangled in their guideline that became detached from its tie-off. Two exceeded the recreational 130 ft (39 m) depth limit, and one dived without a buddy. The two who adhered to safety rules succumbed to inexperience and error. Of the fifteen, seven had no specialty training.

Cave and cavern divers

A 38 year old certified cave diver had been exploring an underwater cave system with two, 4-person groups. On the second dive, group one became disoriented and had difficulty determining the direction out of the cave system. When the first group did not appear, group two began an immediate search. One diver was found alive in an air pocket. The victim was found later with empty air tanks at a depth of 40 ft (15 m), 170 feet (51 m) from the entrance.

A 46 year old certified cave diver died while diving alone in a Florida spring. When recovered, his 80 cubic ft buddy-bottle was empty, but his twin 100 cubic ft tanks had 1,200 psi of air. The primary regulator free flowed and the valve to the second was not completely turned on. He was recovered at 62 ft (19 m), 200 feet (60 m) into the cave. He may have had a faulty regulator.

Four cave fatalities involved victims who did not have cave certification. The first incident cost the lives of two males, aged 18 and 19, in Florida. One source quoted the boys as saying they intended to go just “a little way” into the cave that was located about 80 foot (24 m) down in a sinkhole. They were found more than 50 ft (15 m) into the cave, completely entangled in their makeshift guideline.

A 55 year old man certified as a rescue diver had no cave diving experience or certification. Despite warnings, he dive alone without using a guideline to the surface. His body was recovered 200 feet (60 m) into the cave at a depth of 70 ft (21 m).

An instructor accompanied four of her former open water certified students on a dive at Otter Springs, Florida. They had been admonished against entering the cave. After the instructor and one other diver left the water, three others remained behind. A certified cave recovery diver who happened to be at the scene lent assistance when the instructor realized the three were missing. Within minutes, he located two of the victims, unconscious at a depth of 50 ft (15 m), well into the cave. He pulled one of them to the surface where CPR was successfully applied. In the meantime, he returned to the second victim, who had recovered consciousness; he used his octopus regulator to bring this man to the surface. On his third trip, he retrieved the body of the third man who had been down at least 30 minutes and had run out of air.

A 53 year old man died in Florida while diving with a certified cavern diver and the latter’s 10 year old son. When exiting the silty cavern, the team leader did not see the victim, who was not on the guideline, and passed him.

Technical diving scenarios

A 25 year old man with five years diving experience had been certified as a cave diver only six months. He had logged about 75 cave dives. He was unfamiliar with this specific cave, but was diving with a group of expert cave divers. He went to 250 ft (75 m), 20 ft (6 m) deeper than his deepest previous dive. Using compressed air, he apparently succumbed to nitrogen narcosis and drowned.

A 29 year old certified cave diver with extensive experience was found unconscious at the entrance to a 200 ft (60 m) cave. He may have also suffered from nitrogen narcosis. He was not using a guideline to open water.

Wreck penetration scenarios

A 40 year old instructor had logged hundreds of wreck dives, at least 30 dives on this wreck. He apparently experienced a severe silt-out and ran out of air before he could find his way from deep within the ship. It took five days to recover the body.

While diving in Micronesia, a 67 year old man failed to follow his guide, left his dive buddies, penetrated a wreck, and became lost deep in the stern section. When found dead at 110 ft (33 m) he had wandered hundreds of feet into the stern.

Ice diving scenarios

Diving under ice resulted in two double fatalities in 1990. Two 43 year old experienced divers, one of whom was a certified instructor, died in a Pennsylvania quarry. Their bodies were located two weeks after the incident in 60 ft (18 m) of water. They carried 200 ft (60 m) of rope, but one end frayed and the other end cut. On the surface there was no evidence of a safety line nor was a tender present. Friends still consider it a mystery that the two would have violated the safety principles that they believed in so strongly.

Two brothers, aged 33 and 26 died under the ice in Okauchee Lake, Wisconsin. There was no safety line, and no surface tenders were present. Both victims were experienced divers with advanced certification. They were not trained for ice diving.

Summary

Many factors lead to a diver’s death. Some occur long before the diver enters the water. Pre-existing disease or inadequate training and experience are not difficult to recognize. Running out of air during a dive should be simple to prevent, yet it accounts for several deaths each year. Panic, rapid ascent and embolism continue to occur, usually involving inexperienced divers. A significant number of cardiovascular deaths occur each year.

Ultimate responsibility for safety rests with the diver who makes the decision to dive or not to dive. Each diver should have sufficient training to enable assessment of each diving situation before deciding whether to proceed.

P.S. For 1991, 68 recreational scuba fatalities have so far been reported. The record low for scuba fatalities was reported by NUADC in 1988 when there were 66 deaths. Thankfully, scuba fatalities are beginning to show a definite downward trend.

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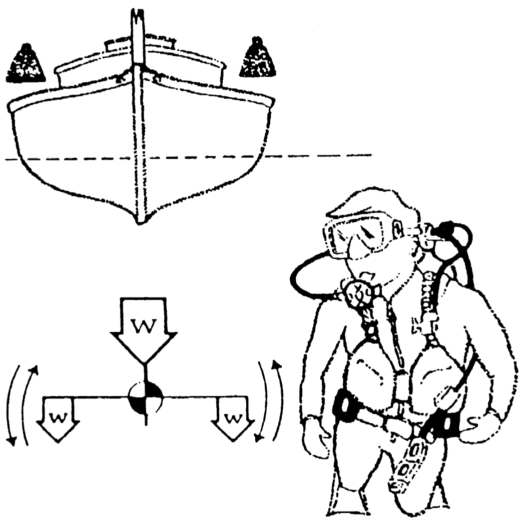
The address of UNDERCURRENT is P.O. Box 1658, Sausalito, California 94965, USA.

MOVE YOUR WEIGHTS FROM YOUR RAIL TO YOUR KEEL

Fred Good

Thanks to the weight carried in their keels, sailboats are difficult to tip over. Divers ought to pay attention.

With tanks up and bellies down, many divers always seem to be struggling to remain horizontal. Turn slightly, and side mounted weights and a shifting tank start you rotating. Relax too much, and you may gravitate to the classic turtle-on-his-back position.



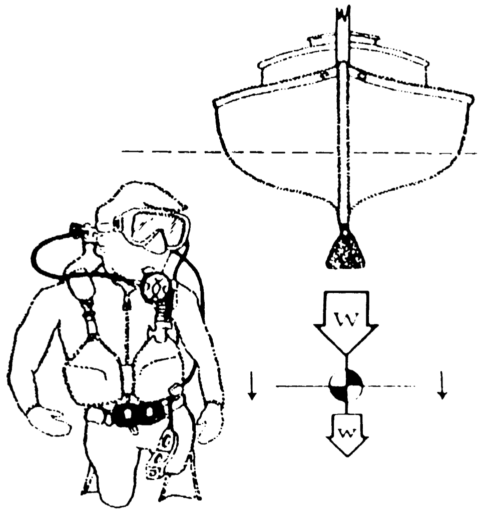
WEARING WEIGHTS THE CONVENTIONAL WAY

Why carry weight on your rails rather than your keel? Why waste air and energy maintaining stability? Rid yourself of your lead love handles and stash your weight on your keel, as if you were a sailboat. Suspend your weight at your navel. It provides amazing stability.

I've made about 12,000 dives this way and introduced the technique to nearly all my guests during the past 15 years. Most returning guests report that they far prefer this simple system.

To rig the belt, place all your weight close together, about three inches from the buckle. When you put on the belt, centre the weight over your navel and place the buckle to the right side so you don't confuse it with your BC buckle. This will facilitate a right hand release. When you release a weight belt rigged this way, it drops freely without the weights getting caught in the BC or tank.

Carry two weight-keepers in your travel kit, so you can put them on your rented belt. Or insert the belt through the first slit in the weight, make a half turn, then run the belt back through. That twist will secure the weight on the belt so it won't slide. If you have a particularly small or large waist, carry your own personal weight belt with you.



THE PREFERRED WAY

After you've descended several feet, it doesn't hurt to tighten your belt so it won't sag like saddle bags or spin around you. Women with prominent pelvic bones will no longer be bruised with the lead, since the weights need not even touch the body while swimming.

Once you become proficient in this simple technique, you'll appreciate the greater stability and ease of diving. The only drawback: putting on the weight belt is slightly more cumbersome, a negligible price to pay for a more comfortable and safe dive.

Reprinted, by kind permission of the Editor, from UNDERCURRENT, 1993; 18(2): 12.

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

NEW IANTD TRAINING PROGRAMS

The International Association of Nitrox and Technical Divers (IANTD) has recently released 3 Deep Air Diver certification programs, Deep Air Diver, Advanced Deep Air Diver and Technical Deep Air Diver. These new programs complement the existing Nitrox Diver, Technical Nitrox Diver, EANx Overhead Environment Diver, EANx Wreck Diver and EANx Cave Diver certification programs.

A brief summary of the full range of IANTD nitrox and technical diving programs available in Australia is as follows:

Deep Air Diver

Staged decompression air dives to 40 m using standard air decompression tables and introducing EANx and/or oxygen as additional decompression safety factors. Redundant independent air supplies are mandatory. Deep Air Diver certification on its own does not allow the diver to obtain EANx from an IANTD Mixed Gas Station.

Nitrox Diver

Non decompression dives to 40 m using EANx32 and EANx36 only. Advanced Open Water Diver certification or equivalent experience is a pre-requisite for this program which is a pre-requisite for all IANTD certification programs except Deep Air Diver.

Advanced Deep Air Diver

Staged decompression air dives to 48 m using custom decompression tables with EANx and/or oxygen decompression. Redundant independent air supplies and equipment are mandatory. Nitrox Diver certification is a pre-requisite.

Technical Deep Air Diver

Staged decompression air dives to 57 m using custom decompression tables with EANx and/or oxygen decompression. Redundant independent air supplies and equipment are mandatory. Nitrox Technical Diver certification is a pre-requisite for Trimix Diver.

Technical Nitrox Diver

Staged decompression EANx dives to 51 m using custom EANx as bottom gas and custom decompression tables with EANx and/or oxygen decompression. Redundant independent EANx supplies and equipment are mandatory.

EANx Overhead Environment Diver

Staged decompression cavern/wreck diving to 40 m within the limits of light penetration using EANx. The use of EANx and/or oxygen decompression is permitted as additional decompression safety factors. Redundant independent EANx supplies and equipment are mandatory.

EANx Wreck Diver

Staged decompression EANx wreck full penetration diving using custom decompression tables with EANx and/or oxygen decompression. Redundant independent EANx supplies and equipment are mandatory.

EANx Cave Diver

Staged decompression EANx cave full penetration diving using custom decompression tables with EANx and/or oxygen decompression. Redundant independent EANx supplies and equipment are mandatory.

IANTD's philosophy is to develop recreational and technical (advanced recreational) diving training programs as technology develops and as a training requirement is needed. Additional diver training programs are presently under development and several of these are expected to be released later this year/early next year.

As from 30 June 1993, all IANTD Instructors will be fully covered by a worldwide professional indemnity insurance while teaching all the IANTD programs listed above within IANTD Standards and Procedures. This IANTD insurance is unique in that it covers recreational and advanced recreational diver training programs not normally sanctioned by the mainstream recreational training agencies.

IANTD has an international board of advisers including scientists, medical practitioners qualified in hyperbaric and underwater medicine and commercial diving operators with extensive experience.

Interest in the IANTD training programs is rapidly growing and IANTD now has representation in 10 countries around the world, U.S.A., Canada, Mexico, Venezuela, Germany, Austria, Israel, Russia, Australia, United Kingdom and throughout the Caribbean region. Representation in several other countries is currently under negotiation.

Reprinted by kind permission of the Editor, from TECH NEWS 1993; May-June: 2

The reader's attention is drawn to the disclaimer printed on the front cover of this issue.

On March 20th 1994, after about 18 minutes underwater on a wreck of the Cooloool off Sydney, a diver convulsed and drowned . He had dived this wreck safely a number of times before. This dive was during a break in an ANDI, the other nitrox teaching organisation, course undertaken with the intention of becoming an instructor. He was using a twin clinder rig filled with air and nitrox. As many of the wrecks off Sydney are deep it seems likely that he was using nitrox beyond its safe limit.

Abstracted from Guidelines, the Newsletter of the Cave Divers Association of Australia. 1994; (52 July): 6-7

U.S.NAVY DIVING STATISTICS FOR 1992

Many people, and most insurance companies, believe diving is inherently dangerous. To some extent they are correct and this position is reflected in higher than normal life insurance premiums for divers. However, when you subtract the civilian population from our ranks, the statistics change as you can see below. If you ask any Navy diver, "With which diving rig are you most likely to incur a diving mishap?", the answer would most likely be scuba. But, look at Table 1 comparing the number of mishaps to the diving apparatus used. Look also at the rate of mishaps per diving apparatus. Suddenly, scuba does not look as bad as MK 15 and free ascents.

TABLE 1
USN 1992 MISHAPS BY DIVES AND EQUIPMENT USED

Apparatus	**Dives**	**Mishaps**	**per 1000**
Chamber	6,965	12	1.7
Mk 15	610	2	3.3
Mk 16	3,681	5	1.4
Experimental	252	0	0.0
Band Mask Mk 1	5,844	1	0.2
Jack Browne	5	0	0.0
Scuba open	71,020	23	0.3
Mk 12	3,032	3	1.0
AGA	9,812	3	0.3
Mk 12 HeO_2	570	0	0.0
Mk 1 HeO_2	28	0	0.0
LAR V	20,834	4	0.2
Superlite 17B	187	0	0.0
Superlite 17NS Mod 0	1,344	0	0.0
Superlite 17NS Mod 1	12,818	4	0.3
Free ascent	302	1	3.3
Totals	**137,304**	**58**	**0.4**

Although one would think that during a treatment, we would have fewer mishaps than during a normal diving evolution because everything is controlled: the atmosphere, the depths, the times: the fact is that the inside tender during a chamber run was the most likely candidate for a mishap in 1992 (Table 2).

What '93 will reveal? Don't be one of our highlighted statistics, dive safe! Give "research" back its notoriety.

Reprinted from the United States Navy publication DIVING SAFETY LINES 1993; 10 (3 June).

Diving Safety Lines is published by the Afloat Safety Directorate, Naval Safety Center, 375 A Street, Norfolk, Virginia 23511-4399, U.S.A.

TABLE 2
U.S.N. 1992 MISHAPS BY PURPOSE OF DIVES

Purpose	**Dives**	**Mishaps**	**per 1000**
EOD operations	18,660	9	0.5
Indoctrination	347	0	0.0
Inside tender			
Aviation DCI	80	0	0.0
Clinical hyperbaric treatment	318	0	0.0
Humanitarian	113	0	0.0
Recompression treatment	406	3	7.4
P&O_2 test	1,479	0	0.0
Inspection	4,831	1	0.2
Instructor or safety observer	6,001	1	0.2
Recovery	1,177	0	0.0
Requalification	4,230	5	1.2
Research	2,324	6	2.6
Salvage	1,285	2	1.6
Search	6,024	4	0.7
Security swim	820	0	0.0
Selection P&O_2 test	1,002	2	2.0
Ship husbandry and repair	24,450	9	0.4
Special warfare	27,849	5	0.2
Student	31,214	10	0.3
Underwater construction	4,694	1	0.2
TOTAL	137,304	58	0.4

EOD operations = Explosive ordinance disposal operations
P&O_2 test = Testing for oxygen toxicity at pressure.
Special warfare = SEAL, green beret, etc.

U.S.NAVY 1993 DIVING MISHAP SUMMARY

The following is a list of diving mishaps reported by active duty commands. Keep in mind that these numbers reflect those mishaps reported to us according OPNAVINST 5102.1C Mishap Investigation and Reporting (Shore) or OPNAVINST 5100.21B (Afloat).

TABLE 1
U.S.NAVY 1993 DIVING MISHAPS BY EQUIPMENT USED

	DCI				Other	
	Type 1	Type 2	AGE	POIS	Mech	Omitted deco
Scuba	1	4	10	1	1	0
Mk 21	1	8	4	0	0	1
Mk 20	1	1	4	0	0	0
Chamber	2	2	2	0	0	0
Free ascent	0	1	2	0	0	0
Experimental	0	0	1	0	0	0

The USN had one diving death in 1993 as a result of an underwater explosion while using a Broco torch.

In 1993 we had 48 diving mishaps, compared to 58 in 1992. Let's try to keep this a downward trend and make 1994 the safest year yet. DIVE SAFE!

Reprinted from the United States Navy publication DIVING SAFETY LINES 1993; 10 (4 December):

Diving Safety Lines is published by the Afloat Safety Directorate, Naval Safety Center, 375 A Street, Norfolk, Virginia 23511-4399, U.S.A.

THOSE WHO GO DOWN IN CAVES

Research with cave divers indicates that psychological tests provide a rough gauge of who will be successful and who will fail in high-risk activities, says Milledge Murphey, a professor in the University of Florida's College of Health and Human Performance. His research was reported by the UPI.

"In this very extreme high-risk group of cave divers, there seems to be cluster of certain types that do not do weel, and nother that do quite well", Murphey said. "The majority of successful cave divers are introverted. Scuba divers are mostly extroverts," he said.

His 10 year study of cave divers showed nine of 65 killed while diving fell into two personality types, one introverted and one extroverted, among the 16 personality types on the Myers-Brigss psychological test. The unsuccessful divers were "introverted-feeling-perspective" and "extroverted-intuitive-feeling-judging".

Successful divers mostly fell into another four categories and were mainly introverted. The cave divers took the test at the beginning of the study, which compared personality traits with activity performance.

There are about 3,500 trained cave divers in the world today, said Murphey, himself a cave diver and President of the National Cave Divers Association. Since 1963, 430 cave divers have been killed in Florida. "Cave diving is the only sport where death is an absolute result of performance failure," he said. "It must be done right or there's no tomorrow."

With its high-tech equipment and precise set of instructions, cave diving requires someone with a mind-set for details. Many of the people the sport attracts work in technical professions.

"The general population probably believes that most people wh cave dive are brash risk-takers who jeopardize their lives for a good time," he said. "But research on cave divers, aerobatic pilots, sky divers and other participants in high-risk sports shows that these are serious, professional people who enjoy technical precision.

"Cave diving, like other high-risk sports, has become increasingly popular since the 1970s, probably in partg because of people's desire for greater risk-taking in their lives," he said.

"Many people in advanced cultures crave more excitement in their mundane lives than going to work, coming home and watching television," he said. "They seem to want to look back toward the gladiator days when people truly lived on the edge."

One reason for cave diving's growing popularity is rapid advances in the technology of the equipment, allowing people with relatively little experience to make deeper and longer dives into caves, he said.

Cave divers, like other participants in high-risk sports, often seek sensations of vertigo, Murphey said. "It's a little like floating outside of a space capsule in outer space," he said. "The environment of an underwater cave is so hostile that there's no possibility of being able to surface if you have an equipment malfunction or technical problem."

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AN END TO COMPRESSED AIR DIVING?
A new generation of rebreathers

Ben Davidson

You know that critters underwater shy away from your bubbles. Think of the turtles or sharks your bubbles have spooked. Or the fish that have fled from your lens as you exhaled.

There may be a solution, at a price. Upcoming are rebreathers, a closed circuit breathing apparatus (compared to scuba's open circuit). Exhaled gas is recirculated through a "scrubber" that removes the carbon dioxide and returns the remaining exhaled oxygen to a bag for reuse. This year at Tec. 93, a meeting of technical divers held before the DEMA trade show, National Draeger, Inc. exhibited their SMS 2000. It created quite a stir, though the initial retail price may be as high as $US 5,000.

Rebreathers will be of particular interest to technical divers, i.e., deep, cave and wreck folks, who have invested almost that much in what they carry on their back now for less bottom time. Gung-ho photographers will be interested. Those who like to got to areas where there are no compressors, or where there is no room to carry a compressor, will find rebreathers an advantage.

Limitations

First developed in the early 1900's, oxygen rebreathers were perfected for World War II and were seen extensively in those WWII frogmen films. Worn on the chest somewhat like the horse collar BC, they consist of a breathing bag filled with oxygen, a scrubber unit and a small cylinder of oxygen. The scrubber absorbs carbon dioxide and recycles the available oxygen. As the oxygen is used, the bag collapses. Once it reaches a given internal pressure, a mechanical valve adds oxygen from the cylinder to fill the breathing bag. Since pure oxygen limits depth to 9 m (30 ft), and some physiologists now recommend 6.3 m (21 ft), these units are restricted to shallow water work.

Scientific, commercial and military divers need rebreathers for deeper work; so another gas must be mixed with the oxygen-compressed air (making the breathing gas a Nitrox mix) or helium (for heliox). Since these dilutants must be added in controlled amounts to limit the partial pressure of oxygen (and the associated oxygen toxicity problems), an electronic sensing device controls the gas breathing mixture.

One advantage of a rebreather over scuba is that a diver can stay down longer and carry less weight, thanks to recycling his breath. One estimate is that a rebreather offers the diving capacity of 10 aluminium 80s for less weight than one aluminium 80 tank. Richard Nordstrom, past president of Orca and now the CEO of CIS Lunar, a rebreather manufacturer, believes that, for certain divers, the reduction in needed equipment, particularly tanks and pre-mixed gasses, will soon outweigh the initial investment made in a rebreather.

The limiting factor with a rebreather is not the amount of oxygen or the dilutant gas but the scrubber. As the rebreathed gas returns to the unit, it goes through a scrubber consisting of a canister of an alkaline hydroxide or superoxide filtration. The alkaline absorbs the carbon dioxide and releases the oxygen. The biggest limitation with rebreathers, says Cliff Newell, NOAA Deputy Diving Director, "is knowing how long the scrubber will work. Everyone used to talk about problems of getting the scrubber material wet and inhaling a caustic cocktail, but all that did was burn like hell. It told you to get out of the water. But with a saturated scrubber you can get a carbon dioxide build up, black out and maybe not come up."

This scrubber unit is the key both to the dive length and to the diver's safety. Ken Greene, General Manager of Carleton Technologies, told us that they can sense oxygen levels, depth, tank pressure, battery levels and the like, "but we have not come up with an adequate CO_2 sensor."

Another problem, Greene told us, is that packing a scrubber unit is much like packing a parachute; it requires training and practice. "If not packed correctly, there can be channeling, that is where the recycled breath follows a channel rather than being dispersed throughout the scrubber unit. When that happens, the recycled breath is not scrubbed of the CO_2. CO_2 does not have a distinct odour or flavour. If the scrubber is not working, the diver won't know until it is too late."

Under Development

The US Navy used a mixed gas rebreather called the Mark 15, manufactured by Carleton Technologies, but it is not on the commercial market. Commercial divers in Europe have been using the National Draeger unit called CRS 600 that was developed for North Sea oil exploration. Dr. Bill Stone has developed the Cis-Lunar model for cave penetrations (see sidebar). Handmade, they sell for roughly $US 50,0000.

Obviously , that price won't swing for sport divers, but three companies are working on rebreathers that may come to the recreational diving market at a price of about $US 5,000. Carmellan Research Ltd. in England is doing design research for National Draeger's SMS 2000. Cis-Lunar is working on a fifth level prototype. And, Oceanic quietly announced, at this year's DEMA trade show, that they had acquired a license to use National Draeger's electronics in the design Oceanic is developing.

A recreational unit will most likely have the capabilities of handling nitrox mixes with a built-in dive computer. National Draeger thinks diver training will take about 50 hours, while Oceanic speculates they can get it down to 40 hours. With a rebreather, the diver must breathe all the time, no skip breathing or long pauses at the beginning or end of each breath as is common among scuba divers. If the diver does not breathe all the time, carbon dioxide will build up in his system and cause blackout.

"We do not know," says Russell Orlowsky of National Draeger, "if the average sport diver will use the equipment often enough to keep their skill level high. If we enter the sport diving market, we are looking at initial training and refresher courses. Diving with a rebreather is not as simple as diving with open circuit scuba."

Rebreather users must descend and ascend at a much slower rate than scuba divers to allow the breathing bag to gain or lose volume and for adjustment of the oxygen percentage in the breathing bag. This is a particular concern if the depth is beyond 36 m (130 ft).

This year National Draeger will be showing the SMS 2000 at several dive shows to gain some measure of consumer interest before they make a final decision. Cis-Lunar needs a cash infusion of around $US 4 million from investors before their unit can be mass produced.

The only thing Peter Radsliff, Marketing Manager of Oceanic, would say is, "Our design is still on the drawing boards and our standard line of equipment will get first priority."

Will they make the market?

Whether rebreathers ever gain hold in the sport diving community may depend upon the extent to which sport divers accept diving with Nitrox, a mixture that is essential for the rebreather. While forces in the diving community are fighting to keep sport diving exclusively compressed air diving, we speculate that Nitrox will gain gradual acceptance.

Yet a greater obstacle to the development of the rebreather for sport divers may be trends in the American legal system. National Draeger's Orloswky told us that "product liability is not a problem with the military and only a slight problem with commercial diving. But the sport diving market is an entirely different matter."

The final obstacle: the price tag. Compare that $US 5,000 introductory price for the rebreather system to the $US 1,200 to $US 1,500 one puts out for a comparable compressed air tank, regulator and computer.

What are you prepared to pay for increased bottom time and no bubbles?

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THERMAL SAFETY

Jay Jeffries

Though the relationship between water temperature and scuba diving accidents has not been rigorously established there is some evidence to suggest that accidents increase as water temperature falls. Some of the physiological and psychological consequences of cold water diving (less than about 24.5°C/75°F) that can affect performance and contribute to accidents are; hypothermia, reduced dexterity, inefficient breathing, reduced mental capacity, increased risk of the decompression illness and pain.

Shivering is an early sign of hypothermia, When it occurs the diver should consider exiting the water. Continued exposure can lead to deep hypothermia, unconsciousness and eventually death. Dexterity is often also a casualty of insufficient thermal protection. While it is usually on easy matter to don one's suit, how often is assistance needed to remove a pair of gloves or unzip a suit at the end of a dive? In particular, facial muscles are easily affected and can make it more difficult to hold the regulator in your mouth and even harder to orally inflate a BCD.

Exposure to cool environmental conditions can also lead to diminished mental function. Thought processes become slow and blurred and the diver's ability to focus becomes difficult and in the extreme near impossible. When temperatures drop to 5-10° (the low 40s) or below a diver may even experience physical pain the forehead, hands or feet. Under these conditions, cumulative damage to body parts can occur. What's more is that cold is a contributing factor to DCI. All of these factors act to impair a divers performance at a time when he or she needs it most and can consequently contribute to accidents. What's to be done?

Adequate thermal protection equipment is essential to diving safety in cold water. Even in relatively warm water above (above 26.5°C/80°F), inadequate insulation can lead to problems on long exposures. Make sure that your thermal protection is adequate for the dive you plan to conduct. Dry suits with an appropriate insulation package have become standard equipment for most technical diving. The diver's comfort and safety can be further enhanced in cold water by utilizing dry gloves, mitts, an attached or dry hood and the use of argon as a "suit inflation gas." Under very cold conditions the use of a full face mask can be invaluable.

Providing adequate thermal protection before and after the dive is also very important to safety.. Your body is like a dive light. Pre-dive chilling can run down your thermal batteries before the dive giving you shorter burn time. Similarly warming yourself between dives is essential and can act to offset any cumulative thermal deficit.

Jay Jeffries is Director of Special Projects and Engineering at Diving Unlimited International. He can be contacted at, DUI, 1148 Delevan Drive, San Diego, California 92102-2499.

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THE HIDDEN FACTOR IN DCS
Little discussed causes of dehydration

Andrea Zaferes

We can lose almost all our fat, half our body protein, and 40 percent of our body weight and still remain alive. But a 10 per cent water loss is serious and a 20 percent water loss could be fatal.

Dehydration facilitates fatigue, irritability, shock, muscle cramps, hyperthermia and hypothermia. It may increase the risk of decompression sickness and be an unrecognized cause in a number of “unexplainable” bends cases.

Thirst and dry mouth are obvious symptoms of dehydration. Reduced urine output and a darkening colour suggest dehydration is problematical. In a diver, it’s even more problematical, because being immersed in water is, itself, a dehydrating activity.

The dehydration journey

The journey begins the night before out trip, when we stay up late packing or partying. The next morning, we drink coffee, or tea and experience the stress of travel. Normally, our bodies hydrate with every breath we take, but airplane air is recirculated and dehydrated. We drink dehydrating coffee, soda and alcohol.

We sweat upon arrival at our tropical destination. The welcome rum punch is dehydrating, and if we consume more protein than usual, for example, bacon and eggs for breakfast instead of a Danish, the metabolism of protein results in the production of the waste product urea and additional excretion of water from our body.

We lug our gear onto the boat, sit in the sun, put on our wet suits too early and come close to heat exhaustion. Seasickness, seasickness pills, and even decongestants may be dehydrating.

In the water, our peripheral blood vessels constrict, shunting blood to the body’s core. The receptor in the heart interprets this as excess blood, increasing urine volume. Furthermore, immersion may increase dehydration by reducing voluntary intake of water due to decreased thirst.

Our regulator delivers cold, dehydrated air to our upper airway, where it is warmed and moistened before passing through the tracheae.

We often get dry mouth, that some instructors tell us, is a normal side effect of diving. “After all, you’re breathing dry air.”

Wrong. Dry mouth means we do not have enough fluid in the uppermost airway where the process of hydrating inspired air begins. Dry mouth will not occur if we are properly hydrated. The more dives we do, the more water we need to drink.

If we do multiple dives over consecutive days, nitrogen may build up in our slow tissues. Dehydration may decrease the efficiency of offgassing and increase the risk for decompression sickness by decreasing blood and other fluids. Although this is theoretical, it is widely accepted.

Still, we tend to drink far too little water. When dehydrated, non-human animals will drink enough water to replace the deficit.

But, many humans will endure “voluntary dehydration” if only water is available or it they do not like the taste of the water. And many people, even if hot and sweating, will not drink water if it is not cold enough.

What we need

The International Sports Medicine Institute recommends that on normal days, unless otherwise advised by your doctor, an adult should drink 1/2 ounce of water per pound (30 ml/kg) of body weight (approximately eight to ten, eight ounce (250 ml) glasses a day for a 150 lb (68 kg) person). An athletic person should drink 2/3 ounce per pound (45 ml/kg) per day. Cool water, citrus flavours and cool juices all help facilitate and maintain the proper water balance.

These volumes may not be enough for divers doing multi-dives over multi-days. At the 1991 DAN Europe International Scientific plenary meeting, Dr. Hans Ornhagen suggested that divers should drink approximately two, eight-ounce glasses of water (500 ml) before a dive. And I would add, that for every glass of a dehydrating beverage, a like amount of plain water should be ingested.

Safe diving requires drinking enough water until you urine is clear and copious (just because you need to urinate when you dive does not mean you have copious urine).

And, remember that thirst and a dry mouth, symptoms of dehydration, may be precursors of the bends.

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

WHY US DIVERS GET BENT

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

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

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

Diver inexperience

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

Illness, exercise and fatigue

Eighty four divers were diving with illnesses such as gastro-intestinal problems, back problems, muscular skeletal problems, asthma, etc. These, however, may be unrelated to getting DCS and there is no specific correlation between any particular illness and the severity of the DCS.

However, any illness or injury that limits an individual's ability to perform physical activity, or inhibits gas exchange, may contribute to DCS.

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

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

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

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

Dive profile

A record number of DCS cases involved repetitive diving to depths 24 m (80 ft) or greater, or multilevel profiles.

The deeper depth, longer duration and multi-level diving may reflect the growing use of dive computers.

Of the DCS cases, 77% dived to 24 m (80 ft) or more. Rapid ascent contributed in only 22% of the DCS cases.

Equipment

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

Symptoms

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

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

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

The cure

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

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

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

Readers will note that the term DCS is used in this paper in place of DCI. United States publications, including UNDERSEA AND HYPERBARIC MEDICINE, published by UHMS, have not embraced the new terminology and continue to differentiate between DCS and CAGE, rather than lumping them under the banner of decompression illness.

GLEANINGS FROM MEDICAL JOURNALS

The following articles have come to the notice of the editorial staff and these notes are printed to bring them to the attention of members of SPUMS. They are listed under various headings of interest to divers.

Any reader who comes across an interesting article is requested to forward the reference to the Journal for inclusion in this column.

CARBON MONOXIDE POISONING

Carbon monoxide poisoning: from old dogma to new uncertainties.
Runciman WW and Gorman DF. *Med J Aust* 1993; 158 (7):439-440

A leading article discussing what is and what is not known about carbon monoxide poisoning. The authors recommend early and repeated hyperbaric treatment for all patients with a convincing history of exposure to or intoxication by carbon monoxide.

JELLYFISH STINGS

First aid treatment of jellyfish stings in Australia. Response to a newly differentiated species.
Fenner PJ, Williamson JA, Burnett JW and Rifkin J. *Med J Aust* 1993; 158: 498-501

Abstract
Vinegar has been shown to inhibit nematocyst discharge in *Chironex fleckeri* the deadly north Australian box-jellyfish and application of vinegar has become accepted first aid, not only for box-jellyfish stings but also for stings by other Australian jellyfish. However, in a newly differentiated species of *Physalia* in Australian waters, which causes sever envenomation, vinegar was found to cause discharge in up to 30% of nematocysts. In treating these stings, the use of vinegar is not recommended as it may increase envenomation. Stings from the single tentacled *Physalia utriculus* (the "bluebottle") are not severe, tentacles with unfired nematocysts rarely adhere to the victim's skin and vinegar dousing is not required. Vinegar treatment is therefore an unnecessary step in the first aid management of any *Physalia* sting but remains an essential firs aid treatment for cubozoan (box) jellyfish tested to date.

Correspondence to Dr Peter Fenner, Ambrose Medical Group, North Mackay, Queensland 4740, Australia.

OSTEONECROSIS

Posterior shoulder dislocation and humeral head necrosis in a recreational scuba diver with diabetes.
Gorman DF and Sandow MJ. *Undersea Biomed Res* 1992: 19 (6): 457-461

An insulin-dependent diabetic who was previously a recreational scuba diver suffered a posterior shoulder dislocation after a trivial injury and was subsequently found to have local necrosis of the humeral head. The only definite conclusion that can be reached is that this patient should not dive again.

HELICOPTER DITCHING

Integrated Survival
Tipton MJ. *J roy nav med Serv* 1993; 79:11-14

Abstract

In this paper the concept of an 'Integrated Survival System' (ISS) is introduced and discussed in relation to the helicopter passenger/crew member, although the principles are equally applicable to many other types of user and circumstance requiring specialised protective clothing.

The fundamental principles behind this concept are first, that the wearer should be given protection against all of the hazardous responses associated with immersion in cold water and secondly, that the individual components which make up the ISS must be compatible and complementary; they may also be interdependent.

WORKPLACE SAFETY

Consumer Perceptions of Workplace Health and Safety Legislation.
Wilks J and Beecham V. *J Occup Health Safety - Aust NZ* 1993: 9 (3): 229-236

Abstract

Queensland workplace health and safety regulations related to underwater diving have received negative publicity in the media and substantial criticism from the recreational diving industry. In response, the Division of Workplace Health and Safety has undertaken a review of the regulations and proposed that they be replaced with a Code of Practice. To clarify which issues are of most concern to the diving industry, 202 registered Queensland scuba instructors were questioned about the regulations. The findings highlight a number of problems with the processes of development and implementation, especially a perception that there was inadequate consultation with those most likely to be affected by the new legislation. The study also found that traditional channels of consultation available to government through union and industry associations appear to have been ineffective in this case. Suggestions for a more co-operative approach to workplace safety are discussed.

MEDICAL WRITING

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

A review of practice leaflets and how understandable they were. The authors found that many were difficult to understand because they used long words and long sentences. They advised that authors should use a simple index of readability (fog test) to test for clarity. This is printed below.

THE FOG TEST

1 Chooses a passage of about 100 words, which must end in a full stop.
2 Find the average sentence length by dividing 100 by the number of sentences.
3 Find the number of long words, defined as those of three syllables or more, excluding
   (a) proper nouns;
   (b) combinations of easy words, like photocopy;
   (c) verbs that become three syllables when "-es", "ing", and"e-ed" are added;
   (e) jargon that the reader will know.
4 Add the average sentence length to the number of long words.
5 Multiply by 0.4 to get the "reading score".

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

HBO AND VASCULAR SURGERY

The role of hyperbaric oxygen in vascular surgery.
Bakker DJ, vd Kleij AJ and Kromhout J. *Undersea Biomed Res* 1992; 19 (Supp): 59

The rationale for applying hyperbaric oxygen therapy in vascular surgery is that this treatment modality improves ischaemia, infection, edema formation and wound healing. The most important indications for hyperbaric oxygen in vascular surgery are those where the need oxygen is only temporarily, that is, in reversible diseases. Hyperbaric oxygen often enables us to gain time in which a collateral circulation can develop or a reconstructive procedure performed. Hyperbaric oxygen can never be considered as a permanent solution. A problem is that we lack objective and reliable indicators for the necessity of hyperbaric oxygen in vascular diseases. Transcutaneous O_2 measurements are helpful in this respect.

From the wide variety of disorders we will discuss the use the results of hyperbaric oxygen in:

1 Revascularisation procedures in chronic occlusive vascular disease of the extremities, incl. our critical limb ischaemia protocol,
2 Carotid artery surgery in high risk patients,
3 Arterialisation of the venous system of the foot,

4 Acute and chronic vasospastic diseases and intoxications,
5 Chronic treatment in patients where arterial reconstruction is impossible, 6. Plain relief in chronic ischemic neuritis.

Pre- and postoperative treatment can be carried out in a monoplace chamber A multiple chamber is necessary to perform operations under hyperbaric conditions.

Selective use of hyperbaric oxygen during vascular reconstructive procedures improves the end results but objective parameters of time of application and oxygen dosages have to be developed to give hyperbaric oxygen therapy a permanent role in vascular surgery.

From the Department of Surgery, Vascular Surgery and Hyperbaric Medicine, Academic Medical Center, Meibergdreef 9, Amsterdam, The Netherlands.

HBO AFTER CARDIAC SURGERY

Management of hyperbaric oxygen (HBO) for anoxic encephalopathy after open heart surgery done under extracorporeal circulation. (A report of four cases).
Juan M. *Undersea Biomed Res* 1992; 19 (Supp): 100

Since 1986, we have used HBO to treat 4 patients who suffered from anoxic encephalopathy after open heart surgery extracorporeal circulation. They got the best result. Their consciousness, intelligence and limb function was restored quickly.

The 4 cases had different congenital heart diseases. Their ages ranged from 3 to 16 years old. After the operation they had severe disfunction of consciousness. Their coma time lasted for 30, 35, 9 and 12 days respectively. During the operation their circulation stopped for 12, 18, 15 and 20 minutes respectively. All 4 cases had low blood pressure and hypoxia. Two of them were cerebral ischemia diseases (shown by brain CT).

The 4 patients came to on the 6th, 2nd, 10th and 4th times of HBO respectively. They walked without any help on the 50th, 10th, 20th, 25th and 20th time of HBO. Three had perfect intelligence restored on the 30th, 25th and 20th time of HBO and then stopped treatment for some reason.

We think that HBO can treat this disease and lessen complications and mortality greatly.

From the Navy General Hospital, Beijing, China.

DIVING SAFETY
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2nd-8th October 1994
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For further details contact

Dr Chris Dueker MD, Diving Safety Digest
P.O.Box 2735, Menlo Park, California 94025, U.S.A.
Fax (1)-415-322-2476

6th ASEAN ORL (ENT) CONGRESS

14th-18th November 1994
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For further information contact

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