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SPUMS JOURNAL

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South Pacific Underwater Medicine Society Incorporated

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COURSES ARE DETAILED ON THE BACK COVER

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OBJECTS OF THE SOCIETY

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

OFFICE HOLDERS

MEMBERSHIP

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

The subscription for Full Members is $A80.00 and for Associate Members is $A40.00.

The Society's financial year is now January to December, the same as the Journal year.

Anyone interested in joining SPUMS should write to

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Australian and New Zealand College of Anaesthetists,
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The SPUMS Journal welcomes contributions (including letters to the Editor) on all aspects of diving and of hyperbaric medicine. Manuscripts must be offered exclusively to the SPUMS Journal, unless clearly authenticated copyright exemption accompanies the manuscript.

Minimum Requirements for Manuscripts

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

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

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

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

References

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

1 Anderson T. RAN medical officers' training in underwater medicine. *SPUMS J* 1985; 15 (2): 19-22
2 Lippmann J and Bugg S. *The diving emergency handbook*. Melbourne: J.L.Publications, 1985: 17-23

Computer compatibility

The SPUMS Journal is composed on a Macintosh using Microsoft Word and PageMaker. Contributions on 3.5" discs, preferably in Microsoft Word for Macintosh (MSDOS or Windows can also be read) or in any program which can be read as "text" by Microsoft Word, save typing time. They must be accompanied by hard copy set out as in **Minimum Requirements for Manuscripts** above.

Consent

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

Editing

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

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The Journal does not provide reprints.

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Dr John Knight, Editor, SPUMS Journal, Suite 304, 126 Wellington Parade, East Melbourne, Victoria 3002, Australia. Facsimile 61-(0)3-417 5155.

Telephone enquiries should be made to Dr John Knight (03) 417 3200, or Dr John Williamson (08) 2245116.

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and
"THE MANAGEMENT OF MEDICAL EMERGENCIES IN DIVING"
4th - 11th December, 1993

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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

In this Journal we publish the 1990 report on Australian diving-related deaths. As usual there were deaths that could not have been prevented, such as death from myocarditis during the night after a dive, or acute cardiac failure at the end of a dive, but most of them were attributable to human error of one sort or another, usually mishandling equipment or not having enough respect for the sea conditions including its temperature.

John Williamson's paper on *Shrinking research dollars* shows that more effort needs to be put into money raising by the general diving community so that Australians can continue to have a diver emergency service (DES/DAN). It is unfortunate that no insurer is, so far, willing to offer suitable insurance for divers as this has allowed DAN in the United States access to some funding.

Jeff Wilks has written about scuba safety in Queensland. Assuming that the figures from the four training agencies, who kindly co-operated with the study, are accurate the incidence of accidents is very low indeed. However there are many divers who dive without the help of the training agencies and their accidents would not be counted. A companion paper about the marketing of second-hand scuba equipment is enlightening. Second-hand equipment may or may not be in good condition and the purchaser may not realise the need to have it checked before use. Even recently serviced equipment has been know to be faulty.

The saga of the AMA and diving medicals is continued. While on the subject of diving medicals there is the matter of price. We had hoped to have space for a paper about the prices of diving medicals, but that will have to wait. The fee for a medical examination and report, typically taking 30 minutes, been used by many SPUMS members as the fee for a diving medical in the past. The 1993 fee agreed to by the Life Insurance Federation of Australia for this service is $77.

Dr M Kluger reports, in a letter to the Editor, a very sick intensive care patient who suffered sever hypotension while attempting to clear her ears. Our book reviews cover an old favourite, now in its 4th edition and a newcomer.

One of David Elliott's papers from the 1993 Annual Scientific Meeting appears. His conclusions are that neurological deficits after diving are theoretically possible in those who have not been treated for decompression illness (DCI), but that there is not enough evidence to say that they do happen. Des Gorman and Maurice Harden present a review of the various series of DCI patients treated in Australasia. The outstanding feature is that in most of the series the patients were either not followed up, or if they were the results were not reported. This makes it very difficult to discover the natural history of the post-treatment course. There should be a minimum follow up of one week, one month and one year in any Hyperbaric Unit which wants to be considered efficient and ethical. Only by such follow up can recompression treatment go from being based on anecdote to being scientific.

Progress in the Royal New Zealand Navy's diving medicine ventures is reported. There seems to be no difference in the effectiveness of oxygen or helium-oxygen recompression treatment. This is different from the Israeli Navy's experience, but they have only used oxy-helium for those with severe spinal cord damage and had good results. Perhaps it will eventually be possible to choose the treatment best suited to the signs and symptoms. This again will need follow up.

From other journals we print John Lippmann's observations about diver rescue. If he appears to perch on the fence, this is to be expected as there is no ONE right way to rescue a diver. It is important for everyone, diver or not, to learn to do expired air resuscitation (EAR) and a case can be made out for teaching everyone how to do CPR. Whether their skills will remain useful without practice is doubtful, but it should be possible to remember that one tilts the head back to open the airway for EAR. As failure to tilt the head back far enough is the commonest cause of failure with EAR this should be emphasised when EAR is being taught. Divers also need in-water dummies and ones that regurgitate "stomach contents" to practise on.

Our last reprinted paper is taken from *aquaCorps*. It is a discussion of the various deaths and accidents in "technical divers" that Michael Menduno learnt about in 1992. He provides a very interesting discussion, and confirms the Editor's belief that deep diving is more dangerous than diving shallow, of the whys and wherefores of these accidents. Human stupidity figures largely among the causes.

A piece of news that has only recently reached the Journal is that Surgeon Commander Des Gorman, RNZN, our President, is now the Director of Medical Services of the Royal New Zealand Navy, and as a result has been pregnant for Captain for some time. The Director of Medical Services is the most senior (boss) doctor in the RNZN. Being pregnant for Captain is to have been selected for promotion but awaiting the actual event. On this occasion our President will have to wait for a Captain (non-medical) to retire from the RNZN before he can be "born".

Finally the Editor wishes to thank the membership for their kindness in presenting him with Life Membership at the 1994 Annual General Meeting.

ORIGINAL PAPERS

PROVISIONAL REPORT ON AUSTRALIAN DIVING-RELATED DEATHS IN 1990

Douglas Walker

Summary

During 1990 there were fourteen identified fatalities in divers. Four were breath-hold divers, eight were, or had been using scuba, and two used hookah (hose supply) equipment. Cold was a significant contributing factor in two of the scuba divers, cardiac disease in two, and an acute gastric haemorrhage in one. Significant coronary artery disease was found in two snorkelers. Neither was known to be other than healthy. It is uncertain whether coronary disease was co-incidental or was the reason (angina) for one man's fall, which resulted in a subdural haemorrhage while standing on a reef. Trauma was the reason another snorkeler drowned. Apparently he lost his footing and fell off a pontoon, hitting his head. None of the medical factors could have been identified at a routine pre-dive medical check. One man was lost in waist deep water while standing on a reef, a shark attack being the presumed reason.

Breath-hold divers

BH 90/1

While on a day trip visit to a Barrier Reef island this 61 year old tourist decided to hire a mask and snorkel and go for a swim off the beach. Others were also snorkelling in the area. She was reputedly a good swimmer, but this was the first time she had used a snorkel. There is no report of the water conditions but there is nothing to suggest the sea was not calm. There were no witness statements mentioning the recognition of her being in trouble, or describing the recovery of her body. She failed to respond to efforts to resuscitate her.

The autopsy showed marked atheroma of the left coronary artery but an apparently healthy myocardium. It is assumed that she suffered a sudden cardiac arrhythmia and drowned quietly, none of the other people apparently being aware of her need for help. It is possible this occurred as a primary malfunction but it may have been secondary to inhalation of water through the snorkel as she was totally inexperienced in its management.

FIRST USE OF SNORKEL. SOLO BUT NEAR OTHERS. GOOD SWIMMER. SILENT DEATH AT SURFACE. SEVERE ATHEROMA ONE CORONARY ARTERY. POSSIBLE CARDIAC DEATH.

BH 90/2

As a social outing during a conference those attending were taken to visit the Barrier Reef and were given an opportunity to swim from a moored pontoon. There was some wind and the water was moderately rough but some at least of the visitors accepted the opportunity to have a swim using the masks, fins and snorkels available. There was a person appointed to watch the swimming area but nobody particularly noted the victim until he has seen not to react when a wave passed over him. It was then realised that he was drifting slowly away from the pontoon under the influence of the wind and a boat was sent to check whether he was in trouble. He was floating face down, his mask and snorkel in correct position, when he was reached.

All attempts to resuscitate him were unsuccessful and at the autopsy the reason became obvious. There were abrasions and a bruise on his lower back and subdural haemorrhage was found covering the occipital lobes and this extended down into the posterior fossa. It is probable that he slipped while on the pontoon, hitting his back and head forcefully and drowned because he was too dazed to save himself. As nobody was looking in his direction at the time, and he made no cry for help, he had no chance of surviving. It is obviously not possible to watch all persons in a crowd simultaneously and this was thought to be a safe swimming area.

SOLO IN A GROUP. SLIPPED AND HIT HEAD. SUBDURAL HAEMORRHAGE.

BH 90/3

This fatality is believed to be due to a shark attack as no other cause can be suggested for the sudden disappearance of an alert and physically fit person from the top of a reef in close proximity to others who heard no call for help or indeed anything untoward. No trace of him or any portion of his equipment was ever found. At the time of his disappearance he was a short distance behind his buddy as they returned to the reef edge where their two companions were trying to free their outboard motor boat to return to their dive base boat. They were on contract to collect trochus shells but had found the area unrewarding. There were some deep channels into the reef and it is postulated that a shark had reached him through such a channel, taking him underwater before he could cry out.

UNEXPLAINED DISAPPEARANCE FROM A WATER COVERED REEF. PRESUMED ATTACK BY SHARK.

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 90/1	61	First use	Not applicable	Solo	Recreation	Not stated	Surface	Nil	Not applicable
BH 90/2	31	No training or experience	Not applicable	Solo	Recreation	Not stated	Surface	Nil	Not applicable
BH 90/3	37	Trained Experienced	Trained Experienced	Buddy Separation before incident	Work	1 (3)	Surface	None	Not applicable
BH 90/4	54	Training, experience not stated	Training, experience not stated	Buddy Separation during incident	Recreation	1 (3)	Surface	None	Not applicable
SC 90/1	25	Trained Experienced	Trained Experienced	Buddy Separation during incident	Recreation	33 (100)	<33 (100)	On	12.7 (28)
SC 90/2	34	Trained Experienced	Trained Experienced	Buddy Separation during incident	Shell fishing	11 (36)	Not stated	On	14 (31)
SC 90/3	48	Trained Experience not stated	Trained Experience not stated	Buddy Separation during incident	Recreation	17 (57)	Surface	Off	Not stated
SC 90/4	51	Trained Inexperienced	Trained Experienced	Buddy Separation during incident	Recreation	4 (12)	Surface	On	11.4 (25)
SC 90/5	66	Just trained Experienced	Trained Experienced	Group Present during incident	Recreation	11 (36)	Surface	On	Not stated
SC 90/6	13	Trained Some experience	Trained Some experience	Buddy Separation during incident	Recreation	3 (10)	3 m	On	Not stated
SC 90/7	45	Trained Inexperienced	Some training Inexperienced	Buddy Separation during incident	Recreation	7 (23)	Surface	On	Not stated
SC 90/8	27	Trained Experienced	Not applicable	Not applicable	Recreation	Not applicable	Surface	Not applicable	Not stated
H 90/1	54	Trained Experienced	Trained Experienced	Buddy Separation after incident	Recreation Scallops	7 (23)	Ascent	On	Not stated
H 90/2	39	Trained with scuba	Trained Inexperienced	Buddy Present during incident	Recreation	11 (36)	Surface	On	13 (29)

DIVING-RELATED FATALITIES 1990

Buoyancy vest	Contents gauge	Remaining air	Equipment Tested	Equipment Owner	Comments
Nil	Not applicable	Not applicable	Not applicable	Hired	Found floating. Dead or unconscious. One coronary atheroma ++.
Nil	Not applicable	Not applicable	Not applicable	Hired	Found floating. Dead or unconscious. Subdural haematoma. Fell, hit head ?
Nil	Not applicable	Not applicable	Not applicable	Own	Shark attack on reef ? Body never found.
Nil	Not applicable	Not applicable	Not applicable	Hired	Unconscious but paddling. Coronary artery disease. Subdural haematoma.
Partially inflated	Yes	Yes	Significant fault	Own	Poor air supply. Failed buddy breathing. CAGE
Not inflated	Yes	Low	Some adverse comments	Own	Cold. Separation. Solo. Drowned.
Not inflated No air	Yes	Nil	Failure no air	Hire	Separation. Solo. Previous angioplasty. GI tract bleed.
Not inflated	Yes	Yes	Some adverse comments	Own	Cold. Unfit. 1st use of thick wetsuit. Inderal for tremor. Drowned.
Not inflated	Yes	Not stated	Not tested	Dive shop	Cardiac death as exiting. Overseas cardiac check.
Not inflated	Yes	Not applicable	Some adverse comments	Hire	Water power at reef. Gauge caught in cleft.
Partially inflated	Yes	Yes	OK	Own	Had panic attacks on previous dives. Surface panic then blackout. Inhaled water or arrythmia. Sudden death.
Not applicable	Not applicable	Not applicable	Not applicable	Own	Rapid cardiac death asleep on dive boat.
Not applicable	Not applicable	Not applicable	OK	Own	Cold, poor visibility, made normal ascent. Surface collapse. CAGE. Recent myocardial infarction.
Inflated	Not applicable	Not applicable	Some adverse comments	Borrowed	First use of hookah. On surface after panic. Fatigued. Inflated vest did not keep head out of water. Aspiration.

BH 90/4

It is not always immediately obvious to others that some person is in trouble, and such is true in this case. The victim was standing close to another person on the edge of the reef to which the Barrier Reef boat trip had brought them. He was seen to fall back into the water but his companion was not alarmed because he saw he was on his back and making paddling actions with his hands. A short time later he noticed that the victim was staring at him in an expressionless manner before he rolled over, face down. When he saw this the companion called out for help. Attempts were made to resuscitate him, made difficult by the vomit and mucus which was coming from his mouth, but these were unavailing. He was still making hand movements when reach but whether there was any possibility of his recovering at this time is problematical.

At the autopsy he was found to have marked atherosclerosis of the coronary arteries (although there was no known history of him suffering ill health) and a subdural haemorrhage resulting from a ruptured right transverse sinus. Whether he fell because of a heart attack pain and hit his head on the reef, or slipped without any such reason cannot be known.

STANDING CLOSE TO COMPANION THEN FELL INTO THE WATER. INITIALLY FLOATED ON HIS BACK MAKING HAND MOVEMENTS. EXPRESSIONLESS STARE. MARKED CORONARY ATHEROMA. SUBDURAL HAEMORRHAGE. RUPTURED LEFT TRANSVERSE SINUS.

Scuba Divers

SC 90/1

This dive got off to a poor start as they were late arriving at the pier. However they had been booked for the dive on a scuttled vessel lying in 39 m of water and the others waited for them. They had adequate time to fully recover from their rush during the trip out to the dive location, and further time when the skipper was unable to locate the wreck as one of the shore “marks” was not visible and proceeded to a nearby dive boat to ask the name of the wreck to which it had a shot line. As this wreck was at a lesser depth, 33m, the four divers agreed to the skipper’s suggestion they dive here. Permission was obtained for them to descend the other boat’s shot line and then their skipper would place his line on the wreck after the other boat had retrieved its divers and left the site. This involved some element of rush as the other divers were soon due to surface.

The particulars of this wreck were given but the buddy took little notice as he was accustomed to accepting whatever his friend did, in spite of the habit the latter had of very fast swimming which left the buddy struggling to catch up. There was another pair of divers on the boat but their dive on this wreck was uneventful and neither pair of divers saw the others at any time after entering the water. The victim descended rapidly, followed by his buddy, leaving the shot line before coming within sight of the wreck. Indeed they found themselves on a barren open sandy sea bed and were unable to locate the wreck. After reaching the sea bed and adjusting their buoyancy, by putting a little air into their buoyancy vests, the victim started swimming quickly a little above the sea floor, followed by the buddy. The latter was soon somewhat short of breath and anxiously hopeful his friend would stop and wait for him, so was pleased but surprised when he turned, returned and indicated he wished to start buddy breathing. The buddy stated afterwards that he thought the intention was to practice buddy breathing, something they sometimes did, or that his friend had noticed his breathlessness and was trying to help him, opinions indicative of his confusion concerning the events.

Although the victim had an “octopus” rig and the buddy a single regulator, it was the buddy who was the donor. After a few successful exchanges the buddy was made more breathless when he inhaled some water from the regulator and had it snatched from his grasp and started to cough. It was returned to him upside down and again he obtained a mouthful of water, which unsettled him so much that he gave a signal to indicate he was going to ascend. He then further inflated his buoyancy vest and started finning to start his ascent. The pair became separated at this time and despite his cough and being unable to replace his regulator in his mouth the buddy reached the surface safely. The victim, a more experienced diver, failed to surface. Two experienced divers were sent down and made a grid search, locating the body some distance from the wreck as they were about to abort their search as low on air. There was insufficient air flow to inflate the victim’s buoyancy vest, so one of these divers disconnected the low pressure hose from the vest and attached the hose from his tank and inflated the vest, making it easier to raise the body.

Examination of the equipment revealed the reason why the victim apparently became short of air so early in this dive. The tank valve had been incompletely opened and the line pressure was set too low between the first and second stages. He had taken an advanced diver (equipment specialist) course and learned about regulators but he had been told this did not enable him to perform regulator maintenance, an action he may have attempted. The reduced line pressure combined with the depth was the reason for the slow inflation rate noticed with his buoyancy vest. It was reported that he had sufficient air remaining to have made a successful ascent had he chosen to do so. For the same reasons his regulator was unable to provide him with sufficient volume to match the demand generated by his rapid rate of swimming, and the buddy’s regulator was insufficiently efficient for his requirements. There were the additional adverse factors of being without reference points (as the sea bed was featureless) and nitrogen narcosis. Neither had ever previously exceeded 20 m depth and neither had made any recent deep dives. That the buddy made a successful out-or-air ascent despite coughing and without a regulator is both noteworthy and fortunate. Had the victim recognised the imperative need to abort the dive immediately he realised his air supply was inadequate, rather than attempting to buddy breath, the problem would have resolved during his ascent and he would have been unaware of having been at risk.

The autopsy showed the presence of air in all four chambers of his heart (the amount was not recorded) but the pathologist hedged his diagnosis of pulmonary barotrauma by suggesting the air could have represented outgassing after death. He also suggested that a lack of air rather than drowning had occurred, a quaint conceit which is not unknown in pathologists ignorant of the fact that scuba divers use mouth held regulators, not full face masks.

EXPERIENCED BUT NO DEEP DIVES RECENTLY. DEEPEST PREVIOUS DIVE 20 m. THIS DIVE 33 m. IMPETUOUS DIVE HABITS. DESCENDED AWAY FROM SHOT LINE. FEATURELESS SEA BED. AIR HUNGER SO STARTED BUDDY BREATHING. THIS FAILED AFTER BUDDY INHALED WATER. SUCCESSFUL FREE ASCENT BY BUDDY. SLOW FILLING RATE OF BUOYANCY VEST AT DEPTH. WEIGHT BELT NOT DITCHED. VEST MINIMALLY INFLATED. AIR TANK VALVE NOT FULLY OPENED. INADEQUATE LINE PRESSURE FOR REGULATOR. REGULATOR DETUNED. HAD AIR REMAINING. AIR IN ALL CHAMBERS OF HEART. AIR EMBOLISM.

SC 90/2

This was the first day of the scallop season and nobody was going to miss out just because it was bitterly cold and there was minimal underwater visibility. The victim was a trained and very experienced diver who kept fit through sporting activities and had been diving regularly for crayfish. He was certainly one of the best prepared for these conditions. He and his buddy were taking it in turns to dive from their outboard motor boat, though they were sometimes both in the water at the same time. After a time the buddy decided he had dived enough but the victim, who had not joined him in the boat, stated he was going to make another dive. Their dives had each been of short duration and by now the victim had made some 5 or 6 with a probable total duration of 30 minutes.

The buddy attempted to follow his friend in the boat by tracking the bubbles but soon lost this contact. After about 30 minutes he became alarmed by the failure of his friend to surface and called out to the occupants of a nearby boat. It was then that the victim was noticed floating face up, with his weight belt still on and buoyancy vest uninflated. The buddy was first to reach the victim and immediately ditched his weight belt and then, with the assistance of others, his back pack. Together they managed to get the body into a boat and commenced CPR, although the victim appeared to be dead. This was a correct response on their part, the more so because of the hypothermia factor. There was no response.

Examination of the (recovered) equipment established that it was functioning correctly and still contained sufficient air for a diver to make an unhurried ascent. Nobody saw him surface or heard any call for assistance. The pathologist found no more than those changes he expected from drowning but commented afterwards that he had not been aware of the full implications of pulmonary barotrauma when performing the autopsy. One possible reason for this fatality is that his lips became too cold to feel the regulator in his mouth and were therefore unable to retain it. This must remain supposition.

VERY EXPERIENCED. SOLO. FIRST DAY OF SCALLOP SEASON. COLD. POOR VISIBILITY. HIGH LEVEL OF FITNESS. SURFACE WATCH INEFFECTIVE. BUOYANCY VEST NOT INFLATED. WEIGHT BELT ON. HYPOTHERMIA PROBABLE FACTOR.

SC 90/3

Despite a history of angina treated by angioplasty about a year before, and a near fatal post-operative course, this man was an apparently fit person and certainly his wife was unaware of his having any present health problems. He was a certificated diver, though his experience is not recorded, and had joined a group which planned to dive on the Barrier Reef, while his wife intended to do the Resort Course dive available to non-diving passengers on the same boat. This was a diving experience run by the diving instructor after the trained divers concluded their diving activities.

The water conditions were perfect, a calm sea and good visibility. The instructor arranged buddy pairs and briefed them on the locality before they entered the water. The first dive was uneventful so they retained the same buddy pairs for the second one. This also was without problems, although the buddy noticed that on this occasion his companion showed less interest in the fish and corals and seemed to be over interested in keeping his BC inflator in his hand. However after they surfaced he spoke in a normal manner to the buddy, commenting that it was lucky that the buddy had noticed his contents gauge was indicating a low air state as it was only then he noticed that his own was reading near empty. Their ascent was unhurried and both changed over to snorkel use for the return swim to the boat. Separation occurred and the buddy reached the boat first. He looked back and saw that his companion was floating as if examining the fish beneath, making no swimming movements. This did not alarm him, but the instructor thought something looked wrong and swam from the boat to check whether there was any problem.

The victim was about 150 m from the dive boat. When the instructor reached him and tried to ditch his weight belt he found it had already been dropped. There was insufficient air remaining to inflate the buoyancy vest so he turned the victim face up and inflated the vest orally before starting to tow him back to the dive boat. The attempt to resuscitate him was unavailing (he was very probably beyond help) and made more difficult by vomit and froth coming into his mouth. The autopsy showed that he had suffered an acute haemorrhage into his stomach, cause not identified, and that his heart appeared to be healthy.

TRAINED. EXPERIENCE NOT STATED. HISTORY OF CARDIAC ANGIOPLASTY. LOW AIR, BUT NORMAL ASCENT. SURFACE RETURN. SNORKELING SEPARATION. SILENT DEATH. DITCHED WEIGHT BELT. INSUFFICIENT AIR TO INFLATE BUOYANCY VEST. ACUTE GASTRIC HAEMORRHAGE. MYOCARDIUM HEALTHY.

SC 90/4

His diving experience was extremely limited, a few scuba dives some years previously and a course on a cruise boat some four months before this dive. This was only the second time he had needed to wear a wet suit and weight belt, previous dives having been made in warm waters. Indeed this was his first dive in a thick wet suit and in really cold water. The dive location was considered so safe that it was used by local instructors while training novices and on this day the water was calm and there was no current in the area chosen for this dive. There were two divers and an instructor in the dive boat. After an initial delay, as the victim's regulator malfunctioned, the two divers entered the water with part inflated buoyancy vests and gave each other the "OK" signal. However the victim then failed to deflate his vest fully and was unable to descend. The buddy had already descended as short distance when he noticed this and came back to the surface. The victim was instructed how to deflate his vest but still remained at the surface so the instructor indicated to the buddy that he should rest on the nearby rocks while this problem was resolved, then drove the boat close to the victim, who was drifting away from them. He threw a line but the victim failed to grasp it, and similarly ignored a second attempt to assist his return to the boat despite the line falling across his shoulders.

By this time the boat drifted away from him and while it was being repositioned he was seen to sink beneath the surface. The instructor expected that he would soon reappear, but this he failed to do and the instructor soon began to feel concerned. A formal search was made and his body was discovered, all equipment in position and buoyancy vest not inflated. The autopsy confirmed that drowning was the cause of death but it was noted that his right coronary artery provided no significant branch to the posterior of the ventricle. It is not known whether this played any significant part in his death or whether the cardiac and respiratory reflex responses to sudden immersion in cold water were the critical factors.

After his death his widow revealed that since receiving radiotherapy for a parotid tumour he had suffered from a left facial weakness and was liable to excessive salivation. He was also subject to episodes of tremor (which was diagnosed as "essential tremor") for which he had been prescribed Inderal (propranolol) 10 mg twice daily. She also described how after his first dive in a wet suit he had suffered an episode of tremors and become so fatigued that he had to retire to bed.

TRAINED. INEXPERIENCED. FIRST TIME THICK WET SUIT AND VERY COLD WATER. SURFACE PROBLEM DEFLATING BUOYANCY VEST. FAILED TO RESPOND TO LINE. SANK WITHOUT INFLATING VEST OR DITCHING WEIGHTS. ONE CORONARY ARTERY INADEQUATE. POST-RADIOTHERAPY EPISODES OF EXCESS SALIVATION AND ESSENTIAL TREMOR. MEDICATION WITH PROPRANOLOL.

SC 90/5

To conform to the regulations this overseas visitor had taken local scuba course although having 20 years scuba diving experience. Before this he had a Diving Medical during which full consideration was given to his story of occasional irregularity of his heart, which had been occurring for over 20 years, and a history of a full cardiac assessment "to please his doctor son" before he came on holiday. A cardiologist advised the examining doctor that there would be no particular reason to declare him unfit to dive as ventricular extrasystoles were to be noted in healthy people.

The dive boat moored at a reef and the six divers aboard made an uneventful dive, surfacing normally about 60 m from the boat. The sea conditions were described as moderately rough as they started their surface return swim. When the victim said that he was feeling tired the dive master swam out with a floating line and assisted his return. By this time he was obviously exhausted and breathless. After being brought on board the boat he said that he felt sick and his pulse was noted to be erratic. He was given oxygen but collapsed and cardiac arrest was noted. He responded to CPR efforts, which were continued as they waited an anxious two hours for the arrival of helicopter with paramedics. The CPR was continued despite the finding of asystole, and this was continued a further 15 minutes by the medical team which arrived later, but he was certainly dead long before attempts were discontinued.

Despite the victim's firm assertion that his angiogram had been normal (for which he provided no documentation) there was found to be partial blocking of the right coronary artery by atheroma and a complete occlusion of the posterior interventricular coronary artery. The cause of death was an acute cardiac failure. As he had been an active scuba diver and mountain climber despite his cardiac irregularity for 20 years it was reasonable for the doctor to assess him as Fit to Dive and it is highly probable an event such as this could have occurred at any time. To restrict people too severely from their desired activity whenever there is some health variation from the template of perfect health cannot be unreservedly justified but is likely on occasion to be called into question.

20 YEARS EXPERIENCE. RECENT DIVING MEDICAL AND CERTIFICATION COURSE. KNOWN OCCASIONAL VENTRICULAR EXTRASYSTOLES. PHYSICALLY ACTIVE MAN. SURFACE SWIM. ACUTE CARDIAC FAILURE. CARDIAC ARREST. CORRECT CPR RESPONSE. DELAY BEFORE RESCUE HELICOPTER, WITH PARAMEDIC AID, ARRIVED. MARKED CORONARY ATHEROSCLEROSIS.

SC 90/6

Misjudgment of water power led to the death of this boy and the permanent invalidism of his father. They were trained but inexperienced and somewhat lacking in self confidence, as shown by their habit of reading diving texts the evening before going diving. When they arrived at the beach some surfboard riders told them the visibility was poor but the father said that he thought it might be better further out from shore, and they then entered the water. The youths watched for a short time but then left the area, the divers then being about 200 m from the shore, still on the surface. The water was cold, visibility poor, the surface choppy, and there were 0.6 m waves. Later a witness on shore saw a diver off shore, apparently swimming at the surface, then he realised that it was strange that he was not reacting as the waves broke over him. He noticed that the diver was drifting rather than swimming and after he entered the surf zone near the beach and made no response the witness entered the water and pulled him ashore. With help from others he brought the diver onto dry ground and the ambulance was summoned. He was unconscious and suffering hypothermia. Although he responded to treatment in the Intensive Care Unit he suffered permanent residual mental impairment and was never able to remember what happened.

The next day the sea had abated somewhat and the police divers were able to make a search for the missing boy. There was still poor visibility and a powerful surge over the reef making it dangerous even for these experienced divers. The body was found on the bottom of a crevice, depth 9 m, all his equipment in place except for the tank and regulator. They were discovered nearby, separated from each other, the contents gauge caught in a small crevice. The autopsy showed the presence of bruising of the back and anterior scalp, but no fractures. It is probable that the unfortunate boy was being moved at the whim of the water surges when his contents gauge became trapped and he was instantly anchored, flailing about on the arc of the gauge's hose. This action would place great force on the attachment of the regulator to the tank and this evidently proved too great, the two parting company and remaining air escaping from the tank.

When it was checked, the retaining knob of the A-piece attachment of the regulator to the tank was fund to be filed to a smooth shape, making it difficult for anyone to get a firm enough grip on it to turn it tight. The dive shop owner, from whom it had been hired, did not admit to letting it leave his shop in such a state but it is unlikely that either the victim or his father had been responsible for its condition. However it was the trapping of the free-hanging gauge rather than any other factor which was the primary cause of this accident.

This was only the fifth post-course dive he had made and the circumstances of this dive were highly unsuitable even for a diver with considerable experience. Although the victim carried a 72 cu ft tank and father an 88 cu ft one, and the latter was most probably filled to a higher pressure, this was not a factor of any significance in his fatality. Separation probably occurred before they reached the rocky area as a result of the surface conditions.

TRAINED. INEXPERIENCED. SEPARATION DURING SURFACE SWIM FROM SHORE. FIFTH POST-COURSE DIVE. COLD. POOR VISIBILITY. WAVES. POWERFUL WATER SURGES AROUND THE REEF. WEIGHT BELT ON. VICTIM TETHERED BY TRAPPED CONTENTS GAUGE. TANK TORN FREE. REGULATOR DETACHED FROM TANK. DROWNING PLUS ACUTE TRAUMA FROM THRASHING ON REEF.

SC 90/7

All the divers making this dive cruise among reef islands were supposed to be both trained and to have adequate experience to manage all the dives, but this was not so in practice. The dive master did not inquire closely about medical fitness, diving experience, or even check that all the claims to be trained were true. The victim was trained but she had not dived in the previous 32 months. The other divers thought that she was somewhat unfit, being overweight. Later checking revealed that she was taking antihistamines, thought this was not an apparent adverse factor, and her diving Log Book recorded episodes of panic and one occasion she had a "blackout" after surfacing from a dive (though it held not details of these events). Her allotted buddy was later found to have never completed a scuba training course and to be inexperienced. It is not known whether the title "Dive Master" was an earned or a de facto title on this boat.

Before the fatal dive commenced the divers were told that they were over a reef, depth 8-9 m which had a drop off to 30 m and they should avoid descending this. Although some of the divers noticed that the victim appeared to become somewhat hot and flustered during her kitting up, the dive master saw nothing of significance in her behaviour. The buddy was wearing a borrowed weight belt which she had not used previously and when they landed on the reef the buddy found she was too heavy to stand up. Fearing she might fall over the edge of the reef, she partly inflated her buoyancy vest and made a rapid ascent, breathing out vigorously as she ascended. She was shortly joined by her companion, who noticed that she had distressed breathing and was coughing, so loosened the top of her wet suit jacket, put more air into her buoyancy vest, and tried to calm her while waiting for assistance from the dive boat. Her signals had been seen and a diver swam to them. He assessed the situation and told the buddy's dive partner to wait his return, then started to tow the buddy back to the dive boat.

When he returned he found that the situation had changed, the diver who had so recently being advising her buddy to be calm now herself showing signs of panic and complaining she was feeling tired. The rescue diver inflated her buoyancy vest further, told her to keep the regulator in her mouth, ditched her weights, and started towing her, against a current, back to the boat. Soon after this he became aware that she had gone limp and the waves were now washing over her face. He ditched her tank and commenced in-water EAR. In a short time others came to assist and she was brought aboard the dive boat but she failed to respond to their resuscitation efforts. The cause of death was drowning but surface panic was why this occurred.

TRAINED. INEXPERIENCED. NO DIVES FOR 32 MONTHS. LIABLE TO PANIC. BLACKOUT ONCE AFTER DIVE. OVERWEIGHT. HEALTH PROBLEM. CALMED BUDDY AT SURFACE. SEPARATION WHILE WAITING ASSISTANCE. DID NOT INFLATE BUOYANCY VEST FULLY. DID NOT DROP WEIGHT BELT. DROWNED DURING SURFACE TOW TO BOAT. BUDDY PART TRAINED. INEXPERIENCED. EXCESSIVE BORROWED WEIGHTS.

SC 90/8

This fatality, sudden cardiac failure, occurred while this young and apparently very fit diver was asleep on a dive boat the night after making several normal dives. This case been included to illustrate the factor of chance which can govern the time of onset of some illness. He was experienced diver had been required to pass several Medical Fitness examinations to achieve his level of certification and had been closely observed while assisting staff instructors. He became acutely breathless during the night and the rapidly instituted attempts to resuscitate him were unsuccessful.

At the autopsy there was no apparent reason for his death but histological examination of the heart muscle indicated there was evidence of a cardiomyopathy. Although the physical demands of diving were inappropriate in the presence of this condition, there were no reasons to suspect he was other than medically fit, and he certainly gave nobody any reason to think otherwise.

TRAINED. EXPERIENCED. APPARENTLY HEALTHY. ACUTE CARDIAC FAILURE WHILE ASLEEP. CARDIOMYOPATHY SILENT TILL FATAL.

Hookah Divers

H 90/1

This was the scallop season and the cold water was being made even colder by the melting snow run off from the land. There was poor visibility underwater but there were plenty of scallops. The victim was described as obese but physically fit, who took adequate exercise. Although he had reported some chest pain about 6 weeks previously a medical check had been satisfactory. He had taken a scuba course 5 years before but his diving experience is not known. As the hookah equipment he was using his own, very probably he had attained some experience in its use, though he had not made any dives for about 7 months.

They were diving from the victim's boat, one person being left on the boat while the victim and his son were diving. They had a successful first day of collecting scallops and the next day also they kept in close proximity while they were collecting, then ascending at the same time and together after each had managed to achieve a full collecting bag. After emptying these onto the dive boat they then descended for a second time. After 10 minutes the victim was seen to give the signal for ascent and this they performed at the normal rate and close together. There was nothing to indicate any problem concerning the victim as his buddy started a surface swim back to the boat, not looking back till he reached it. He then was surprised and alarmed to notice that the victim was no longer at the surface and there were no bubbles to be seen. He immediately swam back, following the victim's air hose and found him floating at 4.5 m (15 feet) depth (bottom at 7 m) unconscious, with the regulator hanging loose and weight belt on. He ditched the weights and began slowly bringing him to the surface, fearing to cause pulmonary barotrauma if too rapid in ascending. Their attempts at resuscitation failed to elicit any response.

Before commencing the autopsy a chest X-Ray was obtained and this showed the presence of air within the heart and some of the other blood vessels, including the aorta and cerebral vessels. A pneumothorax was shown but this was not demonstrated during the autopsy despite using the recommended "under water" procedures for opening the chest. This demonstrates the value of X-raying the chest before commencing the autopsy. Apart from the changes of drowning, the autopsy revealed evidence that he had suffered an infarct of the posterior wall of the left ventricle about 3 weeks before his death. It is probable that he experienced some heart pain while he was diving and decided he required to return to the surface without delay, but was distracted by the pain so failed to regulate his breathing adequately during his ascent, although this was not apparent to his buddy. There was an interval after he had reached the surface before the air embolism impacted in his brain and it was during this time that his buddy separated from him and began his solo surface return to the boat. There was histological evidence of a long standing low grade myocardial ischaemia but no symptoms of the infarct he apparently suffered about three weeks before he died had been evident to his family.

TRAINED. EXPERIENCE UNSTATED. NO DIVES IN PREVIOUS 7 MONTHS. COLD WATER. POOR VISIBILITY. HUNTING SCALLOPS. ASCENT WITH BUDDY SEEMED NORMAL. SEPARATION AT SURFACE WHEN BUDDY STARTED SURFACE RETURN TO BOAT. SILENT DEATH. CEREBRAL ARTERIAL AIR EMBOLISM. MYOCARDIAL ISCHAEMIA. MYOCARDIAL INFARCT 3 WEEKS PREVIOUSLY. NO BUOYANCY VEST. WEIGHTS ON.

H 90/2

The originally chosen dive location had a strong current so the dive group, in three boats, moved to a calmer location which had only a slight current. The two divers involved were using the compressor unit which belonged to the buddy, who had taken a scuba course about 6 months before and had since accumulated about 12-14 hours experience of hookah diving. Though the victim had taken a scuba course 2 years before this dive he had not dived during the previous 12 months and his knowledge of, and experience with, hookah was probably minimal. There was one 75 m long air hose from the compressor and this was connected to a T-junction to which were attached 3.6 m lengths of hose to the regulators.

The two divers descended but the victim very soon indicated he wished to abort the dive so they ascended. The buddy helped him back into the boat as he was too fatigued to manage it unaided. He explained that he had begun to feel panicky. After an interval in the boat the buddy made a solo 30 minute dive, then he returned and asked whether the victim now wished to try again.

The victim's second dive lasted 5-10 minutes and then he indicated his wish to return to the surface, which they did in the correct slow manner. Again the reason given was of a feeling that panic was imminent. The buddy told him to replace his regulator, a suggestion he failed to follow, then inflated his buoyancy vest in preparation for their swim back to their boat. However the victim soon said he felt he was "not going to make it back" so the buddy signalled for assistance.

They were a little separated by now and when he looked back he saw the victim was floating face down with his mouth submerged so he quickly turned him face up but found he was so heavily weighted (13 kg) that his face was still often covered by water. He attempted to ditch the weight belt but was unsuccessful because the belt had twisted round and the buckle was now at the side. It was noted later that the tongue of the buckle was broken, which made it more difficult to open. When this damage occurred is unknown.

His signals for assistance were noted and while the hose was being used to pull him back to the boat by one person, another diver was in the water, helping the buddy keep the victim's mouth above the water surface. Effective CPR efforts were started after the arrival of divers from another boat, the lack of CPR knowledge possessed by the buddy and initial rescuers being criticised when the events were recalled at the Inquest.

Examination of the equipment showed the buoyancy vest to be one designed for use with scuba, which when inflated failed to maintain the head of a wearer above the surface and face upwards. It was suggested that the compressor did not produce sufficient air when a single hose was used to service two divers at the depth of this dive, the result being a feeling of air hunger likely to produce panic in a diver who was inexperienced. The autopsy showed there had been aspiration of vomit, though whether this preceded or followed the drowning could not be established.

TRAINED. INEXPERIENCED WITH SCUBA. POSSIBLY NO EXPERIENCE OF HOOKAH DIVING. PANIC CAUSED ABORT OF BOTH DIVE ATTEMPTS. SURFACE PANIC. REFUSED TO REPLACE REGULATOR. BUDDY UNABLE TO DITCH WEIGHT BELT. BELT TWISTED TO SIDE AND HAD BROKEN TONGUE. INFLATED BUOYANCY VEST GAVE INADEQUATE LIFT AND FLOATED WEARER FACE DOWN AT SURFACE. POSSIBLY INADEQUATE AIR SUPPLY.

Discussion

Every death is a unique and personal event and each of the deaths in this review has features which are special. However there are some lessons which can be extracted from a consideration of these fatalities.

The breath-hold divers were all alone at the critical time, a fact which undoubtedly influenced the course of case BH 90/2, who could have survived had there been anyone watching him at the time. Watching a group of independent surface swimmers can never guarantee that every person is in view continuously. Two of these divers suffered fatal cardiovascular troubles, one died from trauma to his head, and one was probably taken by a shark.

Many factors are responsible for the scuba diver cases. It should be noted that though cardiovascular causes were the critical factor in two (one during sleep in an apparently healthy young man) there were two cases where cold water was undoubtedly the critical factor. Sudden immersion in cold water is capable of immobilising a person and plays a significant role in drowning in cold water. Acute illness by its nature is something which cannot be predicted and here the solo situation at the time it occurred was compounded with extreme prejudice to the victim by his failure to wear a buoyancy vest for this dive. Water power was tragically demonstrated in case SC 90/6. The divers failed to appreciate the severity of the water conditions until they were inextricably involved in a tragic sequence of events. The survivor unfortunately illustrates the lesson that the result of resuscitation may lead to less than full recovery and underlines the need for rapid rescue and effective resuscitation efforts in any case of apparent drowning. Such was not an available option in the circumstances of this case.

Panic is always a no-survive situation and it is unfortunate that the victim in case SC 90/7 had not realised it was necessary for her to either recognise the early stages of development of the panic state so that she could respond correctly to the situation before losing the power to do so, or give up scuba diving. While it is a safe recreation while the rules are followed it is far otherwise when panic develops and destroys the victim's ability to respond in a manner conducive to survival.

In case SC 90/1 there were a number of adverse factors which acted to mould the course of events, summating in death for one. The pair of divers were diving deeper than ever previously, probably feeling some effects of nitrogen narcosis, on a featureless sea bed because they had mistakenly left the security of the anchor line which was intended to guide them to the wreck. The buddy over exerted himself trying to keep up with the victim, who was in the lead and experiencing an inadequate air supply. This was due to two factors, the incorrectly adjusted first stage and the incomplete opening of the tank valve. Not surprisingly their attempts to buddy breath failed, despite previously practicing this procedure, as both divers were affected by air hunger. There was another element in the genesis of this incident, the temperaments of the two divers. While one was content to follow without question, the other (apparently) tended to lead without thought for his buddy's swimming ability.

Now that there is debate about the need to include the practice of out-of-air ascent in the primary training courses for scuba divers, defended on the grounds that it will produce far safer diving, readers are asked to consider whether the above fatal incident resulted from an inability to buddy breathe while making a low-air ascent or because the divers omitted to follow commonly accepted safe diving modalities. They were diving outside their experience and had left the anchor line in mid water, then failed to recognise the need for immediate ascent when short of air. It was unwise of the buddy to continue swimming in an attempt to catch up with his leader when the exertion was making him breathless, and it was incorrect of the leader to place his buddy in such a situation. He should also have recognised the inadequacy of his air supply before suddenly demanding buddy breathing. This was a situation which better training should have obviated.

Case (SC 90/1) is also of interest because the buddy survived a panic ascent while not only distressed by the coughing due to inhaled water but with the regulator out of his mouth. There is no helpful moral to be drawn from this, merely the observation that there are a multitude of factors which influence the outcome of even the worst concurrence of circumstances and these sometimes are favourable to those involved. Indeed survival need not be taken as proof that one is a good diver.

Hose supply diving has problems peculiar to the sudden nature of a cessation of the air supply unless a reserve bottle is carried. It is a type of diving requiring training, one where the inexperienced are at as much risk as is the case with scuba diving. While case H 90/1 was factored by cold and the unsuspected cardiac infarction, case H 90/2 involved a diver who was probably totally inexperienced in the use of this apparatus and certainly fatigued and feeling panicky. That his death occurred at the surface, possibly due to inhaled vomit, rather than from pulmonary barotrauma with cerebral arterial gas embolism (for which he was a prime candidate as he had made his ascent tense with near panic) is a tribute to the training he had received 2 years previously. Unfortunately he was then unable to cope with the problems of surviving at the surface.

In summary, unsuspected health factors, cold water and inexperience continue to be significant factors adverse to survival of divers. It will be noted that this investigation details not only cases in which the diving activity was directly responsible for the death, but cases where health factors were critical and the diving itself was not necessarily the significant critical factor other than in respect to the factors of physical exertion by the victim and the in water location of the problem.

Acknowledgment

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 service in some States in reference to cases where no inquest was considered necessary. Others who supplied identification of cases or supplied information are also thanked. It is hoped that one day there will be a wider involvement in this project by members of the diving community.

PROJECT STICKYBEAK DATABANK

The objective of this on-going project is to identify factors which influence the safety of divers. Reports are requested concerning incidents of all types and severity, particularly where there has been a successful outcome. **MEDICAL CONFIDENTIALITY** is given to every communication received.

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THE WORLD AS IT IS

SHRINKING DIVING RESEARCH DOLLARS

John Williamson

The following Editorial by Dr. Peter Bennett appeared in the November/December, 1992 issue of *Alert Diver*, the magazine in the USA's Divers Alert Network (DAN). The message has direct relevance to Australian and New Zealand diving medicine.

"DAN (Divers Alert Network, Inc.) research in the last few years, with support by NOAA (National Oceanic and Atmospheric Administration) and DEMA (Divers Equipment Manufacturers Association), has primarily been concerned with the epidemiology of diving accidents and has focussed on factors which could be modified to help reduce such accidents and deaths or to help in treatment.

However, there was and is a greater concern. I have been in diving medical research since 1953 and have worked in four countries. Thus, I was in the middle of the tremendous growth and worldwide interest in diving medicine following World War II. The US and British navies spearheaded this uniquely productive research effort and supplied considerable financial support. The growth of deep commercial diving in support of the offshore oil industry in the 1960's stimulated additional interest and finance too in exploring oxygen-helium and trimix (oxygen-helium-nitrogen) deep diving. Other Navies and governments around the world also initiated similar diving research laboratories, and the National Institutes of Health (NIH) in the United States supported major multi-chamber research laboratories at Duke University Medical Center, the University of Pennsylvania and at the University of Buffalo.

However since 1972, when I became Director of the Duke University Hyperbaric Program, research funds have been steadily shrinking. But none of the major diving problems of decompression illness, nitrogen narcosis, or oxygen toxicity, are solved, nor do we know very much about their mechanisms. Today, for example, there are more dive algorithms for tables and computers to bring a diver safely back to the surface than you can count on your fingers. We obviously have much to learn since they cannot all be right! The nitrox controversy will renew interest in oxygen toxicity information and so on. Recreational diving must therefore find its own research funds if it wishes to move forward. There will be little help from the government!

Some time ago, I reported to you of the formation of the Recreational Diving Research Foundation by DAN, PADI (Professional Association of Diving Instructors) and DEMA with a view to promote research dollars for needed research. In the last few years we were able to accumulate only some $67,000, about one third what one normal NIH research grant would cost today! With the advent of a new research granting organisation by PADI in 1991, it became clear that the RDRF could not compete for the same few dollars from the same few divers. So we decided to close the RDRF and after peer review, to disperse several one year grants to the following researchers: George Meyer, an engineer, and Mark Perry, Executive Director of the Florida Oceanographic Society, to Study the "Practical Limitations of miniature scuba cylinder alternatives"; Jolie Bookspan PhD, of the University of Pennsylvania, to study the "Detection of endogenous gas phase formation in humans at altitude"; Wayne Gerth, PhD, of Duke University Medical Center, to study "Quasi-physiological models for calculating flying after diving guidelines"; and Judy Lasher DPsych, with help from Mercy Hospital, in Miami, to study "Trait anxiety sensation seeking and experience as predictors of non-fatal scuba diving injuries".

Their research results will soon be reported and hopefully the new PADI Foundation can then take over where the RDRF left off. However, this year only $50,000 was available from PADI, less than the RDRF, and much, much more is required! Hopefully this will increase but this drop in the bucket will inevitably fail to keep many skilled researchers in diving medicine. The problem with research support is not unique to diving but is a national economic problem too. It is one we should not ignore, for in research is our security for the safety and health of recreational divers now and for the future.

Peter Bennett PhD, DSc
Executive Director, Divers Alert Network"

It is now clear that compressed gas (mainly air) diving as both a recreation and an occupational pursuit, involves a major population base in Australia and New Zealand.[1,2,3] Such diving brings with it a small but definite risk of injury,[4,5] (sometimes fatal[6]), and a need for properly funded research effort into safety improvement. The public of both nations in general remain ignorant of the magnitude of the diving population, the rapidity of this increase in diving number during recent years, and, with the possible exception of oil exploration, of the significance of such activities to their respective national well being. The maintenance of bridges and harbours, shipping and marine biological research, undersea cables and pipelines, oceanography, military and defence activities, and by no means least, tourism[2,7] are all dependant upon safe and competent diving.

Australia and New Zealand have a proud pioneering record in modern diving medicine. The South Pacific Underwater Medicine society (SPUMS), building on the distinguished efforts of the countries' Navies, and of people like Edmonds, Slark, Swain, Thomas, Lowry, Lourey, Walker, Knight, McKenzie, Acott, and more recently Davies, Gorman and colleagues, now occupies a key guiding role in diving medicine in the two countries. With the network of Hyperbaric Medicine Units associated with major hospitals, functioning around Australia and New Zealand on a 24 hours basis, diving medicine (with the intimately related hyperbaric medicine) is slowly taking a legitimate place within medicine at large. However, in addition to other members of the public, many medical practitioners, medical school staff, and hospital and government bureaucrats still remain unaware of the need for education in these fields, let alone the magnitude of the funding need for research.

Until now, such Australian and New Zealand funding has, with isolated notable exceptions,[8,9] limped along, piggyback style, on the clinical activities and good will of a handful of energetic and enthusiastic people (including those named above). No serious, long-term funds, of the amounts referred to by Dr. Bennett, have ever been provided. Some of the disparate members of the giant recreational diving industry are beginning to contribute spasmodic and relatively tiny sums towards the maintenance of Australia's 24 hours, user free (inside Australia) Diver Emergency Service (DES/DAN) telephone. (The epidemiological data gathered by DES/DAN Australia is rich research material.[4]) These small contributions are accompanied by expectation of skilled 24 hour medical and retrieval cover, at no personal diver cost!

Two major and related attitudinal changes are now required. The 24 hour provision of expert medical advice on an emergency basis, as presently provided in Australia by DES/DAN, requires secure and steady funding, A voluntary DES/DAN membership subscription fee by each diver that leads to independent insurance cover for diving, is a successful North American recipe. The New Zealand DES service already has secure funding from the New Zealand Underwater Association, an example for Australian recreational divers! The Australian recreational diving population alone is more than large enough to emulate this. In any case, a continuation of the blind assumption among most, but not all, recreational divers and diving retailers in Australia that the expenses of the DES/DAN service will be underwritten by "the government" (Heaven help us!), or by "someone else", is doomed. Divers can expect to be presented with the bill for their retrieval and recompression from now on, and those costs aren't peanuts!

The second major change in attitude required is the appreciation by the recreational diving industry itself (presently preoccupied with internal commercial competition), of the value of, and need for major funding for Australian and New Zealand diving medical research. As Bennett has indicated for North America, but this applies even more so to Australia and New Zealand, the "drop in the bucket" funding so far provided is Mickey Mouse stuff! Real diving medical research (including that derived from the valuable DES/DAN data and the exciting Diving Incident Monitoring Study (DIMS)[10] requires real funding, $100,000 plus, annually, to produce high quality work. It is potentially an enormously fruitful research field.

There is so much in diving medicine recognised as relevant to safety and efficiency (all the areas mentioned by Bennett, together with equipment design, training, rescue, crisis management, oxygen administration, diving instrumentation, and so on) which has never been adequately investigated, or in which knowledge is inadequate. The recreational diving population needs to assume responsibility for its own destiny, and to get behind diving medicine in a meaningful way. The alternative is recurring accidents, a diminishing safety record, and the threat of "government" regulation.

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SCUBA SAFETY IN QUEENSLAND

Jeffrey Wilks

Introduction

During the 1991 calendar year there were 54,153 new open water certifications issued throughout Australia by the four major scuba training agencies (NASDS, NAUI, PADI, SSI).[1]

Queensland's popularity as a major diving destination is not surprising, given the close proximity of the Great Barrier Reef. Scuba diving is therefore a very high profile tourism activity for the state, with an estimated 100,000 introductory or resort diving courses being conducted each year. These courses generate an estimated $6 million in direct revenue for dive operators.[2,3]

An important consideration in promoting scuba diving as an activity for tourists is the ability to guarantee that the experience will be safe and enjoyable. In a previous paper, ten separate groups of recreational divers were identified in Queensland.[4] A major study was undertaken to count the number of dives made in the state during the 1991 calendar year. Support from four of the Australian scuba training agencies, by way of sharing their confidential certification figures, and from 111 Queensland companies providing numbers on their resort and social dives, allowed the calculation of a very conservative 677,767 dives to be made for the year.

Placing accidents in perspective

In order to determine whether scuba diving in Queensland during this period really was a safe activity, the four Australian training agencies were again approached with a request to provide information on the number of accidents reported by their Queensland members during 1991. An accident is broadly defined by the training agencies and usually includes an injury or illness, ranging from minor to severe, which is the result of participation in diving activities.

It should be noted that the training agencies require their members to submit an accident report form whenever an accident occurs. This requirement is part of the agencies' standards and is linked to members' insurance. All members at leadership level (instructors, assistant instructors and divemasters/dive controllers) need to comply with this accident reporting requirement.

During the 1991 calendar year there were 24 Queensland accidents reported to the training agencies. As a proportion of the 677,767 dives reported in 1991, the Queensland accident rate is 0.00003541. That is equivalent to 35 accidents per one million dives.

Several points of clarification need to be made about this figure. First, the total number of dives made each year in Queensland is still not known. The figure of 677,767 is based on the first ever reliable count of dives, but only covers five of the possible 10 diver categories. The figure is therefore very conservative, but seems to be in keeping with non-empirical "guesstimates" offered in other published literature.[5,6]

The second point to be made is that not all accidents that occur in Queensland (or any other Australian state or territory) will be reported to these four training agencies. Accident reports will only be submitted where an agency member is involved, either directly or as an observer. For example, 50 divers with dysbaric illness were seen at the Townsville General Hospital during 1990.[7] This chamber group included divers from Papua New Guinea and other South Pacific locations, military and commercial divers as well as recreational divers.

The chamber also treats recreational divers who dive from their own vessels or from the shore, and therefore have no contact with training agency members. Since patients in these treatment groups have no contact with instructors or divemasters their accidents would not be reported to the training agencies.

Finally, the real figure for accidents in Queensland during 1991 may well be higher because some recreational divers may not present for treatment until a day or two after their dive.[8] In most cases the chamber staff will try to contact a commercial dive operation if one of their recreational divers presents for treatment. This allows the dive profile to be checked and the gathering of any other information relevant to the diver's treatment. Having been made aware that a customer is being treated for a diving-related problem the commercial operator would then submit an accident report to their training agency. However, in some cases contact between the chamber and the dive operator, for various reasons, may not occur and in these cases an accident may not be reported to the training agencies.

The only way an accurate and reliable perspective on diving-related accidents will be gained is through co-operation and the sharing of data between the chambers, the training agencies, and in Queensland the government Division of Workplace Health and Safety. In the meantime, the only reliable figures for recreational diving are those presented here. However, as mentioned above, it is possible that some accidents may not have been reported.

One particular area of diving safety that is of special interest to tourism groups on the Great Barrier Reef is that of the introductory or resort course program.[9] As noted above, an estimated 100,000 introductory dives are conducted in Queensland each year. Only three (3) accidents with introductory divers were reported to the training agencies during 1991. The accident rate for this specialty program is therefore 0.00003 or three in 100,000 dives.

In previous reports it has been argued that introductory dive programs are very safe, due to the close in-water supervision provided by certified instructors.[2,9] The present study supports the view that dive supervisors are more likely to experience difficulties with certified divers (15 of the 24 accidents reported in 1991 were with certified divers) than they are with introductory dive students. This again points to a need for consideration of mandatory refresher programs, especially for certified divers with less than five logged dives each year.

There is still a considerable amount of work to be done developing empirically valid assessments of diver safety. In the present study no distinction was made between accidents. The training agencies were asked only to provide figures on the number of reports they had received where a diver had been injured. No details were requested on the nature of the injury. Though not part of the present study, it is acknowledged that gaining information on the type of accidents experienced by recreational divers is an essential part of designing effective injury-prevention programs.

While most recreational sports must rely on estimates of their number of participants to calculate the incidence of injuries[10,11] the Queensland recreational diving industry can now use an accurate figure of 35 accidents in one million dives to support its safety record. Compared to the estimated injury rates in the United States[10] of 2.09% for baseball, 1.86% for basketball, 0.20% for water skiing, 0.12% for tennis, and 0.04% for scuba diving, the Queensland dive accident rate of 0.0035% is very low.

Acknowledgment

Special thanks are extended to the four Australian scuba training agencies (NASDS, NAUI, PADI, SSI) for trusting the author with their confidential information.

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MARKETING OF SECOND-HAND SCUBA EQUIPMENT: IMPLICATIONS FOR DIVER SAFETY

Jeffrey Wilks, Brian Delahaye and Vincent O'Hagan

Introduction

Scuba diving is an equipment intensive sport. Properly serviced and maintained, and used by a competently trained diver, modern scuba equipment is generally safe. Unfortunately, diving accidents do occur and equipment faults or misuse often play a significant role in the accident scenario. For example, a recent report reviewing 100 diving fatalities in Australia and New Zealand during the 1980's found that equipment faults and misuse were involved in 35% of the cases.[1] Problems with regulators, fins, buoyancy compensators and tanks, in that order, were most often involved in the fatal accidents.

In a review of 797 diving accidents in the United States, Hardy reported that 13% involved equipment difficulties.[2] He also noted that equipment difficulty did not appear as a sole or primary cause of trouble. Rather, the vast majority of problems with equipment were human errors related to use, care and selection.

According to the Divers Alert Network (DAN) new and infrequent divers may be at particular risk for equipment problems due to their lack of diving experience and skills, and also through not being familiar with diving equipment.[3] Lack of familiarity with equipment is a common problem when gear is rented, borrowed or recently purchased.

While studies have covered the equipment divers currently own,[4-6] and what new items they might be willing to purchase in the future,[5,6] no research has examined the second-hand market. This market is important for several reasons. First, many divers cannot afford to purchase new equipment. After completing an open water course they tend to spend their money on dive trips, and are willing to rent gear while they save up to purchase their own. At this time, less expensive second-hand equipment may be very attractive. Unfortunately, new and inexperienced divers are not knowledgeable customers and may therefore purchase unsafe equipment. This in turn would compound any problems they might normally have in gaining experience as newly certified divers.[3,7]

The second point related to safety is that a large proportion of the scuba equipment passing through second-hand markets probably needs professional servicing or maintenance before it is safe to use. This includes hydrostatic testing for tanks, and general servicing of regulators, buoyancy compensators and gauges. While current Queensland Workplace Health and Safety Regulations[8] place specific legal responsibilities on commercial dive operators to adequately service and maintain rental scuba equipment, no such constraints operate in the second-hand market.

An examination of trends in the amount and type of second-hand scuba equipment offered for sale provides instructors and dive shop owners with an indication of the potential market for their services. Studies of diver dropouts show that lack of personal equipment is one of the primary reasons inactive divers give for discontinuing with the sport.[9,10] While a certain proportion of the equipment entering the second-hand market will be from divers wishing to sell old gear in order to upgrade, there will also be gear for sale as a result of people discontinuing diving. Many of these people may be receptive to the offer of a refresher course,[11] and with appropriate encouragement might start diving again if contacted before they sold their equipment. Dive operators also need to know about the size of the second-hand market and its trends, because, as previously noted, much of the equipment needs to be serviced by an authorised technician before it is safe to be used by the new owners.

Method

The Personal Trading Post is a fortnightly newspaper listing a comprehensive range of goods available for sale by private owners in the Brisbane, Gold Coast and Sunshine Coast regions of Queensland. The Trading Post is sold through newsagents and supermarkets, and has a circulation in excess of 100,000 copies. Sellers place their advertisement in the Trading Post and pay a fee when the goods are sold. Buyers telephone and arrange to view the

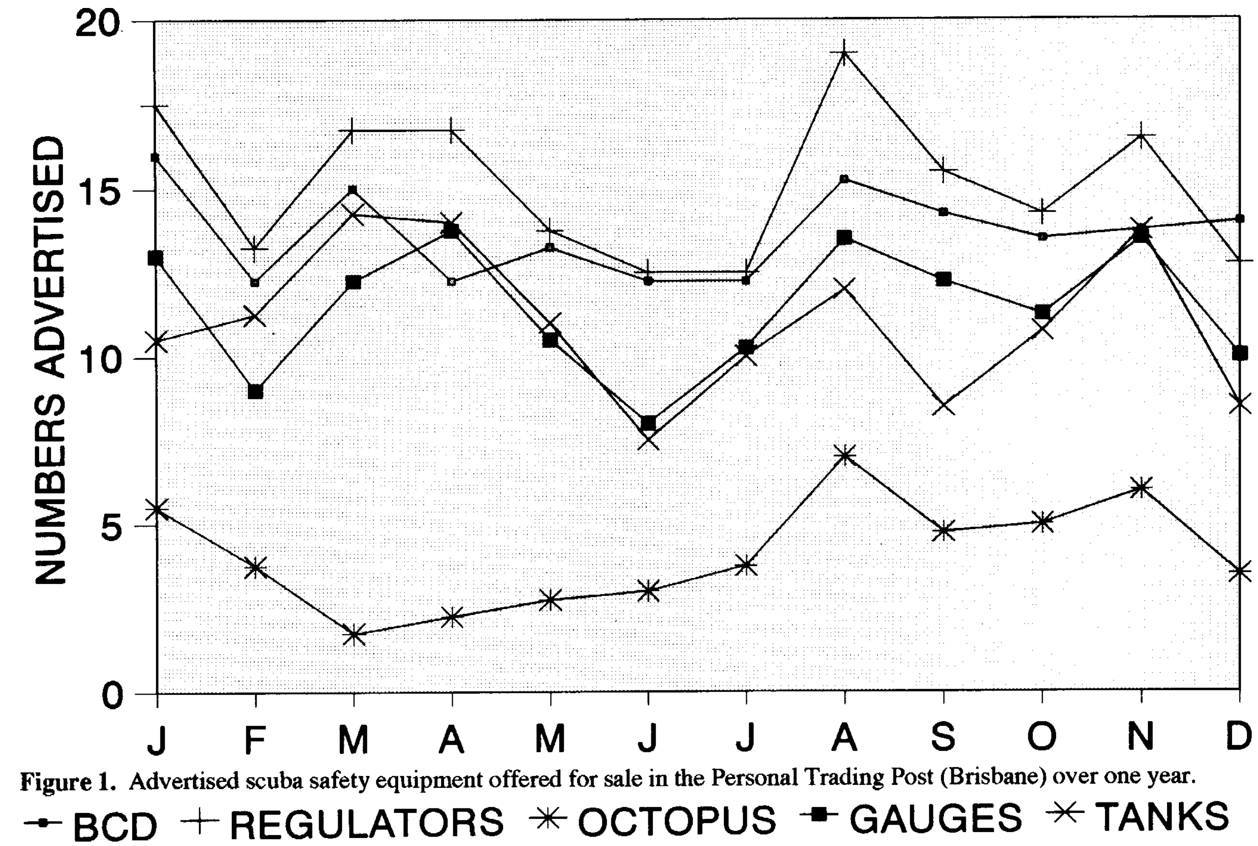

Figure 1. Advertised scuba safety equipment offered for sale in the Personal Trading Post (Brisbane) over one year.

goods at the seller's home. If goods are not sold in the first fortnight then the advertisement automatically runs in the following issue.

All back issues of the Trading Post were obtained for the years 1987-1990 inclusive (96 fortnightly issues). The third author, an experienced scuba instructor, coded each item of equipment offered for sale during the four year period. To ensure that items not sold in any one fortnight were not counted twice, the final sample contained every second fortnight or issue in each year. This would have failed to detect any sales that were only advertised for uncounted weeks. Our figures may under-represent true sales volume.

The full list of equipment coded included masks, snorkels, fins, boots, gloves, wetsuits, weightbelts, buoyancy compensators, regulators, octopus regulators, tanks, gauges, watches, gear bags, dive knives, torches, compasses, dive computers, underwater cameras, and sundry diving accessories. This paper describes the second-hand market only for the main safety items identified in previous accident reports.[1-3] That is, buoyancy compensators, regulators, octopus regulators, tanks and gauges.

Results

Figure 1 plots the number of equipment items offered for sale over a standard 12 month period. The figure is based on averages across the four years 1987-1990 and shows peaks during January, March-April, August, and November for buoyancy compensators, regulators, tanks and gauges. Significantly fewer octopus regulators were offered for sale compared to the other items of equipment, though essentially the same pattern of availability emerged with peaks for octopus regulators during August and November, and a trough in March one month later than that of the other equipment.

TABLE 1

SECOND-HAND EQUIPMENT AVAILABLE FOR SALE 1987-1990

Type of Equipment	1987	1988	1989	1990
Regulators	115	143	232	234
Buoyancy compensators	93	131	215	217
Gauges	86	115	167	181
Tanks	91	113	167	157
Octopus regulators	24	22	79	71

Table 1 shows the total number of second-hand equipment items offered for sale in each of the four years 1987-1990. All safety items showed a progressive increase in numbers during the study period, with largest increases being for octopus regulators (196% increase) and buoyancy compensators (133%). The largest changes occurred in 1989 and these new levels were maintained during 1990.

Discussion

The present study shows that the market for second-hand scuba equipment in south-east Queensland is growing each year. As the number of items passing through the market increases, the diving industry needs to give some consideration to equipment that requires specific maintenance or technical service before it is safe for the purchaser to use.

Diving fatality reports suggest that only a relatively small proportion of scuba accidents are the direct result of equipment failures.[2,3] However, seemingly minor equipment problems (such as a free-flowing regulator) may contribute to a chain of events that results in a fatality, especially if the diver is inexperienced. For example, in his review of 797 accidents in the United States, Hardy found that lack of maintenance or "home maintenance" of regulators was a major factor in equipment difficulties.[2] Edmonds and Walker also found regulator problems played a significant role in scuba fatalities.[1] More recently, Acott noted that from 125 incidents reported by Australian divers, 17 involved direct equipment failure.[12] These included free flowing regulators, malfunctioning buoyancy compensators, and inaccurate contents gauges. The latter problem should be noted in the context of gauges passing through the second-hand market, the vast majority of which are probably not re-calibrated or checked before use.

A similar problem exists for scuba tanks purchased on the second-hand market. Many are not in current hydrostatic test, which is legally required in Queensland every 12 months. Apart from the additional cost for the unwary customer of having the tank tested, and running the risk of the tank being confiscated and destroyed if it fails the test, many of the tanks offered for sale may not be an appropriate choice for the purchaser. For example, Edmonds and Walker report that scuba cylinders contributed to 9% of the diving fatalities they reviewed, not through a fault in the equipment, but because they were either inappropriately chosen or misused.[1] Inappropriate choices included the cylinders being too small (28-42 cu ft) or that they had been filled to less than the customary air pressure.

Queensland Workplace Health and Safety regulations ensure that only certified divers can purchase diving equipment and services from commercial outlets.[8] In addition, most new equipment comes with a warranty or guarantee. No such protection exists for customers in the second-hand marketplace, and since this market will continue to grow it is critical that the equipment offered is professionally serviced and maintained.

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THE AMA AND DIVING MEDICALS (CONTINUED)

John Knight

Readers may remember a paper "Is the AMA really interested in diving medicine"[1] in an earlier issue and letters about it appeared in another.[2-5] Since then there have been some less than satisfactory developments. I was invited to contribute an article to *Australian Medicine* putting forward reasons for the SPUMS stance that doctors should have training before undertaking diving medicals. The Australian Medical Association (AMA) response would be printed alongside. The Editor of *Australian Medicine* has given permission to reproduce these two articles, and that written by Ian Millar published on the same page as the AMA response, so that those members who are not members of the AMA or live outside Australia can keep up with our efforts to persuade the AMA to support what, to us, is a self evident requirement for the safety of divers.

Below are printed the three papers and a Letter to the Editor that I have sent to *Australian Medicine* in the hope that it will be published.

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DIVING AND THE DOCTOR

John Knight explains why he believes doctors should complete a course in diving medicine before attempting pre-diving medicals.

Diving medicine, if it gets a mention at all, only gets a passing reference in the medical course. Doctors, at the end of their medical course, cannot know enough about diving medicine to be able to do a competent diving medical.

Doing a diving medical properly involves giving advice, soundly based on knowledge, about common diving problems. Sometimes the advice must be that diving is not safe for the candidate. If the doctor does not know how can he or she advise ?

Over the years at least two physicians have overruled the advice of diving doctors that their sons' asthma made diving dangerous. One son died during the ascent on his first sea dive and the other drowned when incapacitated by asthma on the surface after some years of diving. One can only say that they did not know the risks that they were subjecting their children to. Would you like to do that to your child or to someone else's child ?

Luckily death is not the only possible outcome of uninformed advice. I know of three asthmatics, passed as fit to dive by doctors who were not aware of the risks, who went unconscious underwater during their training and only survived because of competent first aid. In one case a member of the class, a doctor, performed EAR for 20 minutes before the patient started breathing. In another an instructor did the same. The third never stopped breathing.

Asthma is no great danger to life in the air, but underwater, where one has to rely on a mouth-held regulator, giving cold air, to breathe at all, is different. Cold air precipitates asthma in some people. Hypertonic saline is used as a provocation test for asthma. Regulators quite often give a fine spray of water with each breath. In the sea that water is hypertonic saline !

Divers damage their ears more than any other part of the body. Unless a diver can add extra air to the middle ear during the descent the eardrum is pushed in by the rising pressure. This leads to small haemorrhages in the eardrum which looks like otitis media and is often treated as such by uninformed medicos. But this "infection" is unaffected by antibiotics because it is mechanical damage. Further descent can cause more damage. Swelling of the lining of the middle ear cavity and haemorrhage occurs and the ear may fill with blood. Even inner ear fistulae, with almost complete loss of hearing, can follow failed equalisation of middle ear pressure.

The AMA code of ethics says, as its first statement, that doctors should confine their practice to the areas of their expertise. To undertake diving medicals without any training in underwater medicine can only be unethical. Do you want to act unethically?

Besides the ethical aspect of working outside your area of expertise there is a legal aspect. Recently the High Court held that an ophthalmologist was negligent in not disclosing the very small risk of sympathetic endophthalmitis, to a patient with only one good eye, before operating on the bad eye. If an untrained doctor passed a diver medically fit incorrectly and the diver came to harm that doctor would not have a leg to stand on. He or she would have failed to provide an adequate standard of care.

If you live in Queensland, under the Code of Practice for Recreational Diving at a Workplace (gazetted on 12th December 1992), you have to have done a course in underwater medicine before examining prospective divers. While it is not a compulsory legal requirement, the code is what will be referred to in court if a case is brought. Not having complied will make your defence almost impossible.

Without training, how can the doctor explain to the patient the mechanics of gas uptake while underwater, the dangers of rising in the water without breathing out, how not to hurt ones ears while diving and how to dive safely ? Yet these facts are needed for the doctor to advise the budding diver.

Of course doctors who are divers have a smattering of underwater medicine. They have been taught by their instructors, who have also been taught by their instructors. No doctor would pretend that attending a lecture or two on diabetes, given by a non-medico, prepared him or her to treat diabetics. Especially if the non-medico had been taught by a non-medico, who had learnt from a non-medico diabetic. That is the analogous situation. So just because you are a diver does not mean that you know enough about diving medicine to do diving medicals well. It gives you an edge over the non-diver doctor but that is all. You will appreciate the practical problems of controlling buoyancy and equalising ears. That will help your patients but the fundamental knowledge is just not provided in diving courses. To have adequate knowledge you have to go and learn more than the instructor taught.

There are courses available at Hyperbaric Medicine Units in three states and the Diving Medical Centre holds long weekend courses in NSW and Queensland. The amount of information presented means that the weekends seem longer than they are, you work so hard.

Dr John Knight is a former President of the South Pacific Underwater Medicine Society and is Editor of the SPUMS Journal. He is a senior visiting anaesthetist in Melbourne.

THE COURSES

Royal Adelaide Hospital Hyperbaric Medicine Unit Basic Course in Diving Medicine. Application should be made to Dr John Williamson, Director, HMU, Royal Adelaide Hospital, North Terrace, South Australia, 5000. Telephone (08) 224 5116. The next course is in September or October 1993. The fee is $A 500.00.

Royal Australian Navy School of Underwater Medicine. Application should be made to The Officer in Charge, School of Underwater Medicine, HMAS PENGUIN, Balmoral Naval P.O, New South Wales 2091. Telephone (02) 960 0333. The next course is in October 1993, probably 18th to 29th. The fee is $600.00.

Diving Medical Centre. Three day (long weekend) courses are conducted at intervals to instruct medical practitioners in diving medicine, sufficient to meet the Queensland Government requirements for recreational scuba diver assessment. Application should be made to Dr Bob Thomas, Diving Medical Centre, Jindalee, Queensland 4047. Telephone (07) 376 1056. The fee is $895.00.

Fremantle Hospital Hyperbaric Medicine Unit. Application should be made to Dr Harry Oxer, Director of the Unit. There will probably be a course in 1994.

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A MATTER OF INFORMED CONSENT

Ian Millar

I personally support the proposal that medical practitioners performing recreational diving medicals should have appropriate training. My view of these medicals differs however from that frequently presented.

There is a strong lobby which expects medical practitioners to take responsibility for the safety of divers by actings as “gatekeepers” when performing fitness to dive examinations. This has obvious legal attractions for those in the recreational diving industry, as well as fitting the model developed in the occupational and, in particular, military “schools” of diving medicine. This conventional view is reinforced by the wording used in standards and on certificates: “fit to dive” or “unfit to dive”.

Fitness to dive is not, however, an absolute matter, but one involving opinion and variations of degree of fitness. There are some aspects of relative unfitness that are often accepted (such as obesity) and others that may be most important in the genesis of accidents, but which are largely ignored as too hard to judge, such as unsuitable personality and temperament.

I consider that the functions of the diving medical are:

1 To provide information to the diver (and with consent to the instructor) regarding the diver’s relative risk from diving activity, given his or her state of “fitness”.

2 To assist the potential diver to make an informed decision as to whether this risk of diving is acceptable.

3 To educate the diver regarding safety factors, particularly when individual risk factors are identified.

This view is based upon the philosophy that an individual should have the right to undertake potentially risky recreational activities provided they do not excessively endanger others. The individual needs to be sure, however, that the risks are understood and that coercion or misrepresentation by others is not encouraging unwitting exposure to unacceptable risk. Many of the risks involved in diving are not intuitively apparent and those who supervise or stand to profit from recreational diving activities should have a vital interest in participation on the basis of informed consent - substantial liability could flow otherwise.

Regardless of one's view about which examining doctor role is appropriate, the desirability of suitable training for medical practitioners should be obvious. I believe that the AMA should take a stand supportive of appropriate training. Training is becoming more widely available and can hardly be opposed by a profession pursuing goals of quality assurance, professional development and continuing education.

Dr Ian Millar is an occupational physician specialising in diving, hyperbaric and environmental medicine. He is the AMA's representative on the Standards Australia committees responsible for matters relating to work in compressed air and recreational underwater diving.

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THE AMA'S POSITION

The AMA opposes unnecessary restriction and regulation of Australian medical practice. While there can be no question of the need for specialised training for doctors who treat divers suffering from specific diving-associated medical conditions such as otitic barotrauma and decompression syndrome, the case for requiring specific training to perform screening medical examinations is less conclusive. What is clearly necessary is a greater appreciation by doctors who perform such medicals of the absolute and relative contraindication for diving, also elicitation performance of thorough history and physical examination.

SPUMS' proposals are currently unworkable. The training courses are not subject to external quality assurance, continuing medical education requirements are not specified, and the courses' durations and locations make them inaccessible to the majority of Australian doctors.

Obviously, scuba diving is a recreational activity which is accompanied by considerable risk, but so are mountaineering, hang gliding, bungy jumping and rugby. There exists no legislative requirement for medical examination prior to participation in those activities, let alone for examination prior to participation in those activities, let alone for examination and certification by self-styled medical "experts" in the risks associated with them.

Dr Peter Wilkins
Assistant Secretary General

Reprinted by kind permission of the Editor, from AUSTRALIAN MEDICINE 1993; 5 (15): 17

The Editor,
Australian Medicine.

DIVING MEDICINE COURSES

I was saddened to read "The AMA's position" (on training doctors before they do diving medicals) by Dr Peter Wilkins (Australian Medicine 1993; 5: 17).

Above his letter were printed extracts from the AMA Code of Ethics, yet his letter ignores the first which read "Practise ....within the limits of your expertise". His first paragraph can be summarised as "The AMA recognises doctors need special training to understand the effects of pressure on the human body. Nevertheless we are not going to say so."

His second paragraph is flannel. No training courses of the Royal (and other) Colleges are subject to outside assessment. They are subject to internal (College) assessment. Very few Medical Colleges have continuing education requirements. And if the locations and durations of the courses make them inaccessible to the majority of Australian doctors, the same applies to all the well attended meetings that occur every year, especially those run outside Australia.

Having had to abandon his previous claim that aviation medicine training is not required before doing aviation medicals, he is now comparing diving with bungy jumping, hang gliding and rugby ! In none of these is the participant immersed or subjected to large changes in ambient pressure. To have any degree of competence when advising budding divers, one does need to know what one is talking about. Which means having done a course to find out.

Those who run courses in diving medicine, all of whom are either Consultants to the Royal Australian Navy or appointed to direct a Hyperbaric Medical Unit by the Board of their Hospital, which acts on the advice of a Medical Advisory Board, have every right to be offended by being classified as "self styled medical "experts" ". However I do not expect them to sue Dr Wilkins, the AMA and Australian Medicine for libel. They will merely shrug and think "As we feared, the AMA still more interested in doctors' incomes than patient safety.".

Furthermore Dr Wilkins ignores the article by Dr Ian Millar, the AMA's representative on the Standards Australia diving committees, which appears on the same page. I agree completely with Dr Millar's views.

It really is a pity that the AMA cannot bring itself to act on its expert's (Dr Millar's) advice and recommend appropriate training before doing diving medicals.

Dr John Knight

LONG TERM HEALTH OF DIVERS

Carl Edmonds

A conference/workshop on the long term health of divers was held in early June, with attendance by invitation, on the spectacular island of Godsund, in a fiord off the coast of Norway.

The intent of the meeting was to reach consensus regarding the damaging effects of diving, especially as they apply to the North Sea Oil Rig divers. This latter qualification came as a surprise to many of the delegates, who initially thought we were referring to all divers.

Consensus on such a controversial subject was, of course, difficult to reach. Nevertheless it was achieved as regards the following:

1. Norway is a spectacular country;
2. Godsund is an ideal location for a meeting;
3. The Norwegians are good drinkers.

From then on it became more contentious.

There was also consensus amongst all the participants, other than Norwegians, that the Norwegian government had made a wonderful coup in obtaining the world's leading experts in various fields to advise on the problems of diving, and to make recommendations regarding the prevention of these, whilst avoiding the necessity of paying consultancy fees. Not even a peppercorn, but we did get a colourful umbrella, advertising NUTEC.

Despite the above, it was an extremely productive and interesting meeting, brilliantly chaired by Drs Mike Halsey and David Elliott - fresh from their recent success as technical consultants to the movie *Silence of the Lambs.*

In attendance were experts in otology, Joe Farmer (USA), Otto Molvaer (Norway) and Edmonds (Australia), and in brain damage from diving, Nyland and Vaernes (Norway), Curley (USA), and Edmonds (Australia). There were other presentations related to neurological investigations, by Evans and Sedgwick (UK) and Massey (USA).

Other experts were also there, in respiratory disorders, Denison and Reed (UK), Thorsen (Norway), and Gulyar (Ukraine); in mortality and autopsy studies, Calder and McCallum (UK) and Mork (Norway). There were some excellent papers on the HPNS by Rostain (France), Bennett (USA) and others. Retinal angiography studies were reviewed by Murrison (UK), and the frequency of vascular bubbles by Brubakk(Norway).

My self-appointed task was to try and keep them honest; or failing that, to keep them on their toes.

It needed the brilliance of Mike Halsey to bring all this together, and on the side lines there was a school of Norwegian herrings from the government and the oil companies, together with observers. The latter groups were not allowed to contribute, and in any case they would have found it impossible to get an extra word in.

The proceedings were taped and the comments made by some of the delegates, regarding the quality of work of the others, will be a fruitful source for litigation for years to come.

Dr Carl Edmonds' address is Diving Medical Centre, North Shore Medical Centre, 66 Pacific Highway, St. Leonards, New South Wales 2065, Australia.

SPUMS ADDRESS

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

All correspondence,
addressed to the office holder concerned,
should be sent to
SPUMS, C/o
Australian and New Zealand College of Anaesthetists,
Spring Street, Melbourne
Victoria 3000, Australia.

SPUMS NOTICES

CONSTITUTIONAL AMENDMENT.

The following motion was passed by the 1993 Annual General Meeting. *That the words "30th June" appearing in rule 2 (a) be changed to "31st December"*.

Any member objecting to this motion should notify the Secretary of SPUMS, in writing, before November 1st. If there are no objections it will be assumed that the membership approves the motion and the Rules of the Society will be amended. If an objection is received a postal ballot of members will be held.

Cathy Meehan
Secretary of SPUMS

SPUMS ANNUAL SCIENTIFIC MEETING 1994

Rabaul, Papua New Guinea

MAY 14th to 23rd 1994

Call for papers

The theme of the meeting will be "The causes and management of diving accidents". We wish to address such issues as diver retrieval from the water, the in-water management of the unconscious diver and whether EAR and CPR should be attempted in the water. The guest speaker will be Dr Peter Bennett, co-author of The Physiology and Medicine of Diving. There will also be a workshop on dive computers.

If any member or associate wishes to present papers on these topics please contact the Convener, **Dr Chris Acott**, as soon as possible at

1 Landscape Crescent, Highbury, South Australia 5089.

Rabaul has some of the world's best diving. It was a Japanese fortress during WWII so it has a lot to offer those who are interested in the history of WWII. A pamphlet about the meeting, Rabaul and its diving and a booking form are enclosed with this issue of the Journal.

For further information contact **Allways Travel**

168 High Street, Ashburton,
Victoria 3147, Australia.

Telephone

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

Fax

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

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 SPUMS EXECUTIVE MEETING (TELECONFERENCE) HELD ON APRIL 18th 1993 AT 1000 EST

Apologies

Drs D Wallner and A Slark

Present

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

1 Minutes of the previous meeting

These were accepted as a true record.

2 Business arising from the Minutes

2.1 PALAU ASM

The costs of the meeting were discussed. Allways Travel have been unable to provide adequate details of how they arrive at the registration fee which covers the guest speaker's travel and accommodation as well as the official functions. It was decided that the President shall write to Allways Travel expressing the Committee's dissatisfaction with the inadequate details provided. Allways Travel will be asked to attend the next committee meeting, in Palau, to receive a list of requirements to be met before the Committee will approve the registration fee for 1994. If these requirements are not met before 31/8/93 the Committee will put the 1994 ASM, in Rabaul, out for tender.

Dr Guy Williams reported that pharmaceutical companies had shown little interest in sponsoring the Palau ASM. This could be because their advertising budgets are fixed well ahead. He will try again before their next budgets. SAAB have been enthusiastic and promised $ 5,000 for this year. The dive industry has, on the whole, not been sympathetic to SPUMS but he has been able to obtain some $ 3,000 of diving gear to give away as prizes.

It was decided that the program for the Palau ASM would not be on Allways Travel headed paper but would be in the format of the Diving Doctors Lists with SPUMS prominently displayed. It was decided that the SAAB $5,000 should be used to provide some free drinks at the conference dinner.

2.2 PNG ASM PROGRESS

The dates are May 14th to 22nd 1994. David Pennefather no longer lives in PNG and has declined the invitation to lecture.

The costs (using 1993 prices), ex-Sydney, for flights, transfers, accommodation for 8 nights including breakfast and dinner and a ten tank diving package will be approximately $2,725. Non-divers will pay approximately $590 less. The suggested registration fees are $690 and $490.

2.3 FUTURE ASMs

Dr Sue Paton requested that the speakers for at least the Solomons meeting be chosen so that she could get firm quotes for this meeting. Dr Gorman requested the Committee to produce the names of prospective speakers and topics for workshops to be discussed at the next meeting.

3 Treasurer's Report

There is approximately $50,000 in the bank. Quarterly costs continue at about $11,000. The North American Chapter has been sent its regular quarterly reimbursement of $US 500. However there have been no letters from them since the last meeting.

4 NASDS Journal costs

Before Dr Paton could write explaining the decision to charge an economic rate NASDS had written to the Editor cancelling their order.

5 Correspondence

Dr Knight has had a reply from the AMA to the his article in the September-December 1992 Journal. This has been pruned and published in the January-March 1993 Journal with Dr Knight's reply. A further reply has been sent to the AMA detailing some disasters due to medical parents overriding diving medical advice.

Also Dr Knight has submitted to *Australian Medicine* an article putting the case, on ethical grounds, for doctors to have training in diving medicine before doing diving medicals.

8 Other Business

8.1 DIVERS AGED 12-16

The SPUMS position on divers aged 12-16 is detailed in A4.2 of the SPUMS Diving Medical, published March 1992.

8.2 JOINING DELAYS

Various members raised the delays which occur between applying to join SPUMS and receiving acknowledgement. It is hoped that these departures from the ideal will be fixed up when the new Secretary takes over from Dr Wallner.

8.3 FAX MACHINE FOR TREASURER

It was decided that, in the interests of efficiency of communication, the Treasurer should buy a fax machine.

8.4 CHANGE OF NAME FOR DES

Dr Williamson said that the DES phone system is now to be known as DES/DAN and that from 1/1/94 it will become DAN Australia, part of IDAN (International Divers Alert Network).

8.4 CONTINUING MEDICAL EDUCATION (CME) CREDITS

Dr Williams said that he had applied to the RACGP for the Palau ASM to be recognised for CME credits and expected that this would be agreed to. Dr Gorman pointed out that the South Australian branch of the RACGP, when approached about CME credits for the RAH diving medicine courses, had stated that diving medicine was not part of general practice.

8.5 QUEENSLAND DIVING INDUSTRY WH&S COMMITTEE

Some of the Committee had had a letter from the Queensland Diving Industry Workplace Health and Safety Committee requesting information and advice about Emergency Swimming Ascent Training (ESAT). The covering letter from David Windsor, the Chairman, had included as present at their last meeting Dr Ian Millar had represented SPUMS. Dr Knight said that he had spoken to Dr Millar about this and that Dr Millar had not called himself a SPUMS representative. It was a mistake by Mr Windsor. Dr Gorman will write to Mr Windsor pointing out that Dr Millar is not a SPUMS representative.

9 The next meeting will be held at the Palau Pacific Resort on Monday, May 17th at 1600 .

John Knight
Editor, SPUMS Journal

MINUTES OF THE SPUMS EXECUTIVE MEETING HELD AT THE PALAU PACIFIC RESORT ON 21ST MAY 1993 AT 1545

Present

Drs D Gorman (President), S Paton (Treasurer), D Davies (Education Officer), C Acott, G Williams, J Williamson, L Barr, S Dent (North American Chapter) and C Meehan (proposed Secretary).

Apologies

Drs J Knight, A Slark and D Wallner.

1 Minutes of the previous meeting

Motion "That the minutes be accepted as a true record." Proposed J Williamson, seconded S Paton. Carried.

2 Business arising from the minutes

2.1 PALAU ASM

The letter written by the President to G Skinner of Allways Travel about costing the registration fee was circulated. It was decided that increased accountability was necessary and that Allways should keep a separate account for SPUMS. It was confirmed that there would be a open tender for the 1995 meeting. This would be judged on the cheapest but on the best. It would be an honest tender.

Dr Williams was thanked for his efforts in obtaining sponsorship. SAAB has donated $5,000 and the manufacturers of Spare Air $1,000.

2.2 PNG ASM PROGRESS

Dr Acott said that there would have to be strict control of the diving with divers ranked in grades of experience. The dive sites would also be ranked in grades of difficulty.

The themewill be the cause and management of diving accidents.

The workshop will be on decompression computers. It was suggested that more time should be allocated to this, perhaps even 50/50 split of time for lectures and workshop.

Registration fee costing includes, audio visual equipment, one business class air fare for the guest speaker and land costs for the speaker and spouse, Russell Kit will get one of the FOC, an itemised account for the rest of the costs will be provided by Allways and the budget will be based on 110 delegates.

2.3 1995 ASM

The theme will be Fitness to dive. Choice and number of speakers, possibly Fred Bove or David Elliott, and topic for the workshop will be discussed at the next committee meeting.

3 Treasurer's report

There has been increased income from the increased subscriptions and less expenditure in all categories, except bank fees. It is difficult to compare with last year because of the change in financial year.

4 Correspondence

Discussion of Dr Gorman's letter of 22nd April 1993.

5 Next meeting

A teleconference will be held at 1000 Eastern Australian time on 18th July 1993.

Cathy Meehan
Secretary

MINUTES OF THE ANNUAL GENERAL MEETING OF SPUMS held at the Palau Pacific Resort on May 22, 1993 at 1830

Apologies

Drs John Knight, John McKee, Harry Oxer, Tony Slark and Darrell Wallner,

Present

All members attending the Annual Scientific Meeting.

1 Minutes of the Previous Meeting

Minutes of the previous meeting have been published.

Motion. "That the minutes be taken as read and are an accurate record." Proposed Dr David Davies, seconded Dr Chris Lourey. Carried.

2 Matters arising from minutes.

There were no matters arising.

3 Annual Reports

3.1 President's Report (printed on page 152).

3.2 Secretary's report (printed on page 152) was read by Dr Sue Paton.

3.3 Editor's report (printed on page 153) was read by Dr Guy Williams.

3.4 ANZHMG report (printed on page 154).

4 Annual Financial Statement and Treasurers Report.

(printed on pages 154 and 155).

5 Fix the subscription for the coming year.

Motion. "That subscription rates for 1994 shall remain the same as for 1993." Proposed Dr John Williamson, seconded Dr Tim Wong. Carried.

6 Election of Office Bearers

As the number of nominations equalled the vacancies the following were declared elected.

President	Dr Des Gorman
Secretary	Dr Cathy Meehan
Treasurer	Dr Sue Paton
Editor	Dr John Knight
Education Officer	Dr David Davies
Public Officer	Dr John KnightCommittee
Members	Dr Chris Acott
	Dr Guy Williams
	Dr John Williamson

7 Appointment of Auditor

Motion. "That Mr D.S.Porter be reappointed as auditor." Proposed Dr David Davies, seconded Dr Lori Barr. Carried.

8 Business of which notice had been given

8.1 CONSTITUTIONAL AMENDMENT

At the 1992 Annual General Meeting it was agreed to change the financial year to January to December. The Society had been using a Financial year that ended on 30th April. However the Rules of the Society contain the definition *"Financial year" means the year ending 30th June*. In order to abide within the Rules this definition will have to be changed.

Motion. "That the words "30th June" appearing in rule 2 (a) be changed to "31st December"." Proposed Dr George Westlake, seconded Dr Chris Acott. Carried.

This motion now has to be put to the general membership for a postal ballot. This will only be held if a member lodges an objection to the motion, in writing, with the Secretary before November 1st 1993. If no objection is received the motion will be assumed to have been accepted by the members and will come into effect.

6.2 LIFE MEMBERSHIP

On behalf of the committee Dr David Davies gave a tribute to Dr Knight highlighting his time as a founding member and having served on all positions on the committee. He then proposed the motion.

"That Dr John Knight be given Life Membership."

Seconded Dr Mike Davis. Carried.

Dr Knight was welcomed by everyone as a life member to SPUMS. Dr Knight is now the fourth life member. The others are Dr Carl Edmonds, Dr Douglas Walker and Dr Chris Lourey.

There being no other business the meeting closed at 1920 .

A presentation on Papua New Guinea, the site of the 1994 ASM, by Dr. Chris Acott followed the meeting.

PRESIDENT'S REPORT

It is my pleasure to present this, my third, report as the Society's President. The pleasure is increased in comparison to that of last year by not having to report any financial difficulties or to propose any increases in fees. I would like to divide my report into comments on our Secretariat, Journal, Diploma and Annual Scientific Meeting.

Secretariat

Our Secretary, Dr Darrell Wallner, retires at this meeting. Darrell was prepared to take on this position at a time when no other candidate was available and on the condition that it was acknowledged as temporary. In the end, his tenure has not been temporary and he has performed the duties of the Society's Secretary with enthusiasm, diligence and competence. We owe Darrell a considerable debt, especially given the difficult milieu in which he has had to operate. On behalf of the Society I would like to thank Darrell publicly for his period of service.

It is also an appropriate opportunity to welcome our new Secretary, Dr Cathy Meehan. Welcome aboard Cathy.

Finally, I cannot comment on our Secretariat without acknowledging the performance of Dr Sue Paton as our Treasurer. She has taken control of our finances and I am now confident of the Society's fiscal future.

Journal

The Society's Editor, Dr John Knight, is unable to attend this meeting. Nevertheless his sterling efforts and the ongoing high quality of the Journal reflect considerable merit on John, the Journal and the Society. I sincerely hope that John continues to function as our Editor and the he will continue to get the support he deserves from people such as Dr John Williamson.

Diploma

The Society's Diploma in Diving and Hyperbaric Medicine has been awarded to two more members in the last year. These were Martin Hodgson and Christopher Butler. On behalf of the Society I would like to congratulate these new Diplomates.

Annual Scientific Meeting

Several years ago we changed our Annual Scientific Meeting (ASM) to a theme basis. I believe that this has been successful. This year we added a Workshop as a vehicle to develop Society Policy. By contrast in the past we have asked one or two members to produce policy statements. I am sure that you will agree that this innovation is worth retaining.

This year we have our first sponsors, SAAB Australia and Submersible Systems Inc., the manufacturers of Spare Air. I have great pleasure in acknowledging their generosity and thank them here, before you all and on your behalf, for their donations.

This year's meeting has also been well attended by our North American members. In that context, I would like to pass on our appreciation to Dr Lori Barr and Mr Steve Dent and to thank Dr Ray Rogers publicly for catalysing the formation of the North American Chapter. An enthusiast, he retired during the year from the position of Chairman of the Chapter. We hope that Ray will continue to be involved and to attend our meetings.

I also wish to remind you of our future ASMs. Next year we meet in Rabaul, Papua New Guinea. Dr Chris Acott is the Convener and Professor Peter Bennett is our guest. The theme is the Causes and Investigation of Diving Accidents. The workshop will be on decompression computers. In 1995 our meeting is in the Solomon Islands again and the theme is Diving Fitness.

Conclusion

Before I close the meeting I wish to thank my listeners for their indulgence, the members of the Committee for their hard work during the year and Allways Tours for bringing us here. I look forward to seeing you in Rabaul next year.

Des Gorman
President

SECRETARY'S REPORT

This has been a busy year mainly due to our decision to eliminate our Secretarial Service to reduce costs. This resulted in all our mail being forwarded to me directly from our official mailing address, without any preliminary sorting.

Now our official address is care of the Australian and New Zealand College of Anaesthetists, Spring Street, Melbourne, Victoria, 3000. This occurred because the Australasian College of Occupational Medicine became a Faculty of the Royal Australian College of Physicians and its office moved to Sydney. Our new address appears to be working smoothly and seems to direct mail to the Treasurer or Secretary fairly accurately, thus saving a lot of double handling and saving the Secretary a lot of time.

Membership figures

	December 1992	March 1993
	1,209	**1,244**
Australia	816	844
Full Members	535	
Associates	262	
Corporate	19	
New Zealand	143	144
Full Members	113	
Associates	30	
North American Chapter	173	175
Full Members	121	
Associates	48	
Corporate	4	
Overseas Members	77	81

During the six months July to December we processed 156 new or reinstated members. These figures represent an steady growth in membership. However this is an underestimate since it does not include subscriptions that were late in renewal due to our changed subscription year, now January to December. Our Society is very healthy.

Diving Doctors List

The concept that practitioners involved in examining prospective divers should have done an approved course in Diving Medicine is increasingly being accepted at the medical as well as the Diver Instructor level. This is evidenced by increasing numbers of enquiries regarding Courses, and Instructors asking about qualified doctors in their area, so I believe the message is getting through.

However, this philosophy is not universally accepted. Despite considerable correspondence, the Federal AMA has not supported our view inspite of the situation that doctors examining pilots now are required to have done a suitable course. However I believe that recognition at this level would be valuable.

In March 1993 we had 336 accredited members on our Diving Doctors List, though in some cases we are still seeking details to allow us to publish the full list with the Journal. We will also supply this list to the various Dive organisations for distribution to their various members.

The New Zealanders will be pleased to learn that we can now publish a much more complete list of their accredited members.

These lists are now being kept by our Treasurer (the price of having the computer!).

Teleconferences

We have had four this year, one of which our North American Chapter participated. These are enabling the Executive to run an increasingly large Society economically and effectively

There only remains to thank my fellow Committee members for their help over the past two years and to wish Cathy Meehan, our new Secretary, good luck in her new position.

Darrell Wallner
Secretary

EDITOR'S REPORT

This year we started volume 23 of the SPUMS Journal (or Newsletter as it started life). We hope that by the end of the year we will have an index to the first 22 volumes in your hands. As it is based on the Editor's collection of Newsletters and Journals we hope that his magpie instincts have resulted in a full set.

In response to the financial problems of 1992 it was decided that the Journal should get quotes from many printers and find a cheaper printer. It takes time to get to know a printer's likely mistakes and we have not yet sorted out the new printer !

We have had a good supply of papers offered to the Journal in the last 12 months, but we have very few in the pipeline at the moment. All members and associates are asked to send in case reports and report incidents, whether successfully coped with or not, so that all our readers can benefit from their experiences.

One of the important papers we have published in the last 12 months is "Neuropsychological problems in 25 divers one year after treatment for decompression illness" by Allan Sutherland, Andy Veal and Des Gorman. They have quite properly drawn our attention to the, sometimes crippling, mental changes which sometimes follow decompression illness. This paper came about because Allan, who had helped treat the divers, had a number come back with unexpected problems. He has also raised in the Letters to the Editor what he calls "The over-dived syndrome" which includes tinnitus and some mental slowing.

We know that the syndrome is not confined to New Zealand. We hope that those who recognise Allan's findings in themselves or their patients will make the effort to put their thoughts on paper, preferably including some statistics about the number of dives they have done, and send them to the Editor for forwarding to Dr Sutherland.

John Knight
Editor

TREASURER'S REPORT

At the end of my first year as Treasurer, I will sum up the job as challenging.

I inherited the newly purchased computer, which to quote Graham Barry, our previous Treasurer, was "to make the job ... less onerous, so that one no longer needs to be retired to do it." I still look forward to achieving that aim.

One of the first areas of concern I targeted was the need to ensure that an accurate and comprehensive data base of the 1,247 members was completed, which I hope will surmount the problems that some members have experienced this year. On behalf of the Society, I apologise for any inconvenience caused by our previously old fashioned labour intensive accounting system, the change of address for the Society and change of Treasurer, which coupled with the scrapping of the secretarial service (decided last year to be poor value for money) have resulted in a merry-go-round for some of our mail.

Because of these problems there has been considerable leniency this year with unfinancial members who have continued to receive journals from July 1992 until March 1993, when this service was discontinued to the 13% remaining unfinancial.

Maintenance of the list of doctors trained to perform diving medicals has also become the Treasurer's responsibility. Thanks to the form printed on the back of the published list, members who find themselves omitted from the list or showing an incorrect address or telephone numbers are now able to return the form appropriately corrected. Please note that corrections received on the Treasurer's desk less than six weeks beforethe publication date of the Journal will not be included.

Directing your attention to the audited statement of accounts before you for the eight months to the end of our new financial year 31 December, 1992 (printed overleaf on page 153)

Under itemised expenditure, the sum of $565 for advertising is a part of that spent prior to the 1992 Conference in Port Douglas to encourage increased registrations. Unfortunately we have no way of measuring the level of response to this.

The sum of $2,500 under "loan repaid" represents the final repayment to our previous Treasurer, Graham Barry of his loan to the Society shown in last year's accounts and the residual of costs incurred on the Society's behalf in purchasing the computer.

The North American chapter costs appear for the first time. They include repayment of the previous Chairman, Roy Rogers and the Secretary, Steve Dent for costs incurred, largely with promotion of the Society at the DEMA (Diving Equipment Manufacturers Association) show in 1992. The ongoing costs are in the order of $750 per quarter, primarily for mailing the journal to North American Chapter members, now by bulk air freight to Dr Lori Barr and Steve Dent, who then mail the journal in the USA, so that our North American members receive their journal within a month, without themselves or the Society incurring airmail costs. The increased cost to the society above that of the previous individual international surface mailing is in the order of $100 per quarter.

As the accounts this year represent only eight months (1/5/92-31/12/92) it is difficult to compare these with previous years. However I have compiled an unaudited set of figures for the 12 month period to end April 1993 to compare expenditure. These show a total expenditure in the vicinity of $42,000 compared with the previous 12 month period's $61,140 revealing the success of stringent cost cutting measures undertaken this year. In fact this is the lowest since the 1990 accounts. Costs were reduced in every category except bank charges, which have increased due to the 4% service fee charged on every credit card payment, a facility introduced early in 1992, principally to assist our overseas members with payment of their subscriptions.

I am pleased to report that the Society is now in a healthy financial state, especially compared to the same time last year, due to a combination of the increase in our annual subscription and the reduction in expenditure.

Sue Paton
Treasurer

AUSTRALIAN AND NEW ZEALAND HYPERBARIC MEDICINE GROUP REPORT

The ANZHMG, a standing committee of SPUMS, met at the inaugural Hyperbaric Technicians and Nurses Association (HTNA) Annual Meeting in Darwin where Dr Roy Myers, of Baltimore, was a highly successful guest speaker who spoke on a variety of topics including carbon monoxide poisoning. The meeting was a great success.

AUDIT REPORT TO THE MEMBERS
OF
THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY

I have conducted various tests and checks as I believe are necessary considering the size and nature of the Society and having so examined the books and records of The South Pacific Underwater Medicine Society for the period ended 31 December 1992 report that the accompanying Statement of Receipts and Payments has been properly drawn up from the records of the Society and gives a true and fair view of the financial activities for the period then ended.

David S.Porter FCA
Chartered Accountant

22nd July 1993

(Original report dated 5th May 1993 has been adjusted after missing documentation had been found so allowing accurate attribution of expenditure)

THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY
STATEMENT OF RECEIPTS AND PAYMENTS
FOR THE PERIOD ENDED 31 DECEMBER 1992

OPENING BALANCE					
ANZ bank	- savings A/c	136		6,023	
	- cheque A/c	20		2,963	
Cash on hand and stamps		-		221	
		156		9,207	
INCOME					
Subscriptions		76,161		48,785	
Interest		241		804	
Advertising and Journal Sales		1,443		-	
		77,845		49,589	
LOAN ADVANCED		-		2,500	
			$78,001		**$61,296**
EXPENDITURE					
Advertising 565		-			
Secretarial 6,838		13,098			
Stationery 889		2,930			
Journal		13,764		19,111	
Postage and facsimile		1,945		9,180	
Travel and phone conferences		827		3,136	
Equipment (is written off when purchased)		5,360		8,768	
Miscellaneous		457		2,087	
Bank charges		760		330	
Audit		500		-	
North American Chapter costs		2,876		-	
Donation to DES		-		2,500	
Loan repaid		2,500		-	
		33,746		61,140	
CLOSING BALANCES					
ANZ bank	- Access A/c	6,131		136	
	- Cash management A/c	1,017		20	
	- ANZ V2 PLUS	37,107		-	
		44,255		156	
			$78,001		**$61,296**

At the ANZHMG committee meeting it was proposed that the ANZHMG expand its role to being the Hyperbaric Medicine section of SPUMS. This section could conjointly organise annual on-shore meetings with HTNA, rotating through each of the Hyperbaric Medical Units in Australasia. Approval from both SPUMS and HTNA is currently being sought. ANZHMG will continue working closely with SPUMS and that the above proposed meeting will be a valuable additional meeting for SPUMS members with a specific interest in Hyperbaric Medicine.

The ANZHMG is also keen both to standardise and centralise data collection for hyperbaric medical patients and units. Although much has been done on this already, such data collection is not yet fully operational and it is intended to pursue it with renewed vigour. ANZHMG continues to have increasing attendance and activity and we are looking forward to meeting in Fremantle in 1994.

David Tuxen
Chairman, ANZHMG

LETTERS TO THE EDITOR

ACUTE SEVERE HYPOTENSION DURING THE VALSALVA MANOEUVRE

Hyperbaric Medicine Unit
Department of Anaesthesia and Intensive Care
Royal Adelaide Hospital
2/9/93

Dear Editor,

The need for prophylactic tympanic membrane fenestration (grommets) in patients undergoing hyperbaric oxygen (HBO) therapy is questioned. However barotrauma can limit the rate of compression, maximum depths attained and patient acceptance of further therapy. The following case illustrates an unusual adverse effect of the Valsalva manoeuvre.

A 46 year old female underwent a diagnostic mediastinoscopy. This was complicated by a sudden cardiovascular collapse towards the end of the procedure. The diagnosis of gas embolism was confirmed by echocardiography, which showed air in the right ventricle.

Pulmonary catheterisation showed severe pulmonary artery hypertension. She was then treated with HBO. After treatment she was extubated but remained confused and disorientated with poor short term memory. During a second HBO treatment she complained of pain in her ear. On gentle ear equalisation she developed severe hypotension, 40 mm Hg measured by direct arterial line, which returned to normal when the Valsalva manoeuvre was terminated. This happened twice on descent. Grommets were inserted before further HBO therapy and there were no problems on descent.

Her pulmonary artery hypertension was shown by angiography to be due to complete blockage of the right pulmonary artery and a 50% reduction in the size of her left pulmonary artery. Unfortunately she did not recover from pneumonectomy.

This case illustrates a potential complication of the Valsalva manoeuvre in a critically ill patient and underlines the importance of continuous arterial pressure monitoring in such patients during HBO treatment.

Mikal Kluger, FRCA
Staff Specialist

HTNA MEETING

42/16 Bardwell Road
Mosman
New South Wales 2088
14/9/93

Dear Editor,

The Hyperbaric Technicians and Nurses Association (HTNA) was recently host to the First Annual Scientific Meeting on Diving and Hyperbaric Medicine. The venue for this inaugural event was the Atrium Hotel, Darwin, Northern Territory, Australia. Guest speaker for the meeting was the highly respected Dr Roy Myers, Senior Staff General Surgeon and Traumatologist and Director of the Hyperbaric Medicine Unit at the Maryland Institute for Emergency Medical Service Systems in Baltimore, Maryland, USA. Day one centred on diving while day two concentrated on hyperbaric medicine. Day three saw the AGMs of both the HTNA and the Australian and New Zealand Hyperbaric Medicine Group (ANZHMG).

Papers were well presented by a wide selection of the hyperbaric fraternity and diving community. All Australian hyperbaric units were well represented. The topics covered during the two days were varied, ranging from diving in crocodile infested waters to hyperbaric oxygen for necrotising fasciitis.

Next year's meeting will be held on the 2nd, 3rd and 4th of September 1994 in Fremantle, Western Australia. the meeting is open to anyone interested in the subject of diving and hyperbaric medicine. Fort further details on next year's meeting or the HTNA contact Dave King, C/o Hyperbaric Unit, Royal Darwin Hospital, Casuarina, Northern Territory 0810.

John Brady

BOOK REVIEWS

THE PHYSIOLOGY AND MEDICINE OF DIVING. 4th Edition.

Editors Peter B.Bennett and David H.Elliott.
ISBN 0 7020 1589 X
Published (1993) in the UK by W.B.Saunders Co. Ltd.
In Australia by Harcourt Brace and Company, Australia, 30-52 Smidmore Street, Marrackville, New South Wales 2204.
Recommended retail price (Australia) $Aust 246.40.

This is an expensive book and is apparently being sold in Australia for more than the equivalent UK price. The reviewer has seen a British flyer for the book advertising a price of £80.00 which is only $Aust 192.00. However it is good value, even with five misprints in 613 pages. It continues the grand tradition of the first three editions, each of which was better than the one before. But don't throw your third edition out. It compliments this new edition with different slants on the much of the information. The fourth edition is much the same size as the third. Although there are 43 more pages there are fewer lines of text on each page. Perhaps it is just that my eyes are getting older but I found the new edition typographically less easy to read, although it uses the same type face as the third edition, but with thinner (less dark) letters on shinier paper.

It has been much altered from the third edition. Sixteen authors have been dropped due to death or ceasing activity while nine new ones have been added. The chapters on *A short history of diving*, *Design principles of underwater breathing apparatus*, *Hydrostatic pressure physiology*, *Liquid breathing* and *Isobaric gas exchange and supersaturation by diffusion* have been dropped. Much of their content has been added to the many rewritten chapters. Chapters on *Clinical hyperbaric oxygen therapy*, *The long term health of divers* and *Fitness to dive* have been added. Every chapter has extensive references.

The chapter on *Compressed air work* has a new author and different emphases as the new author is Eric Kindwall (USA) replacing Dennis Walder (UK). SPUMS Journal readers have had a preview of much of Glen Egstrom's chapter, *Scuba-diving procedures and equipment*, in the papers from the 1991 ASM. John Bevan's *Commercial diving equipment and procedures* has been rewritten and includes some of the information previously in the UBA chapter. It also includes hyperbaric rescue and lost bell procedures. Yancy Mebane and Norman McIver have written an excellent chapter on *Fitness to dive* covering both amateur and professional divers. There are case reports in the text but they are difficult to spot as they are not clearly differentiated. The fitness recommendations are conservative when dealing with diabetes and asthma. Oddly enough the hypertonic saline provocation test does not get a mention as an aid to assessing asthma.

Lanphier and Camporesi have rewritten large parts of *Respiration and exertion*. They have dropped the discussion of equal pressure points and the discussion of alveolar exchange has been shortened. Added is a discussion of dyspnoea at depth while the control of breathing, carbon dioxide and the effects of submersion have been updated. Page 100 sported the first misprint, pulmonar instead of pulmonary. The chapter on *Oxygen toxicity* by James Clark has been reorganised. The sequence of pathological changes has been dropped while the discussion of lung oxygen toxicity changes on lung function has been enlarged.

The chapter by Peter Bennett on *Inert gas narcosis* is basically unchanged from the third edition. A number of more recent references have been added. The chapter by Bennett and Rostain on *The high pressure nervous system* (HPNS) has not been rewritten to any extent but some 6 pages of deep dives, 2 on hydrogen-helium-oxygen mixtures and 4 on the origins and mechanisms of HPNS are quite definitely worthwhile additions. Unfortunately a paragraph present in the third edition about the Comex 450 m dive in 1979 has been left out of the fourth edition making the bottom paragraph on page 219 less than lucid, as it refers to the missing paragraph.

David Elliott and Peter Bennett have included sports divers in the chapter on *Underwater accidents*. My only grumbles are that the treatment of hazardous marine life is very brief and that there are two misprints (figure numbers) on page 240. *Management of diving accidents* is much changed by its new author, Des Gorman. There are considerable changes from the third edition. Instead of ploughing through the diagnoses in set order his approach is to have a logical progression from the accident to the final treatment. He discusses the difficult diagnoses and what to do with those whose consciousness is impaired or have the acute brain syndrome.

Joe Farmer's chapter on *Otological and paranasal sinus problems in diving* is hardly altered from the third edition. There are a few new paragraphs. New is a case of intracranial pneumocephalus due to middle ear barotrauma. The reviewer has some difficulty imagining the track followed by the air on its way into the skull as it is not described and there is quite a lot of bone between the middle ear and the inside of the skull. Also added are descriptions of alternobaric facial paralysis and recent studies of inner ear barotrauma. Dr Farmer recommends not operating for inner ear barotrauma, window rupture, until there has been no improvement after 24-48 hours observation. The reviewer's, admittedly limited, experience is that those who have their ruptured window repaired as an emergency get their hearing restored while those whose operation is delayed, even if they get some improvement, are left with a permanent hearing loss. I would like my operation as soon as possible if I ever suffered from an inner ear window rupture.

The chapter on *Thermal problems: prevention and treatment* has been rewritten by John Sterba. It now includes a discussion of the problems of the necessary heat loss in warm water and when wearing full protective clothing. It highlights the problems of overheating at work and when swimming. There is an excellent section on the treatment of heat exhaustion and heat stroke. There is a good section, quoting work up to 1991, on cold acclimatisation. There is a good discussion about hypothermia, though the old, and instructive, graphs and pictures from Pugh and Edholm have been consigned to the waste paper basket. Hempleman's chapter on the *History of decompression* is little altered from the third edition, even to the misprint on page 255 where compression is printed when decompression is meant. The discussion on isobaric counter-diffusion has been dropped. Nevertheless it is a must read chapter which explains a lot.

Ed Thalmann has joined Richard Vann as the second author for the chapter on *Decompression physiology and practice*. The result is rewritten chapter with a very interesting discussion of probability modelling. Nishi has rewritten the chapter on *Doppler and ultrasound bubble detection* making it easier to understand. James Francis and Des Gorman have written a new chapter for the *Pathogenesis of the decompression disorders*. My only disagreement with this excellent discourse is that the reason that excretion of gas is slower than uptake has been known to anaesthetists for some 30 years. It is a basic physical fact that uptake is driven by higher pressures than output and therefore, not surprisingly, output is slower than input. One also wonders why the authors have difficulty accepting that the most likely place for bubbles to form is where gas removal is least, in the tissues away from capillaries, which allows supersaturation to linger longer.

David Elliott and Richard Moon have rewritten *Manifestations of the decompression disorders* basing it on the new descriptive classification of decompression illnesses. Their wide-ranging description is easier to follow than the comparable chapter in the third edition. The *Treatment of the decompression disorders* has been rewritten by Moon and Gorman. They start with evaluation of the patient and carry him or her through to leaving the chamber. There is a useful table of published series of decompression illness, excluding those which were mostly arterial gas emboli.

On page 521 Table 18.3 is referred to for decompression instructions, but unfortunately there are two tables marked 18.3, the first is a series of graphs of bubble size, positioned correctly between 18.2 and 18.4. The other, which is the one referred to, is unexpectedly placed between tables 18.11 and 18.12.

Eric Kindwall has contributed an excellent chapter on *Clinical hyperbaric oxygen therapy*. However the chapter on *Dysbaric osteonecrosis: aseptic necrosis of bone* is little changed except for a few new paragraphs. This is not surprising as the UK Decompression Sickness Registry has been closed for 10 years, effectively preventing new work. Elliott and Moon contribute the last chapter on the *Long-term health effects of diving*. They discuss possible hazards, including the effects on the lungs and brain, the new imaging techniques, subfertility and general health. This chapter makes it quite clear that there is still a lot to learn about the effects of diving on humans.

To sum up this book should be read by everyone with an interest in diving medicine. It makes a good starting point for exploration of many topics by following up the references.

John Knight

SCUBA SAFETY IN AUSTRALIA.

Editors Jeff Wilks, John Knight and John Lippmann.

JL Publications, PO Box 381, Carnegie, Victoria 3163, Australia.

ISBN 0 9590306 7 0.

RRP in Australia, including postage, $Aust 29.00, overseas $Aust 39.00.

Since its first meeting on Heron Island in 1972, SPUMS has been vitally interested in the promotion of scuba diving safety. This book, edited jointly be John Lippmann, John Knight and Jeff Wilks, brings together the many facets of the subject and crystallises them into a single volume. Those members who have regularly attended the SPUMS Annual Scientific Meetings will recognise the contents of many of the chapters as having been based on papers presented in recent years.

As with all books with multiple authors there is an element of repetition of information. However this would only become onerous if the book is being read from cover to cover as I did. The authors of the many chapters are all well known in the diving community and their information is presented in an easily readable style.

The book is divided into four sections, the first of which covers an outline of the history of recreational diving in Australia and I was delighted to see that the seminal work of my mentor, Ted Eldred, in the development of the two stage single hose regulator was not overlooked. It was a great loss to this country that his design had to be sold overseas as there was insufficient finance available here for it to be fully developed and marketed.

Later in this section are chapters on the development of the Diver Emergency Service in which Des Gorman pulls no punches, emergency care and retrieval and a review of the hyperbaric chamber facilities available in Australia. I thought that the chapter on dangerous marine animals would have been better sited in section four along with other special topics such as women and diving, the role of SPUMS in medical education, diving and the law and decompression.

Section two has chapters on diver monitoring opening with Project Stickybeak, ever an unfortunate name. It is written by its progenitor, Douglas Walker, and is a review of the results over many years. The concept of this project was first class and the time spent on its development, maintenance and correlation has been enormous. For many years the interim reports published in the SPUMS Journal by Dr Walker were the only indications we had that diving was not completely accident free. The study was not exhaustive as it included only deaths from diving and not near misses. As Dr Walker states, "It would be far more satisfactory to learn about the problems which have been successfully managed" and this is a good lead in to the chapter by Chris Acott on the Diver Incident Monitoring Study in which he reports on the first 125 incidents collected by the team in Adelaide. Jeff Wilks concludes the section by discussing some strategies for preventing accidents.

The third section encompasses the training and education programs available for the various agencies and discusses some of the differences between them. There is no evidence that any one agency teaches safer diving practices than any other. It is my impression, as an outsider, that the same information is being taught by all the agencies, the only differences being in when and how it is taught. I agree with John Lippmann when he states that rescue and resuscitation skills are essential for all recreational divers and the earlier they are acquired the better.

Chapter 15 defines concepts such as "duty of care", "negligence", "contracts" and "liability", all of which become vitally important in the teaching environment and may be easily forgotten when there are commercial pressures to educate increasing numbers of students. There is a heavy responsibility falling on the shoulders of anyone who proposes to become an instructor or dive leader and it cannot be taken lightly.

This book must be read with an open mind. There is not one correct way of diving safely or of teaching diving safety and it is the responsibility of all divers to remain current with not only the latest equipment in their dive store but also the latest techniques in safe diving, diver rescue, resuscitation and first aid. This information can be gleaned from many sources such as the SPUMS Journal, Dive Log, dive magazines, refresher courses and the speciality courses run by your favourite agency.

Scuba safety in Australia present a comprehensive review of the many aspects of the research and teaching that are necessary to maintain and improve the standards of safety of recreational diving in this country. It is a book that should be recommended reading for all divers and compulsory reading for all entry level divers during their first course. At a price of $ 29.00 it is not a severe imposition on the pocket of any described in Jeff Wilks' chapter on the travelling diver.

David Davies
Education Officer, SPUMS

Continued from page 184

2. *Basic Cave Diving: A Blueprint for Survival* . **This book should be required reading for all technical divers** (Ed. technical Diver) and can be obtained from the National Speleology Society, Cave Diving Section, PO Box 950, Branford, Florida 32008-0950, USA.
3. As explained in "Basic Cave Diving," the original recommendation stemmed from the hazards of deep diving on air. Today it is generally recognised that deep air diving is hazardous. As a result, the emerging community standard is to discourage air dives beyond about 54-60 m (180-200 ft) depending on the operation and environment.
4. The US Navy is reportedly cutting back their oxygen exposure limits as are others. For example, the new DCIEM Nitrogen/Oxygen (EAN) tables classify working PO_2s of 1.5 - 1.6 ata as "exceptional exposures."
5. Agreements are still needed between the two enriched air training agencies, ANDI and the IAND, if there is to be a consistent set of national training and pumping standards promised at the Enriched Air Workshop held at Houston in 1992 January (See technicalDiver 3.1, 1992 July, for details).

For additional information on Accident Analysis read

Chowdhury Bernie. *Wreck Diving Accident Analysis, 1970-1990*. (in affiliation with The National Underwater Accident Data Center)

McAniff John J. *US Underwater Fatality Statistics, 1989, Report No. URI-SS12-91-22*. 1991.

For copies phone USA (401) 792-2980

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SPUMS ANNUAL SCIENTIFIC MEETING 1993

NEUROLOGICAL DEFICITS AFTER DIVING

David Elliott

Abstract

The residua of acute decompression illness are relatively obvious, their origin is not in dispute and they are not considered further in this context.

The neurological sequelae which have given rise to recent anxiety are those which might arise in an individual who has never had decompression sickness. The majority of allegations result from studies of neuropsychometrics, neurophysiology and neuro-imaging. Among possible causes for "abnormalities" are the "silent" bubble or the failure to recognise decompression symptoms. The High Pressure Neurological Syndrome (HPNS) has been blamed for some findings after very deep dives as has the "unmasking" of effects from an earlier head injury. Many of the conclusions are, at the very least, debatable. It can be concluded only that, while clinical vigilance must be maintained, there is as yet no evidence of long-term damage among those who dive within recreational limits and adhere to recommended diving procedures.

Introduction

The first case of neurological decompression illness was reported exactly 150 years ago.[1] Since then the neurological deficits which can occur after diving have been all too obvious. When a diver becomes paraplegic as a result of diving, whether he was diving in accordance with accepted procedures or whether he flouted them, the cause of his paralysis can be identified as one particular dive. The subsequent natural history is that, unlike paraplegia due to transection of the cord, the diving caused paraplegic, who has multiple discrete multi-level lesions, has a much greater chance of subsequent improvement. Indeed, the extent of functional recovery can be quite remarkable. Only rarely is there subsequent deterioration and this appears to be confined to those who are severely neurologically injured, whose ability to cope depends so much upon willpower and among whom a few may be unable to continue the required level of effort. The natural history of acute decompression illness (DCI) is that it may lead to neurological deficit, which might improve subsequently.

In the last few years there have been an increasing number of publications in the scientific literature which allege or report neurological deficits in divers as a consequence of their occupation. This has led to a number of articles in journals such as *The Economist* and *The New Scientist* with titles such as "Hidden Cell Damage Puts Divers in Peril" and "Diving Disease Linked to Brain Damage". The implication is that divers who perform normal dives and with no episodes of decompression illness, may progress to subtle neurological deficits.

These two extreme examples may be linked by the concept of "sub-clinical decompression illness" a condition in which bubbling and the associated haematological effects occur but which never produce sufficient symptoms to prompt the diver to seek recompression.

The purpose of this paper is to review the current status of so-called neurological long-term health effects. It is tempting to begin at the beginning, but there is not enough time. An excellent foundation is provided by the review by Edmonds and Hayward[2] which was presented to the Underwater Physiology Symposium in Japan. In this paper the authors demolish with accuracy the design of a number of papers which, nevertheless, are still regularly quoted. They concluded that more assessment is required even though their studies of the Australian abalone divers did not confirm any association between brain damage and excessive air diving.

In this review, the studies based upon the post mortem examination of divers will be summarised first. This is to demonstrate that there are indeed pathological changes associated with diving although, of course, these findings cannot tell us to what extent they might have affected the quality of life for the individual.

Pathology

Excluded from this review are those reports which focus on the changes found following acute decompression illness. Nevertheless it is worth taking as a starting point the case of a scuba diver who, in 1976, developed neurological decompression sickness with improvement upon recompression.[3] He was left with some weakness of his left leg and did not dive again. Some four years later the individual was examined by a neurologist at the University of Newcastle Upon Tyne as part of a study of divers. At this time he had brisk reflexes in both legs with clonus at the ankles and knees and showed an extensor plantar response. Together with some other signs, this led to a conclusion that there was residual cortico-spinal tract damage. A few days later, the patient died accidentally. At post mortem the changes in the spinal cord were more widespread than were suggested by the recent neurological examination, but were entirely compatible with the original manifestations at the time of recompression.

The conclusion is that a good functional recovery following neurological decompression sickness (DCS) could lead to the opportunity to be passed as fit to return to diving but would be associated with persistent damage to the central nervous system (CNS).

However, our concern is more with divers who, as far as one can tell from the records, had never suffered acute decompression illness during life. In a group of 11 divers, all of whom except 2 had died in diving accidents, Palmer et al.[4] described the changes which were compatible with the mode of death. But they did not stop there. The cords were also studied for tract degeneration using the Marchi method in which positive staining is not found until 7 to 10 days after the original insult. In 3 of the professional divers there was extra-cellular Marchi-positive material with a beaded appearance indicating myelin degeneration. However, no Marchi-positive material was found within the macrophages, indicating that the causative insult must have been less than about 10 weeks before death.

The implication that cord damage may follow apparently symptom-free diving was not supported by another study[5] which used immunocytochemical staining. The microscopic examination did not reveal signs of nervous tissue lesions or reactive changes in any of the spinal cord sections from 20 divers. While Mork et al. concluded that diving does not lead to lesions in the human spinal cord, they had not included the Marchi stain in their series. The Marchi stain is one developed for studies of neuroanatomy specifically to detect tract degeneration at an early stage and, until some cords are examined both by this method and by the standard immunocytochemical stains, this apparent contradiction will remain unresolved.

The same groups in Cambridge and Bergen have also examined the brains of divers. In a preliminary study Mork[6] found an increased incidence of corpora amylacea in the white matter, hyalinization of the blood vessels and some ependymal and periventricular changes in the brains of some divers. Similar findings have been reported in the brains of 25 divers by Palmer et al[7] with an additional 10 divers in a more recent study, control brain material was obtained from 15 male airmen who died as a result of flying accidents.[8] Hyaline degeneration of small arteries were found in 12 divers, small foci of necrosis in the cerebral grey matter of 8 and evidence of patchy white matter changes in 10 divers. As far as is known none of these divers had an episode of acute decompression illness.

From the very limited number of examinations performed on such material, the difficulty of adequate controls and some apparent contradictions, it is very difficult to draw conclusions but sufficient has been observed to suggest that the laborious task of histopathology in such subjects must continue. The concern is whether or not such findings were associated in life with any decrement of function.

Clinical examination

The meticulous neurological examination of divers is the foundation for any study of long-term effects. In spite of the earlier reports by Rozsahegyi[9] that there might be a progressive disseminated encephalopathy following acute decompression illness, it does need to be remembered that many of the persons whom he studied continued to work in compressed air. If they had reported subsequent manifestations, they were referred to him only if they lost 3 days' work. Under these circumstances, and in the absence of confirmation from any other sources, the hypothesis of progressive encephalopathy is not proven. The conclusions by Rozsahegyi in both clinical neurology and psychometrics, must be regarded with caution. Nevertheless he does describe two cases where symptoms apparently began with no history of previous decompression sickness, an observation which must cause us to examine divers with even greater care but, as yet, without finding a similar progressive illness.

Lehman[10] examined 23 divers who had had decompression illness and 23 non-diving seamen as controls. He found no evidence of any progression of the physical findings of some two to ten years before. It is also important to note that the 23 controls had "a surprisingly high number of neurological signs" although not so many as the divers. A study by Dolmierski et al.[11] of 150 professional divers does not contain enough detail from which to draw firm conclusions. Certainly, they report minor neurological lesions in some divers who are reported not to have had decompression illness, but the value of this paper is to alert us to a problem which needs to be evaluated.

Norwegian professional divers have been studied in great detail.[12] One hundred and fifty six divers were compared with a 100 age-matched non-diving controls. Unfortunately the examinations were conducted unblinded, after the diving medical history had been taken. Also, the criteria used for the label "DCS" were not those used in other studies. If the divers reported fatigue, mood lability, irritability, concentration or memory problems such as inability to remember appointments, this was considered as evidence of a decompression deficit. Autonomic nervous system symptoms included palpitations, diarrhoea and constipation, excessive sweating and sexual dysfunction and each was also considered evidence of decompression sickness. The physical examination recorded, as positive: increased postural tremor, modified Romberg and reduced sensation in the feet. No specific syndrome was detected but, when all the isolated symptoms and signs were added numerically, there was a preponderance in the diving population. As the majority of these divers continued to dive, the significance to the individual of these findings, though statistically significant, has yet to be fully understood. Further discussion of these and other papers is available in Evans and Shields[13] and Elliott and Moon.[14]

Neuropsychometric investigations

One must be ruthless and exclude the many anecdotal reports of divers who suffer mental impairment and behavioural changes following deep dives in particular. The stories may be true, but there are many confounding variables and no reliable control studies. Indeed, little that is new has been reported since the review by Edmonds and Hayward.[2] Curley[15] found some transient alterations in 25 Navy divers following saturation but with no evidence of neuropsychological abnormalities. In contrast, Vaernes et al.[16] studied 64 deep saturation divers and 32 experienced divers who were only just commencing saturation diving. The authors found some mild-to-moderate changes which could be interpreted as random variations but they state that these could also represent some specific abnormalities. They conclude that their findings are broadly in agreement with Curley[15] in that no major deterioration was evident. Nevertheless they suggest that their more meticulous examination might indicate the presence of a mild pathological process which cannot be detected by standard neurological examinations.

A study of 282 commercial divers and 182 non-diving controls[17] suggested that there is an impairment of cognitive function in apparently healthy divers who have experienced decompression sickness. In those without previous decompression illness there was some evidence of impairment memory and non-verbal reasoning but these changes were interpreted as related to age and not to diving. There was no evidence of clinical personality change associated with diving experience and they conclude that less than 10% of the total decline in divers with no history of decompression illness is due to their diving. The report does not detail the control of, for instance, IQ, head injury or alcohol history and the previous educational attainments of the divers and non-divers was not matched in the major study.

Thus the evidence relating to neuropsychometric changes in diving is not strong but, once again, there is sufficient "smoke" to justify a properly constructed longitudinal study.

Diagnostic imaging

The advances in diagnostic technology over the last two decades has made available to occupational medicine a number of techniques, designed for hospital use, which permit imaging of parts of the CNS not previously observed. The proper approach to problems in occupational health is to construct an hypothesis on the basis of clinical observations and to use whatever techniques are available for the subsequent investigation. In contrast the approach over the last ten years seems to have been one in which a new technique has become available so "lets try it on a bunch of divers to see what it shows". The results have been rather like going through a hedge backwards: ragged with an inability to see ahead.

A MRC workshop on diagnostic techniques in diving neurology concluded that the use of X-ray computerised tomographic scanning (CT) had no place in screening for long-term neurological effects in divers.[18]

Magnetic resonance imaging (MRI) has a much greater potential. Like CT, it was first used in cases of decompression illness but in a study of 156 divers with 100 controls[19] found that up to 33% of all divers had high signal intensity changes whereas these were present in 43% of the control subjects. A very similar study by Rinck et al.[20] came to a similar conclusion. Rinck[21] has challenged conventional diagnosis in these circumstances. He concludes that, despite the fact that several million MRI brain examinations have been performed all over the world during the last decade, ranges of normality still have not been set. He also says that selecting a control group for clinical studies may be a more difficult task than is generally thought, particularly if such a group's range of normality has not been determined and that the results of such studies may have to be interpreted *cum grano salis.*

The use of single photon emission computed tomography (SPECT) and, in particular the use of $^{99}Tc^{m}$ HMPAO was described by Macleod et al.[22] and Adkisson et al.[23] The first use of this technique was in submarine escape trainees with a known episode of cerebral gas embolism. The subsequent use of this technique in divers following acute decompression sickness has led to some uncertainties about interpretation.[23,24] Basically this is because there appears to be no correlation between the four unusual patterns described in the divers with their decompression history[24] and no adequate control series to determine the range of normality.[25] HMPAO is a lipophilic amine which is bound by the cerebral tissue on the first pass through the cerebral circulation after injection. The images from the gamma camera are an indication of perfusion and not of specific anatomical or functional deficits.

It is unfortunate that the techniques used are not standardised between different diagnostic centres. This means that different studies adopt different diagnostic criteria. So no multi-centre comparisons appear to be valid. Studies using HMPAO in a healthy diving population are not likely to be extensive because most centres regard the use of this radioactive marker in apparently healthy persons as unethical. From this it follows that from evidence of long-term neurological deficits is unlikely to come from using this technique. The higher resolution of positron emission tomography (PET) is being evaluated in some divers after HMPAO but has yet to be used in divers with no history of decompression illness.

The use of retinal fluorescein angiography to examine the fundi of divers has been reported by Polkinghorne et al.[26] This pilot study investigated 84 divers and 23 non-diver controls. The findings were statistically significant with 22% of divers developing pigment changes in their first year of diving but the significance of this is uncertain. Nevertheless the prevalence of pigment changes was 36% in all divers without decompression illness and 92% in divers with a history of decompression illness. At the posterior pole of the eye in divers, there were also dilated arteriolar terminals and microaneurysms, but none in the non-divers. No subject had any loss of visual acuity and the observed changes are often seen in older individuals. Once again, longitudinal studies are needed.

Electrophysiological investigations

The use of the spontaneous electroencephalogram (EEG) and of evoked action potentials has, like other investigations in this field, began with the study of persons who had suffered acute decompression sickness. To use the electroencephalogram in a study of apparently healthy divers needs careful definition of procedure and of diagnostic criteria.[27] Abnormal signs are at best only a possible indicator of pathology which needs to be supported by other evidence. Nevertheless the finding of some EEG changes in a proportion of symptom-free submarine escape trainees does suggest its potential for the detection of sub-clinical abnormalities due to embolism.[28] A study of 21 divers with a history of decompression illness and 37 naval diver controls in Finland[29] found that 57% of the dysbaric group had abnormal EEG findings compared with 21% of the control group.

In a larger study by Todnem et al.,[19] 18% of the divers and 5% of the controls showed abnormal EEGs. The abnormal EEGs were correlated with saturation diving and neurological decompression illness. Because saturation divers more frequently had abnormal EEGs, even in the absence of a history of decompression illness, led the authors to advocate the use of the EEG in the periodical health examination of deep divers. This may be a useful baseline but they do not offer a definition of pass/fail criteria without which the examination has limited value.

A number of studies using evoked responses during and after acute decompression illness have shown that the changes can be significant, but there have been few studies in divers with no such history. The view that the somatosensory evoked potential (SSEP) is less sensitive than a careful neurological examination in detecting abnormalities in divers with the effects of decompression illness[30] is not necessarily relevant to studies of SSEP in the research laboratory where the technique can be more precisely controlled.

Conclusion

Does diving damage your brain? One must agree with Calder[31] that there is positive proof that cerebral vasculopathy develops in divers who are fit for work. The mechanism is somewhat speculative but one possibility is that a primary provoking agent must be damage to the blood vessel wall by a bubble. These changes are subtle but may contribute to an acceleration of the continuous process of degeneration that occurs with aging.[32]

There is only one conclusion. Although the evidence for functional deficits in divers with no history of decompression illness is very slender, there are theoretical mechanisms that would account for such changes. As there are relatively few professional divers in any nation's working population, the annual medical examination of each needs to be recorded not only meticulously but also centrally for the purposes of longitudinal epidemiology. Indeed a proposal for an international divers' medical registry was made by the European Diving Technology Committee some 20 years ago. Since then, the UK Health & Safety Executive has discontinued the Decompression Sickness Registry in Newcastle so that no longer is one able to see how the changing patterns of commercial diving affect diver health. Of course, such studies, whether within a registry or whether as isolated investigations, would be expensive. Against that expense must be balanced the benefits to the community which are brought by the professional diver who, for the foreseeable future, will not be replaced by unmanned robots.

For sports diving, the data is equally unknown but, the risks of long-term damage are probably less than those of an acute incident. So, in closing, may I wish that all your bubbles remain silent.

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OUTCOME AFTER TREATMENT FOR DECOMPRESSION ILLNESS IN AUSTRALASIA

Des Gorman and Maurice Harden

Abstract

In the decade, 1983-1992, there were at least 20 published reports of series of Australasian recreational divers who were treated for decompression illness. These series have been reviewed. With one exception they were retrospective and none were controlled. Only two series reported the type and severity of sequelae. Nevertheless, it would appear that conventional treatment regimens are often unsuccessful in controlling such decompression illness and that many divers are left with depressed mood and disordered higher functions.

Introduction

Australasian Hyperbaric Units still use algorithms based on United States Navy (USN) Treatment Table 6 (USN-6) to treat divers suffering from decompression illness (DCI). Although the USN has demonstrated a final success rate of more than 90% for divers treated with a USN 1, 1A, 2, 2A and 3,[1] and also with USN 5 and 6,[2,3] a review of reported outcomes from Australasian Hyperbaric Units suggests that overall success in treating DCI with a USN 6-algorithm may be less than 70%.[4]

Some fundamental differences between these groups (military versus recreational divers, time from onset of symptoms to treatment, type of post-treatment assessment) may invalidate this comparison. Therefore a review of the series of DCI treated in Australasia, and published in the decade from 1983 to 1992, is presented.

Clinical Series of DCI in Australasia, 1983-1992

AUCKLAND, NEW ZEALAND, 1967-1989.

A retrospective review of 23 years clinical experience at the New Zealand Naval Hospital identified records of 125 treated cases of DCI.[5] In most of these, a USN-6 algorithm was used. At discharge, only 57 (46%) had recovered fully; this frequency was not significantly changed in those reviewed subsequently. The timing of these reviews was not detailed, nor was the distribution or severity of sequelae described. However, outcome did not appear to be related to the delay prior to treatment. Some of these patients have been subsequently described in detail. One of these developed severe depression and intellectual impairment despite numerous hyperbaric oxygen treatments.[6] Twenty-five of the divers were treated in 1987; they were carefully monitored over the following year.[7] Two were lost to follow-up. Forty four percent had persistent problems approximately one month after discharge, increasing to 68% at the (about) one year review. In decreasing frequency, the reported problems were depression, problems with higher functions, motor and sensory disorders. It must be noted that these data were acquired retrospectively and (perhaps consequently) conflict with an earlier report of the same population.[8] A subgroup of these divers was also reported elsewhere,[9] but outcome was not described.

CHRISTCHURCH, NEW ZEALAND, 1979-1988

A retrospective review of 10 years clinical experience at Princess Margaret Hospital.[10] showed that 59 divers had been treated for DCI. However the outcome of these divers was not described.

SYDNEY, NEW SOUTH WALES, AUSTRALIA, 1983-1986

Patients admitted to the Royal Australian Navy School of Underwater Medicine (RANSUM) with DCI, from 1983 to 1986, inclusive were treated with a USN-6 algorithm and intravenous hydration.[11] These patients have also been reported on since then and by different authors,[12,13] but subsequent reports add little new data or analysis. Of the 87 entered into the study, 3 left RANSUM after treatment with persistent problems. Forty six presented for a review both at one week and one month after treatment. The frequency of abnormality changed significantly in that time, increasing from the time of discharge to the one week review (46 reviewed; 10 had overt neurological deficits, 22 had an abnormal EEG, 20 had poor psychometric performance), and then decreasing at one month (46; 2, ? and 8 respectively). This study suggested that :

a the time of measuring outcome after DCI is treated is critical and discharge morbidity will over-estimate treatment efficacy;

b the natural history of DCI sequelae is for early resolution;

c CT scanning of divers after treatment for DCI has an unacceptable frequency of false-negative results;[13] and

d. neuropsychiatric sequelae are as likely in those divers who initially have musculoskeletal symptoms only, Type 1 DCS,[14] as in those who have neurological symptoms and signs.

However, this study had limitations. Firstly, the psychometric screen that was used is probably inadequate.[15] Secondly, there was only a poor correlation between those divers with EEG abnormalities and those with psychometric deficits, and thirdly, the loss of patients to follow-up may have caused considerable bias.

ROCKINGHAM, WESTERN AUSTRALIA, 1984-1992

The Royal Australian Navy treated 40 divers with DCI in the period from 1984 to 1987 inclusive at HMAS STIRLING.[16] These divers were treated with USN-5 and USN-6. Six of the 40 did not recover fully. The type of sequelae was not described and no follow-up was reported. There was also no obvious relationship between final outcome and delay prior to treatment. A subsequent letter to an Editor,[17] referred to 111 cases of DCI treated at HMAS STIRLING since 1984. No outcome was described, but it was claimed that women in the series had a greater frequency of neurological involvement than men.

SYDNEY, NEW SOUTH WALES, AUSTRALIA, 1985-1989

An analysis was made of 100 cases of DCI occurring between 1985 and 1989 and presenting to the Prince Henry Hospital.[18] However, neither outcome nor type of follow-up was clearly identified.

ADELAIDE, SOUTH AUSTRALIA, 1987

Sixty four divers were treated for DCI at the Royal Adelaide Hospital during 1987.[19] A USN-6 algorithm was used. At discharge, only 31 of the patients had recovered completely. The distribution and severity of sequelae was not described. The time from onset of symptoms to treatment did not appear to be related to outcome.

MELBOURNE, VICTORIA, AUSTRALIA, 1987-1990

One hundred consecutive cases of DCI treated at the Alfred Hospital were reviewed.[20] A USN-6 algorithm was used. At discharge, 34% of the divers had obvious sequelae. These sequelae were not described and nor was follow-up reported.

ADELAIDE, SOUTH AUSTRALIA, 1990

Twenty divers with DCI were treated with a USN-6 algorithm at the Royal Adelaide Hospital in 1990, and were reviewed both at one month (15% had sequelae) and one year (10% had sequelae).[21] The type of sequelae was not described.

FREMANTLE, WESTERN AUSTRALIA, 1990

Forty-one divers with DCI were treated at Fremantle Hospital in 1990.[22] The treatment used, any follow-up and outcome was not described.

HOBART, TASMANIA, AUSTRALIA, 1990

Three cases of DCI were reported, without follow-up outcomes.[23]

TOWNSVILLE, QUEENSLAND, AUSTRALIA, 1990

Fifty divers with DCI were treated in 1990 at Townsville General Hospital, using a USN-6 algorithm.[24] Forty percent of the divers did not recover fully. No follow-up or analysis of the sequelae was reported.

EMERGENCY SERVICES AND MONITORING STUDIES

Both the Australian Divers Emergency Service[25] and the Diving Incident Monitoring Study based at Royal Adelaide Hospital[26] have reported series of divers with DCI (210 and 14 cases respectively) but did not describe outcome.

Discussion

All of the clinical series reviewed above are, to some extent, flawed; none of the series were controlled and only the original series from Sydney was prospective.[11] Most of the series did not report outcome after discharge, nor the type of follow-up, if any, nor the type or severity of sequelae. The series do however have the following in common: USN-6 algorithm treatments and treatment failure rates much in excess of those reported for such regimens by the USN.[2] There are several possible reasons for this difference:

a. the USN data is largely derived from the early treatment of male military divers;

b. the Australasian data is from the, usually late, treatment of male and female recreational divers; and

c. the early USN data did not include a thorough mental state examination.[1]

The relative risk of being female and developing DCI is controversial.[17,27] There are no data showing that being female is an independent risk for poor outcome after treatment.[5,19]

The significance of early versus late treatment of DCI is assumed, but not supported by data. For example, in three of the Australasian series,[5,16,19] delay to treatment was not significantly correlated with outcome. The difference between the USN and Australasian data may be best explained by the relative severity of the provocative decompressions. It is unlikely that the USN divers will have exceeded (or approached) decompression schedule limits. However, in the Australasian series employing a factorial analysis,[5,19,] a poor outcome (sequelae) was significantly more likely if the diver had exceeded conventional decompression limits.

It is clear from the series reviewed above, that treatment failures for DCI in Australasia, using a USN-6 algorithm, are common. Treatment failures vary from 5 to 60% at discharge,[5,11,16,19,20,24] from 15 to 51% at one month[8,11,21] and from 10 to 68% percent at one year.[7,21]

The natural history of "treated" DCI is not established by these series. Two reports suggest that the frequency of sequelae does not change significantly in the year after treatment,[5,21] another reports a significant increase in residual problems in the days after discharge with an almost complete resolution by one month[11] and a fourth report suggests that the frequency of sequelae may actually increase during the first year.[7]

Unfortunately, only two of the reports included a description of follow-up technique and type and severity of sequelae. The divers treated by the Royal Australian Navy most commonly had EEG and psychometric abnormalities.[11]

Similarly, those monitored after treatment by the Royal New Zealand Navy complained of, in order of decreasing frequency; depression, disorders of higher mental function, headaches, sensory and motor deficits, and impaired balance and "aches and pains".[7] Uncommon sequelae included visual disturbances, dysphasia, dyslexia and bladder and bowel problems. Other reports of some of these patients indicate that they were both incapacitated and invalided by these problems.[6,8]

In summary then, many Australasian recreational divers treated for DCI with a USN-6 algorithm do not recover fully. The, largely retrospective, uncontrolled and non-critical surveys reviewed here do not enable the natural history of these divers to be described, but it would appear that the brain is predominantly involved in sequelae.

Not surprisingly, the prospective controlled studies of oxygen versus oxygen-helium[4] and lignocaine versus placebo[28] involve a review of patients at discharge, and one week, one month and one year later. This review includes a careful neuropsychiatric assessment.

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A PROGRESS REPORT ON DIVING MEDICINE STUDIES IN THE ROYAL NEW ZEALAND NAVY

Des Gorman, Alison Drewry and Maurice Harden

Abstract

Studies of oxygen-helium and lignocaine in the treatment of decompression illness and the role of girdling in protecting against pulmonary barotrauma are underway at the Royal New Zealand Navy's Auckland Naval Base.

Introduction

A series of diving medicine studies are underway at the Auckland Naval Base. These include:

a prospective controlled randomised studies of oxygen versus oxygen-helium and lignocaine versus placebo in the treatment of decompression illness (DCI) arising from recreational air diving; and,

b a study of the role of chest and abdominal splinting in the prevention of pulmonary barotrauma.

These studies are reviewed below.

Oxygen-Helium Study

The rationale for a comparison of oxygen and oxygen-helium as the ideal therapeutic gas mixture to be breathed during the recompression of divers with DCI has been described previously.[1] This study is now underway. The progress results are detailed in Table 1. The outcome data after discharge are still being accumulated for these patients and are not reported here. Treatment, including compression to beyond 2.8 bar, and retreatments were determined by the study protocol.[1] No patients were compressed beyond 4 bar. Clearly, no significant advantage has been demonstrated yet and the study continues.

Lignocaine Study

The potential efficacy of lignocaine in the treatment of DCI has been demonstrated by both in-vivo studies and a clinical report.[2] A pilot study of lignocaine in

TABLE 1

PRELIMINARY RESULTS FROM A PROSPECTIVE CONTROLLED RANDOMISED STUDY OF OXYGEN VERSUS OXYGEN-HELIUM IN THE TREATMENT OF DECOMPRESSION ILLNESS

Parameter	Oxygen group		Oxygen helium group	
Number of subjects	29		24	
Compression beyond 2.8 bar	3	(10%)	4	(16%)
Number retreated	19	(65%)	16	(66%)
Mean number of treatments (±SD)	3.1	(1.8)	2.4	(1.4)

cases of DCI that are refractory to recompression and rehydration has been completed. Patients with DCI, who had persistent symptoms and signs and no sustained improvement after two consecutive hyperbaric treatments were given a 48 hour lignocaine infusion (240 mg for one hour, 120 mg for one hour and then 60 mg/hour continuously. Treatment was adjusted to relieve toxic symptoms and/or maintain plasma levels between 6 and 9 mmol/l). Seventeen patients have been given such an infusion and the results are detailed in Table 2.

TABLE 2

RESPONSE OF SEVENTEEN DIVERS, WITH DECOMPRESSION ILLNESS THAT WAS REFRACTORY TO RECOMPRESSION, TO A 48 HOUR LOW DOSE LIGNOCAINE INFUSION

Patient response	Number	%
Complete resolution	5	29
Improvement	8	47
No change	4	24
Deterioration	0	
Total 17	**100**	
Toxic symptoms	5	29

It is evident that most divers with symptoms and signs of DCI that are refractory to recompression will recover, in some cases completely, if given a lignocaine infusion. A prospective controlled randomised study of lignocaine versus a placebo (saline) infusion in refractory DCI is about to be initiated. Once the oxygen-helium study (described above) is completed, the lignocaine study will be extended to include the initial treatment of divers with DCI.

Pulmonary Barotrauma Study

Studies on rabbits and cadavers have shown that girdling of the abdomen and chest protects against pulmonary barotrauma.[3] Application of this technique has not proceeded because none of the girdles that have been trialled has produced a consistent change in pulmonary function.

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Key Words.
Pulmonary barotrauma,
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lignocaine and
oxygen-helium.

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ARTICLES OF INTEREST REPRINTED FROM OTHER JOURNALS

DIVER RESCUE
SOME CONSIDERATIONS AND UNCERTAINTIES

John Lippmann

Case report

A successful rescue

The victim and his buddy were both relatively inexperienced divers. During the descent, the victim's buddy signalled that he wished to ascend. The victim did not want to ascend and continued his descent, leaving his buddy to ascend alone; which the buddy did safely.

The divemaster entered the water several minutes after the victim had descended. On the way down, the divemaster noticed a continuous plume of bubbles, which indicated a free-flowing regulator. He went over to investigate and found the victim apparently sitting on a rock at a depth of 21 m. His regulator was out of his mouth and was free-flowing. His mask was in place. The victim began to topple as the divemaster approached. The victim, whose eyes were open and staring blankly, was unresponsive. The divemaster put his own octopus into the victim's mouth but it fell out immediately. At this stage he knew the situation was serious. He replaced the octopus in the victim's mouth, held it in position, and put some air into the victim's buoyancy compensator (BC) using the direct (scuba) feed, which functioned adequately.

The divemaster positioned himself behind the victim, tilted his head back and held the octopus in the victim's mouth. He left both weight belts in place and inflated his own BC to provide enough lift for the ascent. Contact was maintained during ascent, as was head tilt, by grasping the victim's chin. The divemaster noticed bubbles and froth coming from the victim's mouth during the ascent.

The ascent was more rapid than usual, although the divemaster believed it to be no faster than about 18 m/minute. He dumped air from his own BC to control the ascent.

Witnesses reports suggested that the victim had been submerged somewhere between 5-10 minutes. Since the diver was alone, it is not known for how long his regulator had been displaced. The water temperature was around 18°C. The divemaster spent a total of 2 minutes underwater.

Once on the surface, the victim was quickly taken to the boat, which was very close. No expired air resuscitation (EAR) ventilation was attempted in the water because of the proximity of the boat. Surface conditions were calm.

The victim was rolled onto the marlin board, his gear was removed and he was dragged onto the boat. His wetsuit jacket was cut open. It was a full 7 mm wetsuit with hood. The victim's eyes were very bloodshot and his skin was described as grey. A substantial amount of froth was coming from his mouth and nose.

Breathing and pulse could not be detected. Two operator CPR was commenced. The divemaster performed EAR and a diving instructor compressed the chest. Ventilation was complicated by froth, regurgitation of stomach contents (which included quite a lot of sea water) and the victim's jaw being clenched and only partly open.

CPR was performed for approximately 5 minutes, at which stage it was noticed that the victim's eyelids had begun to flutter. Compressions were stopped and ventilation was continued using a bag-valve-mask device with supplemental oxygen.

The victim and an instructor were transferred to another boat, along with the oxygen equipment. The victim continued to be ventilated with the bag-valve device en route to the shore.

A rescue helicopter arrived and an ambulance officer was lowered onto the boat. On arrival, the officer found the victim to be semi-conscious and in an irritable state. Since the victim had difficulty breathing spontaneously, the officer ventilated the victim using his Oxy-Resuscitator. The victim responded and eventually established his own regular breathing pattern. His pulse was 85 per minute, and was regular and strong.

On arrival at shore, the victim was transferred to the rescue helicopter. Pulse oximetry showed his oxygen saturation to be 75% without oxygen. This increased to 85% when placed back on oxygen.

Once in the helicopter, the victim was transferred to the hospital and recompression chamber. En route, he was administered 100% oxygen via a demand valve (Oxidem 2000) and tight-fitting mask. He appeared to have no difficulty breathing from the demand valve with mask (although he would not tolerate the demand valve with a mouthpiece instead of a mask).

At hospital, the victim was assessed, found to be confused and had poor blood gases. He was intubated and recompressed to 2.8 ATA. Over several days he received 3 to 4 hyperbaric oxygen treatments and was released from hospital the next week with no apparent sequelae. The chamber staff believed that his symptoms were probably caused by near drowning alone, without complication by decompression illness.

The victim did not remember the cause of the incident. However, the divemaster noticed that the mouthpiece was missing from the victim's second stage regulator after the victim was retrieved.

The divemaster mentioned that he regularly practiced rescue techniques and CPR. Consequently, he found this rescue to be a relatively straightforward procedure.

Discussion

At some time, a diver may find himself in a situation where it is necessary to rescue an unconscious diver, either submerged or on the surface. Fortunately, such situations are rare.[1]

Some training agencies include a protocol for the rescue of an unconscious diver during their basic (openwater) dive course. Other agencies do not teach the skills until the Rescue Diver level. **Rescue and resuscitation skills are very valuable tools that *all* divers should acquire as soon as possible. However, once learned these skills need to be practiced reasonably often (i.e. at least every six months) to maintain the required level of performance.**

The actual protocols currently taught vary between agencies, and from instructor to instructor. One common problem is that many dive students leave the course with the belief that there is only one correct method to perform such a rescue. Although, within the time constraints of a commercially oriented dive course, it is often only practical to train the students in one particular protocol, the divers should be made aware that unconscious diver rescues are not necessarily straight forward. There is still a lot of uncertainty surrounding various aspects of diver recovery since there is a paucity of data to support or refute the rationales behind certain suggested techniques. In addition, diver rescue is not a black and white situation where one set of specific actions universally applies. There is no "standard rescue". Divers should be made aware of the general principles of rescue, so they are better equipped to adapt to a particular situation, should it arise.

The purpose of this paper is to present issues that some divers may not have considered, and to encourage thought, discussion and research on this important topic.

One point to consider is the degree of urgency of the situation. Whether the outcome will be a possible rescue or a body recovery depends on a variety of factors, which include: (1) the duration of submergence; (2) whether or not the diver is still breathing from his regulator; (3) how much time has elapsed since the diver stopped breathing; and (4) the temperature of the water and insulation of the diver, among other factors.

The partial pressure of oxygen (pO_2) in arterial blood supplying the brain is normally at least 80-90 mm Hg. When a person stops breathing, the pO_2 falls rapidly and by the time it reaches 40 mmHg, consciousness will be seriously impaired.

It has been argued that, on land, it normally takes approximately 90 seconds from the time consciousness is seriously impaired (40 mm Hg), for the pO_2 to drop to levels where permanent damage to the central nervous system may occur (approximately 20 mmHg).[2] Consequently, it has been suggested that, where possible, rescuers should aim to have the non-breathing, injured diver brought to the surface and ventilated within 90 seconds of losing consciousness.

However, although this time frame appears to be reasonable on land, the situation may be very different with a diver underwater.

Non-diving casualties have uncommonly made dramatic and successful recoveries after resuscitation following long periods (up to about 60 minutes) of immersion without breathing in very cold water.[3] The lower oxygen usage resulting from the reduced blood flow to the non-vital organs (diving reflex) and slowed metabolic rate from hypothermia, together with the higher oxygen partial pressures associated with depth, have been used to explain this phenomenon.

In one series of 50 cases of individuals who had been submerged in cold water for periods of between six to sixty minutes, 45 had suffered no detectable neurological impairment after being resuscitated and rewarmed.[4] Consequently, it is recommended that resuscitation and rewarming be attempted on any casualty who has been submerged for up to 60 minutes in water of 21°C or cooler.

Unfortunately, there is a lack of data to indicate how the wearing of an exposure suit and diving mask effect the survivability of a diver who is unconscious, submerged and not breathing. It is theoretically possible that such equipment could reduce the chances of survival by delaying or reducing the protective effects of hypothermia and the diving reflex.

Consider the scenario where a diver encounters an apparently unconscious diver underwater.

Normally, the first step is to determine whether or not the diver is really unconscious. This may be done by approaching and quickly observing the diver. Exhaust bubbles may indicate that the diver is breathing and may, or may not be conscious. The absence of bubbles for more than about 5-10 seconds indicates that a diver is not breathing. A slumped position, eyes closed or blankly staring may indicate impaired consciousness. Gently shaking the diver should elicit a response if he is fully conscious. A diver who doesn't react at all, or only reacts very weakly, should be brought to the surface.

The rescuer should get a firm grip on the injured diver, and take a couple of seconds to compose himself and assess the best course of action to take, while quickly locating the diver's weight belt and BC inflate/deflate mechanisms. **Although it is important not to waste time, the few seconds taken to assess the situation may save unnecessary complications down the track.**

Whether the diver is breathing or not, if the regulator is in place the rescuer should support it in the diver's mouth to ensure that it does not become dislodged. Positioning the injured diver's head with backward head tilt should maintain an adequate airway.

Backward head tilt is normally used to open the airway of an unconscious person on land. When an unconscious person is lying on his back, the tongue falls against the back of the throat and can obstruct the airway. Tilting the head back and lifting the lower jaw should allow air to enter and leave the lungs will minimal obstruction.

Some rescue protocols suggest that the rescuer should support the victim's head in a neutral position (i.e. not tilted back or forward).[5,6] Whether or not a neutral head position will provide an adequate airway in this situation is debatable. It has been suggested that because the unconscious victim underwater should normally be brought to the surface in an upright position, airway obstruction from the tongue is less likely, and, therefore, a neutral head position should be adequate to allow air to enter the lungs of an unconscious, breathing diver (with an air supply), or to vent from the lungs of a breathing or non-breathing diver.

One argument put forward against using backward head tilt is that any water that has collected in the diver's mouth could be encouraged to enter the throat if the head was tilted back. If the diver is not fully unconscious, this water could cause a reflex spasm of the larynx, known as laryngospasm. Laryngospasm may last for minutes. It usually abates as the diver becomes very short of oxygen (deeply hypoxic). The likelihood of laryngospasm decreases as the injured diver lapses further into unconsciousness.

If laryngospasm occurs during the ascent, expanding air in the lungs may not escape effectively, increasing the possibility of a pulmonary barotrauma. Although it has been asserted that air can still escape from an unconscious person's lungs despite laryngospasm,[2] this assertion has not always been supported by anaesthetic experience.

In anaesthesia, in fully developed laryngospasm, both inhalation and exhalation may be impossible. However, this situation only occurs in a partially conscious person and not in the fully unconscious person.

Some rescue protocols urge the rescuer to inspect the victim's mask. If there is no water in it, it is usually recommended to leave the mask in place, although a possible exception to this is discussed later. However, if there is water in the mask, it has been argued that the mask should be removed.[7] The rationale is as follows: If the mask contains air and water, the air will expand on the way to the surface. The expanding air will force water through the victim's nose and into the throat, possibly causing laryngospasm if the diver is not fully unconscious.

If the mask is full of water, it can either be removed underwater, or on reaching the surface. It probably will not make much difference.

If the diver is breathing and the mask is removed, the rescuer can pinch the injured diver's nose to prevent water entering during the ascent. However this needs to be done promptly after removing the mask and is yet one more thing for the rescuer to do.

Certain protocols suggest that the victim's weight belt be removed.[6,8,9] The injured diver is often heavy (many being substantially overweighted[10]) and it may be necessary to remove his weight belt to increase the diver's buoyancy. If the victim's belt is removed, the rescuer must have a firm grip on the diver before removing the belt, as mentioned earlier. It is also a good idea to locate the injured diver's BC inflate/deflate mechanism, since it may save time finding it later. The victim's weight belt may then be removed and pulled well clear to prevent it tangling with other gear, and dropped.

However, not all rescuers find it necessary, or desire, to remove the victim's weight belt underwater (see the case report). The main reason put forward is the difficulty in controlling the subsequent ascent.[11] Some suggest adding air to the victim's BC, via the direct feed, to provide the necessary positive buoyancy.[12] Unfortunately, this will not be possible if there is no air in the victim's tank or the scuba feed is not functioning. It may not be practicable even if the air supply is not depleted, especially in deep water. Tests have demonstrated that it can take up to a minute or more to inflate certain BCs at depth, with low supply pressures.[13,14] This delay could be detrimental to the outcome of the rescue.

Alternatively, the required buoyancy may be achieved by the rescuer inflating his own BC.[5,12] The advantage of this is that it is usually easier for a rescuer to control buoyancy using his own familiar device. However, this may mean that the injured diver remains negatively buoyant, at least for some of the ascent. Again, a firm grip on the victim is essential, especially in a current.

Where possible, the injured diver should be positively buoyant throughout the ascent in case contact is lost. If the divers separate for any reason during the ascent, the victim's positive buoyancy should ensure that the victim will continue to ascend towards the surface, where he can be more easily located. If the victim is negatively buoyant and contact is lost, he will sink and may be difficult to relocate. This is one of the potential problems with leaving the victim's weight belt on and using the rescuer's BC to provide sufficient buoyancy for ascent. It is also one reason why the removal of the rescuer's weight belt is not recommended.

Positive buoyancy may not be appropriate if direct access to the surface is hindered, such as in a cave. In such situations, it may be necessary to leave the injured diver's weight belt in place and try to achieve neutral buoyancy for both rescuer and victim, and swim the diver out.

Although it is taught by some instructors, there appears to be little justification for the rescuer to release both the victim's and his own weight belts, even in shallow water.[8] Some divers forget that the risk of a lung overexpansion injury is greatest during the last metres before the surface. The rescuer should normally retain his own weight belt, at least until after reaching the surface and after making the victim positively buoyant. In addition to creating an uncontrolled and rapid ascent, a rescuer who ditched his own weight belt, would be unable to interrupt the ascent, or to descend, if it became necessary due to his dropping the victim, to entanglement or to some other unforeseen circumstance.

The next decision is a somewhat controversial one. The rescuer has to decide whether to maintain contact with the victim throughout the ascent, which is the usual teaching, or to ensure the victim is positively buoyant, let him go and follow him up. The decision may be influenced by the depth of the water, and the rescuer's own situation.

The most commonly taught technique, and probably safer, is to maintain contact with the victim throughout the ascent. In this procedure, the rescuer ensures positive buoyancy by initially removing the victim's weight belt and/or adding air to either the victim's or his own BC. Contact is maintained, and both divers ascend towards the surface, driven by positive buoyancy. If the diver is breathing, it is possible that he could regain consciousness during the ascent. If this occurs, the diver will be very disoriented and may panic. Therefore, the rescuer should have a firm hold of the injured diver, possibly better from behind, to enable the rescuer to restrain the injured diver if necessary and, equally important, to ensure his own safety. The rescuer can control the ascent rate to some extent by releasing air from his own BC and/or the victim's. This is a time when skill acquired by regular practice, and an extra pair of hands, would be very helpful !

The rate of ascent can vary considerably. If both divers are wearing full 7 mm wetsuits and the victim's weight belt has been ditched, very fast rates can occur near the surface, especially if expanding air has not been dumped from the BCs on the way up. The rescuer should ensure that he breathes in and out, possibly exhaling more than normally (although not continuously) when approaching the surface. Angling the fins and arching the body to create extra drag can also help reduce the ascent rate.

In 1974, a radically different protocol was suggested for retrieving a diver who is found lying on the bottom, (e.g. 18 m) unconscious, regulator out.[2] It has been adopted, to varying degrees, by some rescuers, despite the absence of substantial supporting data.

When a non-breathing diver is brought to the surface, the partial pressure of oxygen in the diver's body rapidly falls due to the reduction in ambient pressure and the body's oxygen consumption. It was argued that, as the gases in the chest expand and escape during the ascent, the pO2 in the lungs will drop. Oxygen would pass from the blood, which has a higher pO2, into the lungs. Oxygen will be drawn away from the body tissues into the blood, which now has a pO2 similar to that in the lungs, and transported to the lungs. This would rapidly deplete the oxygen in the blood and tissues and could lead to oxygen starvation (hypoxia) and death. The deeper the victim is found, the greater the potential for oxygen drain due to the larger pressure differential and increased distance and time of ascent. It was reasoned that the injured diver must be brought to the surface as rapidly as possible to minimise the oxygen drain from the tissues. Consequently, it was suggested that if a diver is found unconscious with his regulator out, the rescuer should remove the injured diver's weight belt and mask, raise him to the vertical position, inflate the victim's BC and let him go. It was suggested that the rescuer follow at a safe rate of ascent, retrieve the victim on the surface and commence expired air resuscitation. The procedure was recommended as an option of last resort in circumstances where the surface is clear of obstruction, calm and there is some concern that the rescuer cannot make a safe reasonably rapid ascent.

It was argued that, by positioning the diver vertically with the head up, the pressure on the lower chest will be greater than that on the upper chest. This pressure differential should force excess air out from the mouth and prevent further water from entering the larynx. As the diver ascends, expanding air should vent from the lungs and out from the mouth, so preventing a pulmonary barotrauma. Some preliminary tests were conducted to investigate the effect of positioning a person vertically with the head up in the water. The few tests conducted did appear to support the claim that the upright position encourages airflow from the lungs. It was further reasoned that, on arrival at the surface, the diver would shoot from the water and then fall back into a horizontal face up position, provided he was wearing a BC that will float him on his back (which many current BCs will not do).

The vision of an unconscious diver ascending rapidly to the surface, probably with his chin down against the chest, raises the obvious concern of pulmonary barotrauma and associated complications. However, whereas a conscious, panicking diver can initiate a variety of responses that can prevent air from venting adequately from his lungs during ascent, it was argued that the unconscious victim may be in less danger from a lung overpressure injury, even at the very rapid ascent rates that could be achieved with this suggested rescue procedure.

Air cannot enter the lungs when an unconscious person has the head slumped forward. However, it has been asserted that, even if the unconscious diver's head has slumped forward, expanding air from the lungs can passively open the airway from below and escape safely. In support of this idea, it has been pointed out that a conscious person who takes a deep breath and then tucks his head down so that his chin is firmly against his chest can still exhale easily. In addition, medical experience has shown that people with laryngeal cancers blocking the vocal cords, who have great difficulty breathing in, can vent air or oxygen introduced directly into the trachea below the obstruction quite satisfactorily. However, the belief that air can always escape from an unconscious person's lungs when he is vertical has not been verified by anaesthetic experience, which is normally conducted with the patient lying flat.

So, the rescuer must decide how to get the victim and himself to the surface as quickly and as safely as possible. The best way to achieve this must be assessed according to the prevailing circumstances.

The rescuer who was trained to leave the victim's weight belt on may in fact need to remove it to raise the victim. A rescuer who had planned to maintain contact with the victim throughout the ascent may be forced to release the victim in order to prevent himself rocketing to the surface.

The rescuer should be able to quickly adapt if circumstances become different to what was expected. If the rescuer had planned to bring the victim to the surface in a controlled manner and finds that he is forced to allow the victim to rapidly ascend alone, he should not abort the rescue in the belief that he has prejudiced a successful outcome. Upon reaching the surface, the rescuer should locate the victim and continue the rescue as appropriate. It is even possible that the rapid ascent may have in fact increased the injured diver's chances of survival.

Once both divers are on the surface, it is important to establish a clear and open (patent) airway and ventilate a non-breathing victim as soon as possible. To achieve this effectively in the water, the rescuer should ensure that both he and the victim are sufficiently **buoyant** before attempting ventilation. It is always essential to **remove the injured diver from the water as soon as possible so that more effective assessment and resuscitation procedures can be implemented.**

Various protocols differ on if and how in-water EAR is to be achieved.

One protocol recommends that the rescuer should attempt to ventilate the victim as soon as they reach the surface and prior to making any buoyancy adjustments. Buoyancy is adjusted after the first breaths of expired air resuscitation have been given.[8] Another protocol suggests that after checking for breathing and draining water from the victim's mouth, ventilations are initiated, if required, prior to adjusting buoyancy. These procedure are extemely difficult to so effectively, especially if both weight belts have not been removed. Both victim and rescuer are at risk of inhaling water. Other protocols recommend that buoyancy be increased before ventilation is attempted.[5,6,9,12]

The (positively buoyant) victim's face must be supported above the surface. This can usually be achieved effectively by the rescuer adopting the do-si-do position, by placing a hand under and cradling the victim's neck and various other means.

The amount of buoyancy required to enable the rescuer to deliver "dry breaths" to the victim depends on a number of factors which include the skill of the rescuer and the surface conditions.

The victim's weight belt should have been ditched underwater or on reaching the surface. There is normally no advantage in leaving the victim's weight belt on at this stage. Many rescuers, especially those carrying a lot of lead, may be better off ditching their own weight belt at the surface, ensuring it is pulled clear and held away from themselves and the victim, before dropping it. However, some divers find it difficult to maintain the desired orientation in the water without a weight belt. This may sometimes occur with a diver wearing a full and very buoyant exposure suit. Occasionally, the rescuer might be reluctant to remove his weight belt in case he may need to resubmerge for some reason.

Partial inflation of the victim's BC usually provides sufficient support for the victim. Fully inflating the BC may restrict the victim's chest movement and may also make it more difficult to get close to the victim's head for ventilation. As long as the rescuer has ditched his weight belt, it is usually unnecessary to inflate his own BC, although it may sometimes be useful, especially if little buoyancy is provided by the wetsuit. If both BCs are substantially inflated, it can be more difficult to get close enough to the victim to ventilate him without pushing his head underwater. This depends to some extent on the types of BCs worn and is more of a problem with jacket-type BCs. Some people have used the analogy of two very obese people trying to make love, it is important to approach at the correct angle!

The rescuer should position himself appropriately when assessing breathing, establishing a patent airway and/or attempting ventilations. It is usually better to approach the victim from behind the shoulder, rather than from beside the chest. This reduces the chances of pushing the victim under while attempting ventilations. The rescuer can often turn the victim's head slightly towards him to get a little closer, if surface conditions permit.

On the surface it may be very difficult to determine whether or not the injured diver is breathing. If the injured diver was breathing during the ascent and if surface conditions are choppy, it may be better to leave the regulator in the diver's mouth, as long as there is enough air in the victim's tank. Holding the regulator in place (and leaving on the mask, if present) should help prevent the victim from inhaling water. The diver's head should be tilted back and chin supported, if possible, to open the airway. If the diver is breathing effectively from the regulator, the rescuer should hear the demand valve being triggered.

If the diver was not breathing underwater it is highly unlikely that spontaneous breathing would have begun on reaching the surface. As mentioned previously, it is also very difficult to detect breathing in this situation. Consequently, some protocols do not include a breathing check before commencing in-water expired air resuscitation.

If the diver can be landed very quickly, it is usually better not to lose time trying to ventilate him in the water.

Over the years there has been debate about whether or not the rescuer should try to drain the airway before beginning in-water resuscitation. Although on land it is relatively easy to roll the victim onto the side to clear the airway, the situation is much more difficult in the water.

The victim may have vomited or regurgitated, or there may be frothy sputum coming from his mouth. The rescuer can attempt to scoop out any obvious material with his fingers, although this will be difficult to do effectively in the water.

Although it has been suggested that the rescuer pull down the corner of the victim's mouth to allow water to drain out,[7] this may not only be unsuccessful but can allow water in from a passing wave.

Most protocols do not require the rescuer to attempt to clear liquid foreign matter from the airway. When in-water EAR is commenced, any foreign matter blown into the larynx will not cause laryngospasm, unless the victim is not fully unconscious. Complications caused by inhalation of liquid foreign matter will be addressed, if necessary, when the victim arrives at the hospital.

It is important to try to open the victim's airway as widely as possible when delivering the breaths. The first step in achieving this is to tilt the victim's head back maximally. In addition, the injured diver's chin should be supported, if possible. If performing mouth-to-mouth ventilation, chin support may be more easily provided if the rescuer can use a cheek seal (rather than his fingers) to seal the victim's nose, so freeing one hand for chin support. Jaw support can also be provided relatively easily if mouth-to-nose ventilations are used. It may also be easier to obtain a good contact seal with mouth-to-nose, rather than mouth-to-mouth ventilation. Mouth-to-nose ventilation may be the only alternative if the victim's jaw is clenched and the mouth cannot be opened. Each case will be different and the optimal method for each particular circumstance must be chosen by the rescuer.

A pocket-style resuscitation mask can be very useful. Working from behind the victim's head, the rescuer can use jaw thrust to lift the jaw and tilt the head back. In this way, easier and more effective ventilations can be achieved. Only masks that float should be used.

Some rescuers are taught to use a snorkel as an aid to ventilation. Mouth-to-snorkel resuscitation can reduce rescuer fatigue by enabling the rescuer to stay lower in the water. The rescuer can sometimes provide chin support with the same hand that is sealing the snorkel in the injured diver's mouth. However, the technique can be cumbersome and difficult to perform, requires regular practice, and cannot be done effectively with certain snorkels, and on some victims, e.g. those without teeth.

The Australian Resuscitation Council (ARC), which is the guiding body for resuscitation protocol in Australia, recommends that expired air resuscitation be commenced with five full breaths delivered over approximately 10 seconds, followed by a check for a carotid pulse. If a pulse is detected, ventilations are delivered at the rate of one every 4 seconds.[15] Unfortunately, it is often very difficult and impractical to maintain the recommended sequence when rescuing an injured scuba diver in the water.

Sensible rescue protocols do not require a pulse check in the water because of the difficulty of detecting a pulse when hindered by cold hands and diving gear, and because in-water CPR is impossible. The majority of procedures make the assumption that a pulse is present and call for ventilation to be maintained until the diver is landed as quickly as possible and assessed adequately.

If a pulse is in fact present, effective ventilations should provide the necessary oxygen to preserve life. However, if the victim's heart is not beating effectively (cardiac arrest), the ventilations will serve no useful purpose and are likely to delay transport of the victim to the boat or shoreline where CPR can be implemented.

If the victim is pulseless, it is very important to leave the water and begin CPR as soon as possible and to ensure that an ambulance is called without delay. Data from the United States have indicated that the highest hospital discharge rate has been achieved in those patients for whom CPR was initiated within 4 minutes of the time the heart stopped beating effectively, and who, in addition, were provided with advanced cardiac life support within 8 minutes of cardiac arrest.[16]

Obviously, time is crucial to the non-breathing, and especially to the pulseless victim. If the rescuer suspects that the victim's heart has arrested, which is likely if he was submerged without breathing for more than about 3-5 minutes, it may be better not to attempt EAR if the shore or the boat can be reached fairly quickly.

Several years ago, a study was conducted to assess whether it was possible to perform effective CPR in the water. The technique was demonstrated on an instrumented aquatic manikin, which was ventilated with a specially modified, pressure limited second stage regulator. The trials were performed in full scuba gear by trained rescuers. The results achieved on the manikin met the minimum limits for CPR.[17] However, the technique requires that the victim be positioned head up in the water and it is doubtful whether adequate circulation would reach the victim's brain in this position. In addition, the procedure requires a specially modified regulator if performed by a single rescuer. Not surprisingly, the technique never caught on.

If EAR is continued while towing the diver to a boat or shore, the rescuer should endeavour to maintain a regular rate of ventilation and prevent water from entering the injured diver's upper airway.

It is difficult, physically tiring and time consuming to try to maintain the sequence of one breath every 4 seconds as recommended by the ARC. No sooner has the rescuer begun to get underway when he has to stop to ventilate the victim. Consequently, it may be a reasonable compromise to provide a sequence of 2 slow breaths every 10-15 seconds. The rescuer can tow for about 5 seconds before stopping to interpose the 2 slow breaths. If surface conditions are choppy, the rescuer can often cover the victim's mouth and nose while towing, to prevent water from entering the airway.

The rescuer should pace his or her physical exertion to avoid exhaustion. Unnecessary equipment can be removed to reduce weight and drag. What gear to ditch and when to do so depends on the particular circumstances. Any assistance that is available should be utilised to hasten the rescue and reduce rescuer fatigue. Techniques for removal of a victim from the water are important, frequently neglected and demand regular practice beforehand. Divers need to develop and practice techniques suitable for their boat and dive sites.

Once the injured diver is landed on a solid surface, the normal resuscitation protocol should be followed. The injured diver should be rolled into the recovery (lateral) position, the airway cleared and the breathing and pulse checked. Resuscitation should be continued, as appropriate, until medical aid arrives and takes over the management of the victim. Oxygen, at the highest possible inspired concentration, ideally 100%, should be administered if available.

The attending medical personnel should be urged to contact DES/DAN Australia on **008 088 200** and/or the local hyperbaric facility if sufficient people are present.

If the injured diver regains consciousness he should not be allowed to sit up, in case he has an arterial gas embolism, and to minimise the effects of shock. The diver must go to hospital for observation and/or treatment, even if he appears to have recovered. This is because a proportion of victims of near drowning develop lung problems some hours after apparent recovery.

It is stressed again that there is no one correct way to perform all rescues. There are so many variables that can influence the management of each emergency and affect the eventual outcome. Each rescue and resuscitation is likely to be unique. The potential rescuer should have an overview of various possible rescue protocols and an understanding of the basic underlying principles.

Some key points to remember are:

* Unless the victim reaches the surface he will certainly die.
* The rescuer should get the non-breathing diver to the surface as quickly as possible without endangering himself.
* Once on the surface, sufficient buoyancy of the victim should be obtained to protect his or her airway, to facilitate leaving the water and to provide dry ventilations, if required.
* The diver should be landed as quickly as possible to enable proper assessment and management.
* The rescuer should enlist help as soon as possible and ensure an ambulance is contacted with minimal delay.
* The rescue should be paced to avoid exhaustion of

the rescuer.

* The early introduction of 100% oxygen for the victim is desirable if the necessary skills and equipment are available.

* The diver should be kept in a horizontal position whether conscious or not.

* The victim must be medically assessed, even if he or she appears to have recovered.

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SAFETY FIRST
AN ANALYSIS OF RECENT TECHNICAL-DIVING ACCIDENTS

Michael Menduno

"A man [sic], viewed as a behaving system, is quite simple. The apparent complexity of his behaviour over time is largely a reflection of the complexity of the environment in which he finds himself."

Herbert Simon

Cited by John D. Barrow in *Theories of Everything.*

Over this past (1992 Northern) summer's diving season there were at least eight fatalities and a number of injuries in the US involving "technical-level" exposures and reportedly even more in Europe. Unfortunately in most of these cases, experienced divers violated one or more basic safety principles and died as a result. According to a recent study of diving accidents conducted by Mano and Shibayama,[1] over 45% of the sport diving fatalities investigated were due to "lack of technique" or "reckless diving." Their conclusion is probably even more applicable to technical diving where there is little margin for error. With today's technologies and the complex diving environments that are accessible, it's easy for people to get in over their heads. Safety is the primary objective in technical diving. We offer the following information in the hopes that others ill be able to learned from these tragedies and events.

Fatalities

ALACHUA SINK, FLORIDA

1992 July

A newly trained cave diver got lost in the cavern zone after being separated from the team's line in zero visibility conditions at Alachua Sink and drowned. His partner survived. Instead of following the permanent line which begins at a log in the basin, the team ran a reel during the evening dive in order to make their way down through the sloping cavern zone to the main tunnel. The basin had near zero visibility conditions due to the seasonal algae bloom which usually clears at about 39 m (130 ft) at the upstream/downstream tunnel junction. About 18-24 m (60-80 ft) into the dive, the team realised they had missed the main tunnel. After searching for the tunnel for several minutes in 1 m (3-4 ft) visibility they decided to turn the dive and lost visual and physical contact of each other. The surviving partner reeled in believing his partner was ahead of him on the line. Reaching the surface alone and realising his partner was still in the water, he attempted numerous line searches in order to locate the diver without success and went for help. Though the lost diver had several hours of gas in his double 95s he was unable to find his way up and out of the funnel shaped cavern zone. *A contributing factor may have been that he was only carrying a 15 m (50 ft) "jump reel" rather than a 45m (150 ft) "safety reel" recommended by the cave diving training agencies.* Ironically, if the dive had been conducted during the day observers speculate that it should have been easy to find a way out.

Alachua Sink is considered an advanced dive by experienced cave divers due to low visibility conditions, depth and the arduous climb out of the water. Most divers wait for the winter season to make the dive because of the low visibility in the basin during the spring and summer. Due to the poor conditions, it took three and half days for teams to recover the body which was found wedged in the ceiling of the cavern.

ANDREA DORIA, NEW YORK

No 1 1992 July

An experienced diver wearing double over pressurised 72s *ran out of gas* while making his eleventh penetration dive on the *Andrea Doria* (72 m or 240 fsw). His partner who entered the water with a "half-filled" set of steel 120s, *insufficient gas to make the dive safely*, survived. Both were breathing trimix though neither was formally trained in its use. The team was separated during a penetration in the wreck. When the surviving partner exited at 66 m (220 fsw) with only *several hundred psi remaining in his doubles* and found his stage bottles clipped off near the anchor line, his partner was no where to be found. The body was later recovered. His tanks were empty. A close friend who had trained with the diver reported that the diver had had problems "managing his gas" on several prior occasions. What's more is that the diver was *using trimix as a suit inflation gas in the chill 7°C (45°F) water* which was possibly a contributing factor to the accident in that cold could have impaired the diver's judgement.

No 2 1992 July

Two weeks later another trained, experienced diver drowned after getting separated from the mainline during a wreck penetration on the *Doria* while the team worked as planned at two different places within the wreck. Though the trimix used to conduct the operation was a big safety factor, analysts on site believe the diver left the line to explore just a little further for artifacts before making his planned exit, *contrary to the dive plan*. He wasn't running a *gap reel*. In addition his primary light apparently failed leaving only a single *"dim"* secondary light to exit the silted wreck. This probably added to his confusion. Lost in the wreck he ran out of gas and drowned before the team was able to locate him. His body was later recovered at 69 m (230 fsw). Though he was a cave-trained police diver who regularly dived solo and had been trained in mix, he did not have extensive wreck penetration experience and had become slightly disoriented on their previous dive. Sadly, the diver apparently told his partner prior to the dive that he just "had" to bring home a Doria artifact for his pregnant wife.

ARUNDO, NEW JERSEY

1992 July

A very experienced deep wreck diver *knowingly* dived beyond the NOAA oxygen limits while conducting an enriched air dive on the Arundo (40.5 m or 135 fsw), suffered an oxygen seizure and drowned. The diver was breathing an EAN 40 (40% O_2, balance nitrogen). This mix has a rated "Maximum Operating Depth" or MOD of 26 m (87 fsw) (giving a partial pressure of oxygen (PO_2) of 1.45 ata). However, *the deck of the wreck is at 33 m (110 fsw) with a maximum depth of 40.5 m (135 fsw)*, resulting in a PO_2 *of 1.7-2.0 ata* which is well above the CNS toxicity threshold.

The diver had told others in the past that he did not follow the NOAA guidelines as he believed they were too conservative. An individual who knew the diver well believed he was probably diving the USN's "exceptional exposure" limits for oxygen which are generally not considered conservative enough. In one case, the diver recommended that another follow his example *(After all diving air at 75 m (250 fsw) is a PO_2 of 1.8 ata. No problem!)* The problem is that CNS toxicity is a function of both PO_2, time and other factors, many of which are not well understood. His body was found approximately 45-50 minutes into the dive with regulator out of his mouth and 1,500 psi in his doubles. Maximum depth on his computer was 33.8 m (132 fsw).

CHESTER POLLING, MASSACHUSETTS

1992 July

An experienced 45 year old wreck diver suddenly lost consciousness during a 51 m (170 fsw) air dive on the *Chester Polling* and drowned in the arms of his partner. The exact cause of his death is unknown. The team descended on the "near virgin" wreck at 42-51 m (140-170 fsw) for what was planned to be a short first dive of the day leaving their inflatable boat unattended but anchored into the wreck. Conditions were good and there was no current. About 10-15 minutes into the dive, the surviving partner called the dive and begin to ascend to the bow at 42 m (140 fsw) to free their anchor.

The diver who died drifted back down to the bottom briefly for one more sweep of the area. When he returned to their ascent line he did not look right to his partner who signalled, "OK?" The diver signalled, "NO. Not OK" but did not indicate what was wrong. His partner grabbed him by the harness to maintain contact during their ascent. As they ascended the diver began moving his arms and legs and then his legs went limp at about 27 m (90 fsw). At 24 m (80 fsw) his regulator fell out of his mouth and the diver lost consciousness. The surviving partner was "freaked" and tried to resuscitate the diver without success. At 4.5 m) 15 fsw the surviving partner elected to complete a portion of his decompression before surfacing, removed the diver's weight belt, inflated his BC and pushed him to the surface. *There was no surface support person or anyone on their boat*. The surviving partner completed about 5 minutes of air decompression, surfaced and went on oxygen. A nearby sailboat had picked up the drowned diver and had radioed the Coast Guard station which was only a few minutes away. CPR was applied to no avail. There were no life signs. The diver was evacuated to the hospital and pronounced dead. The autopsy stated the cause of death was drowning. It is highly unlikely that the event was an oxygen convulsion (a PO_2 of 1.26 ata at low to moderate work levels). The diver had no previous history of cardiac problems and was reportedly in great shape.

DEVIL'S EYE, FLORIDA

1992 July

A trained cave diver lost consciousness and drowned while making an enriched air stage dive at Devil's Eye cave system. His partner survived. The multi-level dive was conducted using air as a travel mix and a bottom mix of EAN 40. The maximum depth of the dive was 31.3 m (104 ft). The dive team staged into the system on an aluminium 80 of air which was breathed for approximately 15 minutes into the dive before the switch to EAN 40. After about 60 minutes into the dive the surviving partner turned to see the diver stop and begin shaking before losing consciousness and spitting the regulator out of his mouth. His partner tried unsuccessfully resuscitate the diver and then attempted to swim the unconscious diver out of the cave. Soon realising that his efforts were futile, the surviving diver exited the cave to get help. The body was recovered a short time later by a recovery team.

Investigators believe that an oxygen seizure was the cause of death. Though PO_2s for most of the multi-level dive were at or below 1.4 ata (25 m or 83 ft on EAN 40), due to the configuration of the cave there were multi-minute portions of the dive with PO_2s as high as 1.5-1.7 ata (29.5-31.5 m or 95-105 ft) *placing the profile outside of the NOAA Oxygen Limits* (*a maximum PO_2 of 1.6 ata*) which are based on moderate diver work levels. The team was reported to be swimming hard in the upstream system which would have resulted in CO_2 build up and possibly increased the diver's sensitivity to convulsion. The family refused an autopsy.

LA JOLLA CANYON, CALIFORNIA

1992 July

Two "untrained" recreational divers reportedly died in La Jolla Canyon attempting to beat their personal best depth records of 60 m (200 fsw) which they made in the Canyon the week before *using recreational scuba equipment*. Their goal was to hit 75 m (250 fsw). Apparently neither of the divers had training or experience at these depths and had not done prior work up dives. According to newspaper reports, when questioned by friends about their "record" dive the previous weekend one of the team said they got narked "big time", and rather than dangerous or stupid believed their continuing push for depth was "cool". Both of the divers were recreational divemasters, one of the divers had just received his divemaster certification earlier that month.

La Jolla Canyon begins about 150 m (yards) off shore in 13.5 m (45 fsw) of water and quickly drops through a series of slopes and ledges to about 90 m (300 fsw). The team apparently swam out alone sometime in the afternoon covering probably about 600-800 m (yards) on the surface (probably building up CO_2 levels) before dropping into the canyon. *They were conducting the dive on single aluminium 80s* without a stage or pony bottle and there was *no descent/ascent line or surface support personnel.* (Assuming a conservative surface consumption rate of 0.75-1.0 cf/minute the transit to and from depth would have required between 30-40 cf for each diver not including time on the bottom, decompression requirements, their surface swim or *reserves in the event of an emergency.*) Since their bodies were never recovered and there were no witnesses, we can only speculate as to their dive and the exact events that led to their deaths.

Other fatalities

Apparently numerous fatalities occurred this summer in the UK and Europe involving technical level exposures. Many of these accidents reportedly involved deep air diving in overhead environments. As of this writing (late 1992) we have been unable to get sufficient details to include these in this report.

Injuries

U-WHO BOAT, NEW JERSEY

1992 June

An east coast wreck diver "blew up" to the surface as a result of operational problems while diving trimix on the newly discovered, unidentified New Jersey U-boat, the *U-Who* (64.5 m or 215 fsw). He omitted about 30 minutes of decompression and suffered decompression illness during his evacuation. According to on site observers, the diver, who had completed a trimix course, was *"grossly overweighted and was diving new equipment including stage bottles that he was not well practiced with"*. On descent, the diver missed the anchor line, separating from his partner, and sank straight to the bottom at about 64.5 m (215 fsw) missing the wreck. Rather than trying to surface immediately or send up a lift bag indicating "diver in distress", the diver searched for the wreck on the bottom under low visibility conditions and burned through approximately 200 cf of gas in less than 10 minutes. Out of bottom mix, lost, overweighted with no ascent line and unable to gain sufficient buoyancy with his dry suit or back mounted wings, the diver elected to ditch his weight belt and blew to the surface switching to his EAN 50 decompression gas at 45 m (150 fsw) on the way up.

The diver showed no symptoms of decompression sickness upon surfacing and was immediately put on surface oxygen. He was evacuated by a Coast Guard chopper *which did not have any oxygen on board*. Unfortunately, he was not packed with an O_2 cylinder and manifested symptoms in flight. Upon landing he was successfully treated with a single Table 6. Clearly this incident was a "blow up" and cannot be counted as a traditional DCI case. To date there appears to have been only one known incident of decompression illness involving trimix in approximately 500-600 recent US "technical" dives.

ANDREA DORIA, NEW YORK

No 3 1992 August

A very experienced cave diver omitted approximately 68 minutes of decompression rather than executing a free floating hang while conducting a solo air dive on the *Andrea Doria* and suffered a severe case of decompression illness. The diver was wearing double 104s pumped with air and an oxygen stage bottle for decompression and there was a surface-supplied O_2 system on board. Apparently the dive had gone near "picture perfect" in the 3-3.6 m (10-12 ft) visibility water when the diver's guideline broke at his "turn" and he was swept off the wreck by the strong current. After spending precious minutes swimming hard a about 57 m (190 fsw) to regain the wreck and find the anchor line, the diver was forced to begin his ascent due to his dwindling gas supplies. In the resulting confusion, *he neglected to deploy the reel and lift bag that he was carrying*. He ascended without a line and completed his 15 m (50 fsw) stop and ascended to 12 m (40 fsw) at which point he had minimal air in his doubles.

At that point, the diver reported he did not think of using his upline and bag and elected to surface rather than to ascend and pull his oxygen decompression free floating in the current and risk getting separated from the boat. Upon surfacing his computer showed 31 minutes of run time. The onset of symptoms was immediate and severe and progressed to include nausea, vomiting and vertigo. Oxygen and fluids were administered immediately by a fellow diver, an RN, and the diver was evacuated for treatment by helicopter. Reportedly he spent nearly 40 hours in the chamber and was released with a slight deficit in his left leg.

LAKE JOCASEE, NORTH CAROLINA

1992 July

An experienced cave diver suffered an oxygen seizure during decompression following a special mix open water dive to 90 m (300 ft) in Lake Jocasee was treated for fresh water drowning and luckily survived due to excellent top-side support.

Utilising a pair of large inflatables for surface support, safety divers and an continuous ascent/decompression line system, the eight minute planned jump to 90 m (300 ft) was conducted on trimix 14/33 (14% oxygen, 33% He, balance N_2, maximum working PO_2 1.41 ata) with two intermediate mixes, an EAN 32 (to start at 42 m or 130 ft) and an EAN 60 (to start at 18 m or 60 ft) to be followed by surface supplied oxygen at 6 m (20 ft). Back up oxygen bottles were carried by team members. Total planned decompression time was 61 minutes. Prior to reaching the 6 m (20 ft) oxygen stop, PO_2s on the diver were at or below about 1.4 ata with the exception of two minutes at 36-39 m (120-130 ft) (PO_2 of 1.5-1.6 ata), and 6 minutes at 15-18 m (50-60 ft) (PO_2 of 1.5-1.7) during the intermediate gas switches. The dive team discussed and dismissed the need for "air breaks" (the practice of breathing air for 5 minutes every 20-25 minutes during oxygen decompression which greatly reduces sensitivity to convulsions) as unnecessary during the oxygen decompression phase of the dive due to the short time (36 minutes) involved.

The dive proceeded as planned without incident until about 20 minutes into the oxygen decompression. The diver unclipped from the decompression line switching to his oxygen stage in order to swim over and check on a second team on a nearby decompression line on the second support boat. He did not communicate what he was doing to his partner who lost visual contact with the diver as soon as he swam off. Swimming slowly the diver lost some buoyancy, drifted down to about 10.5 m (35 ft) (PO_2 of 2.06) and he believes he dozed off for several moments due to his excessive fatigue. He startled awake when his breathing became abnormal and quickly checked his depth as the onslaught of oxygen toxicity began. Fortunately experience took over. Holding his regulator in his mouth with one hand he hit his power inflator with the other as the seizure began. His actions saved his life. As he ascended uncontrolled, he was aware of losing his regulator at about 3 m (10 ft) and hit the surface convulsing, face down and helpless before losing consciousness. The diver was rescued within moments of surfacing by the team's support personnel. His breathing had stopped. CPR was applied and the diver was resuscitated. He was soon evacuated to a nearby hospital, treated for fresh water drowning and recovered.

Though the diver's profile would normally be considered "light" from an oxygen tolerance perspective *the short spike to 10.5 m (35 ft) coupled with the lack of an "air break" apparently led to trouble.* Extenuating circumstances appear to be his condition before making the dive. A paramedic by profession, the diver had just come off of a 24 hour shift and *had less than 2 hours of sleep the night before the dive.* Fluid intake had been minimal and little food had been consumed over the previous 14 hours. Diver fatigue was believed to be the main factor in the accident.

Accident Analysis

About twelve to fifteen years ago in response to the then growing number of accidents, the cave diving community developed a set of safety principles based on the then new tool of accident analysis. Later refined by pioneer Sheck Exley,[2] and elucidated in his book *Basic Cave Diving: A Blueprint for Survival*, accident analysis is a means to rigorously dissect an accident into its constituent parts with the goal of determining what went wrong. Applying this tool to cave diving it was found that most diving accidents could usually be attributed to a primary causal factor and typically one or more contributing factors. What is more is that these factors could be boiled down into five basic cave diving safety principles; *be trained, utilise a continuous guideline to the surface, manage your gas according to a third's rule or better, don't dive deep (on air),*[3] *and carry at least three lights.* Accident analysis and these resulting safety principles have become the cornerstone of cave diving safety ever since.

As shown in Table 1 the predominant causal factor in the accidents above was ***the lack of a "continuous guideline" (line system) to the surface*** that serves as a critical navigation device in the overhead environment of a cave or wreck and an important staging tool during open water staged decompression. Even in the absence of rough sea conditions executing a five to ten stage open water hang in the absence of a decompression line is hazardous and tricky, particularly when using hyperoxic mixtures for decompression, where depth control is critical.

Though the use of a continuous guideline is one of the fundamental safety tenets in cave diving, the use of lines is still not accepted among many of the hardcore wreck diving community ***though its absence has resulted in many wreck diving deaths, near misses and injuries.*** Fortunately this mindset is changing. In the accidents discussed above **getting separated from the line and or not carrying/running a reel was the primary factor responsible for the death at Alachua, the second death and decompression incident on the *Andrea Doria* and was a contributing factor in the La Jolla deaths and the *U-Who* blow up**.

The second most common factor, responsible for at least three of the incidents above, was "***inadequate gas management*"**, including the lack of pre-planning and violation of gas management rules, for example conducting the dive according to the "Rule of Thirds" (turning the dive when the first member consumed one third of his or her gas supply leaving two thirds for the return transit and a reserve). **Out-of-gas emergencies are the single greatest risk factor in self-contained diving**. The practice of burning down one's gas supplies to 500 psi or less at depth, and or relying on a pony bottle to exit a wreck and ascend to a decompression gas stage is dangerous and irresponsible. It not only endangers the life of the diver in question but jeopardises the safety of the entire team. **In at least two of the cases above, the first fatality on the *Andrea Doria* and the La Jolla deaths, the dive team entered the water *with insufficient gas to conduct the dive safely and handle an emergency*.** They were in effect conducting suicide missions.

Though "special mix" was used in six of the cases discussed above, four involving helium mixes, the important issues appear to be operational problems of running out of gas, blow ups and depth control and in the two enriched air diving incidents oxygen management. Helium was not the problem. Reducing nitrogen levels (i.e. nitrogen narcosis) at depth by using a helium mixture is clearly a major safety factor and *the failure to use trimix in the deep dives above would have made this worse.* ***Clearly,***

the most critical factor in special mix diving for technical divers is oxygen management.

Inadequate oxygen management was the primary factor responsible for death on the *Arundo* where oxygen tolerance limits were knowingly pushed to an extreme. In the case of the death at Devil's Eye, *oxygen levels were outside of the recommended NOAA limits* (PO_2 not to exceed 1.6 ata) and involved high work levels though there may have been other contributing factors which in the absence of an autopsy will never be known. *Given the depth profile of the system and high work levels, an EAN 32 or 36 mix giving a maximum PO_2 of 1.2-1.5 at the maximum depth of 31.5 m (105 ft) would have been a wiser, more conservative choice of gas mix.* Gas mix choices were not an issue in the case of Lake Jocasee convulsion. Rather the problems were that the diver *lost depth control* during decompression resulting in a PO_2 spike, *"air breaks" were not utilised* and there were known extenuating circumstances being *extreme diver fatigue* which is believed to have been a major contributing factor to the incident. *This dive should probably have been "called" before it began.* **These incidents highlight the caution and respect that must be used in managing oxygen tolerance and underscore the need for "conservatism" in utilising hyperoxic mixtures** *which includes air beyond about 57-60 m (190-200 ft).*

Today there are numerous groups that are running "high" PO_2 levels during the working phase of their dives, and there seems to be considerable misunderstanding about oxygen tolerance and some misapplication of management tools such as the NOAA Oxygen Limits which were never designed for technical diving exposures and don't take into account multilevel profile or varying diver work levels. What is more is that there are still major gaps in our understanding about oxygen tolerance, considerable individual and daily variability exists, and there is scant hard to CNS toxicity involving multilevel exposures. As a result, the trend in oxygen management over the years across many different communities, including both commercial and military divers, has been to reduce excessive PO_2 exposures (of 1.6 ata or more) in order to avoid oxygen convulsions.[4] What was thought to be "safe" ten to twenty years ago is now viewed to involve unacceptable risks.

This trend seems to be continuing in technical diving and the emerging community "consensus" seems to be directed at conservatism; **running PO_2s at about 1.2-1.45 ata during the working phase of the dive, boosting oxygen levels to a maximum of 1.6 ata during resting decompression and taking regular "air breaks" during the 6 and 3 m (20 and 10 ft) oxygen stops**. In addition, EAN mixtures such as EAN 50 are being used in place of pure oxygen for decompression in some applications offering the advantage of greater operational flexibility. The potential danger of an in-water seizure is also spurring the development and use of full face mask and block systems which act to prevent drowning in the event that a diver loses consciousness and will facilitate the use of needed underwater communication systems. **As a result many people believe that full face masks and blocks will become the standard equipment for technical diving much as it has in commercial and professional communities**.

Note that in the accidents presented above, *the resulting narcosis from the* ***use of air beyond about 57-60 m (190-200 fsw)*** was likely a major contributing factor in the La Jolla fatalities and possibly an issue in the case of the diver failing to employ his reel and lift bag on the *Doria (incident 3)* which resulted in him taking a hit. It also appears to have been a major factor in a number of this summer's deep diving deaths in Europe according to informed sources.

Lack of proper equipment was probably a contributing factor in the second fatality on the *Doria* in which the diver was only carrying single, arguably inadequate, back up light. The cave diving community recommends that divers carry a primary and two back up lights. That way in the event of a primary light failure the diver still has a secondary light and a back up. The wreck diving community seems to have taken this principle one step further. The thinking today is that divers should carry two primary lights or at least a "substantial" secondary light. Switching to a one to two watt back up in a silt out or low visibility situation after running a 50-75 watt primary is likely to add to the distressed diver's confusion.

Clearly improper equipment was also the major contributing factor to the La Jolla deaths. The diver's were not equipped to conduct the dive they intended to do. ***It can be easily argued that the typical recreational diving set is inadequate for conducting dives beyond about 39-45 m (130-150 fsw) and for decompression dives,*** the major problem being inadequate gas volumes (to handle emergencies), the lack of self contained redundancy, a "long hose" on the back up regulator and lines. That is not to say that these dives can't be done; in fact they are done regularly in some communities. ***The point is that these dives cannot be conducted safely using recreational equipment and methods***. Unfortunately many recreational divers seem to be unaware of this fact as evidenced by "beyond the limit" dives regularly conducted at warm water resorts and in home waters.

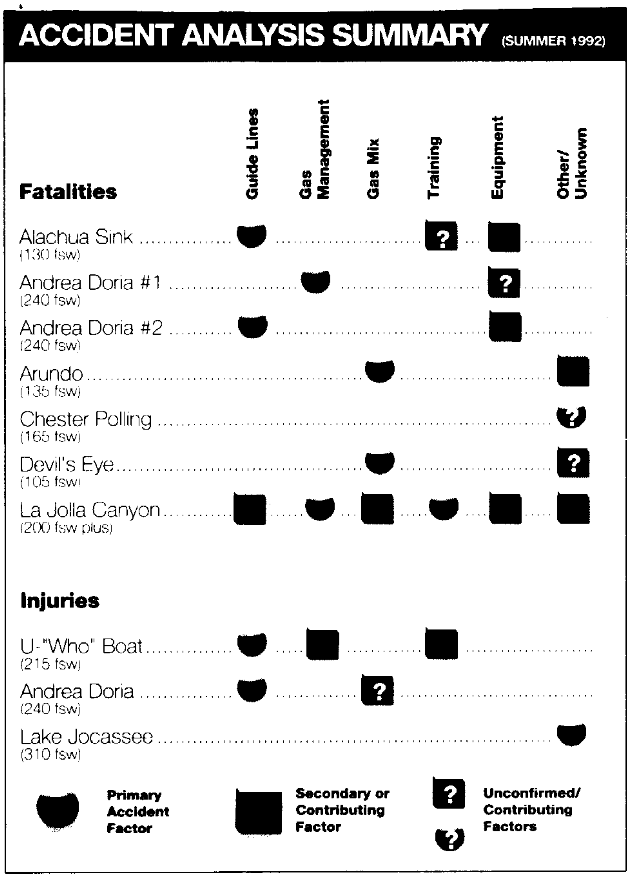
Though it can be argued that the lack of training is almost always a causal factor in diving accidents, particularly as the term is used in athletic sports i.e "continual work and practice," formal training seems to have played only a contributing role in all but one of the accidents presented above. With the exception of the La Jolla fatalities and the *U-Who* incident in which the diver had not "trained" on the equipment he was diving, all of the incidents involved "trained" and "experienced" divers. The point is we need to be careful in assigning accident causality and not treat training courses as an automatic panacea.

It is doubtful whether a formal "nitrox certification" would have prevented the death of the very experienced "self-taught" enriched air diver on the *Arundo* who chose to disregard recognised oxygen limits. Similarly, though it can be argued that the dive team involved the first *Doria* fatality were not "formally" trained in the use of trimix, that is not what killed the diver in question or nearly killed his partner; poor gas management did. In fact the divers had made previous mix dives, worked with other divers who were "trained" in its use, and were "experienced" by any diving standards.

The fact is that with the exception of enriched air training[5], there is at present no formal "standardised" special mix training programs or recognised safety standards in technical diving and only a handful of individuals (and few instructors!) have much experience at all. That is not to say that some of the existing training programs and instructors are not excellent and that the efforts to set up and build a certification system are not to be applauded. Rather the facts suggest that simply "getting a card," which is only just a starting point (a carry over from recreational diving?), is not enough and should not be promoted nor treated as a one-stop licence that in itself will make a diver drown proof, better qualified, or more of an "expert" than others. What is more is that training is very much *task and environment specific* and experience in one environment (e.g. caves or wrecks) does not necessarily qualify a diver for another without additional work. Under these circumstances it makes good sense for divers to take responsibility for their own safety, continually seek out the best training available for the dives they plan to conduct and to build up their experience base slowly through practice. ***The bottom line is that technical diving involves a lot of hard, dedicated work, continual practice, expense and represents an ongoing learning process***.

Several final factors that contributed to more than one of the incidents above is the ***lack of adequate surface support*** and apparent ***macho attitudes*** which are a theme in this issue of *technicalDiver*. The emerging community consensus is that adequate surface and diver support is essential for the safety of the dive team for many if not most technical level exposures. In this, technical diving is similar to its commercial counterpart. Adequate support might have made a difference in the *Chester Polling* incident and was certainly responsible for saving the lives of the divers on the *Doria* (incident 3) and at Lake Jocasee.

Macho attitudes do not have a place in any kind of diving, particularly those involving technical level exposures. Of course given enough time, the forces of natural selection will eventually take care of the problem and empirically it's much cheaper and more effective than government. Fortunately, as we have learned from the cave diving community, there is a better way. As a techni-



cal community, we would be wise to follow their example. Safety first.

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Please send any reports or information regarding accidents involving "technical-level" exposures to aquaCorps at PO Box 4243, Key West, Florida 33041. Fax 305-294-7612

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