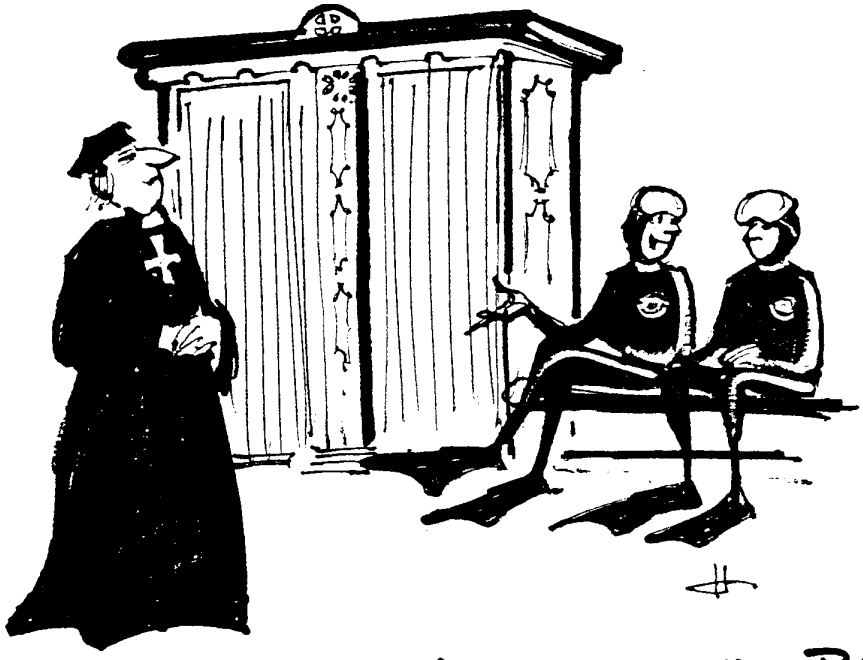
SPUMS JOURNAL

South Pacific Underwater Medicine Society

JANUARY TO MARCH 1981



HE'S TOPS ON CONFIDENTIALITY, BUT HE REFUSES TO PUBLISH INCIDENT REPORTS!

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EDITORIAL

The SPUMS meetings in Singapore and Pulan Tioman last year were the occasion of many informative and thought provoking papers, extracts from some of which are published in this issue. A particularly welcome feature was the high input of personal experience these papers contained and the suggestions concerning our possible responsibilities to "Diving". Dr Michael Davis reminded his listeners of what is probably one of the most important facts affecting survival and safety that most diving accidents result from a series of things which do not fit together properly so that when something goes wrong a whole lot of other events build up to make things worse. From this he developed the theme that as physicians interested in diving medicine we have to be interested in the whole philosophy of sport diving. Training and practice. Concerning the management of "an incident" he stressed that divers were taught about a number of well defined Diving Diseases but were likely to be faced by "a bloke who looks bloody crook", a very different matter. It is most likely to be someone with no medical experience who is the one first involved in making the critical initial management decisions. Members may think that SPUMS should formulate an incident Management flow chart to guide divers faced with such a situation and readers, both lay and medical, are invited to make suggestions for such an aid to management.

We accept nowadays that divers should receive instruction in CPR during their initial training courses and Dr John Miller drew attention to a requirement in the USA that all physicians, nurses and paramedics have certification in cardio-pulmonary resuscitation and remain current in such abilities. On the subject of Decompression Sickness, he explained why those affected need early recompression, an adequate treatment if applied before the bubbles become foci for the accretion of other materials. Possibly any adventurous careful diver will hereafter take along oxygen, a Meyer cocktail, diving tables, a Treatment Flowchart and a highly dependable buddy when venturing beyond close contact with civilization. Should serious misadventure nevertheless strike, remember the stories told by both Dr Miller and Dr Tony Slark about the fallacy that air transport is necessarily the fastest and best for the patient.

It has always been Editorial policy to choose papers dealing with people rather than cases, though most welcome are instances where cases of great clinical interest are joined with the diving details. Here are presented a case of near-drowning, a transient facial palsy and an asthmatic incident in a diving situation. There is additionally a non-incident, an excellent example of the value of unsolicited advice when the donor is well informed. It is not good enough to stand back, like one of Robbie Burn's Unco Guid, smug in our righteousness in matters medical and subaquatical, waiting to pick up the pieces.

It is with pleasure that we reprint several pre-conference abstracts of papers presented at the UMS/EUBS meeting last year in Athens. The co-operation of UMS in this matter is appreciated. The information they contain is worthy of careful consideration.

One of the basic requirements for the morbidity-free exploration of what one's environment has to offer is to learn speedily from the example of others, so as to benefit painlessly from their successes and failures. It is in this context that Reporting Schemes are beneficial. To balance out the community benefits against the individual loss of experience-benefit vis a vis competitors may be an ethical decision on occasion, but usually reports can be freely made under cover of confidentiality of source (to avoid red faces and/or libel actions!). The method of obtaining a desirable degree of such confidentiality is raised in the discussion paper on reporting schemes. Yes, correspondence will be welcome. That information can be shared is evidenced by a report, to appear in the next issue, on the recent Bell incident in the North Sea. The company concerned, Wharton Williams Taylor, have been generous with details. Hypothermia was the critical factor and the Diver Survival Kit proved vital.

Most people think the initials SCUBA stand for self-contained underwater breathing apparatus. The Australian Army says it means Stock Controlled Usage Based Army. The Army's new SCUBA supply system was successfully tested in Sydney last month.
Daily Telegraph - 23 March 1981

REPRINTING OF ARTICLES

Permission to reprint articles from this journal will be granted on application to the Editor in the case of original contributions. Papers that are here reprinted from another (stated) source require direct application to the original publisher, this being the condition of publication in the SPUMS Journal.

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LETTERS TO THE EDITOR

Dr MY Khan,
Rampure 458-118
M.P. INDIA

2nd March, 1981

Dear Sir,

The postman delivered the SPUMS JOURNAL in today's mail, which was in tune with better late than never. The absorbing and interesting articles made me to finish the complete issue soon. My thanks for the fine format and upbringing of the journal.

In his article 'ACUTE HEARING LOSS FOLLOWING DIVING INTO AND IN WATER' Dr Molvaer bursts in the problem like a comet. But all throughout the course it seems he was still whispering rather than thundering. No words however well carefully composed can express my appreciation for his work. His conclusions have added new dimensions in understanding the diver's problem. This correspondence in no way belittles his achievements nor is it aimed at. I am sure he will take it in a scientific spirit.

Aural barotrauma is a property of single feature depth eg. less than ten metres. A depth beyond this depicts the downward slope of the incidence. It is most common among subjects ignoring the colds and coughs prior to diving or chamber occupation. Violent manoeuvering in and underwater for clearing the tubes or pressure equalisation is almost always fraught with dangers. The pain of unequalised tubes is sufficient enough to abort the dive. A fast descent will translate the painful ears into the comparative relief of perforation. Ascent barotrauma is less common entity. "Of diving and hyperbaric exposure due to ears" are most common. Unconscious patients clear their ears under effects yet to be researched. Divers, irrespective of interest are thoroughly trained and has to go through rigorous medical examinations followed by in between check-ups, so as to prevent and stop the occurrence of morbidity and mortality. These are the salient features of my paper 'PROFILE OF AURAL BAROTRAUMA AMONG THE DIVERS AND CHAMBER OCCUPANTS'. In the light of above observations my curiosity grows for the following points to be clarified in his article.

1. The total number of cases examined is not mentioned. Thus the incidence of the dysfunction is not coming out.

2. A thorough scrutiny of the cases shows that most of the incidence could have been easily avoided had the diving rules and regulations been followed in toto.

3. Cases 3 to 13, 15 to 21 and 23 to 25 in all probability could have been avoided because they had colds and forcefully equalised the ear pressure against the diving procedures. Cases 1, 2, 3, 4, 7 and 23 entered the water without qualifying for the same.

4. The pathophysiology of the hearing loss is not discussed.

5. The morbidity and mortality statistics as available in the international literature has never reached such a proportion. Similarly the incidence is in no way at par among the divers, simulators, chamber occupants for treatment or otherwise, aerospace centres, noisy factories. A supersonic jet boom might have rendered the population deaf.

6. Acoustic acuity of the diving mammals is further to be incorporated in the work.

Diving will have to be abandoned if the present rate of aquatic dysfunction is brought to bear on the community.

Yours faithfully,

MY Khan

We sympathize with Dr Khan in his frustration with the postal service. Nine months from Melbourne to Rampura *is an excessive time, but the Journal, for financial reasons, is sent sea mail.*

While Dr Molvaer did not discuss the pathophysiology of the hearing loss of divers, the pathophysiology of inner ear fistulae, the cause postulated in most of Dr Molvaer's cases, was discussed in detail in the paper by Drs Donoghue and Knight in the same issue.

SEA SLUGS REVEAL NUCLEAR DUMPING IN OCEAN DEEPS

Sea slugs dredged from 1,400 metres down in Sagaimi Bay, near Tokyo, have been found to contain-dangerously high levels of radiation. Some Japanese scientists have claimed that they were contaminated by nuclear waste dumped there 25 years ago. The claim has made it difficult for a Government mission to persuade the fishermen and other inhabitants of Ogasawara Island that they will be safe if nuclear waste is dumped near their island. There were plans to dump 5,000 barrels of nuclear waste in the western Pacific in 1981, but they have been postponed, it is reported. The Science and Technology Agency admitted that 39 drums were dumped in the bays in 1975 and 1977. Random checks detected site levels of cobalt 60 and caesium 137 up to 10 times the normal. Officials do not admit that the drums have leaked, suggesting that Chinese nuclear tests may be the cause. It is perhaps time to accept that chemicals deposited in the depths may return through the cycle of life, to kill.

SUBSCRIPTIONS

Members pay $20.00 yearly and Associate Members $15.00. Associate membership is available to those neither medically qualified nor engaged in hyperbaric or underwater related research. Membership entitles attendance at meetings and the Annual Scientific Conference and receipt of the Journal/ Newsletter. Anyone interested in joining SPUMS should write to the Secretary of SPUMS, Dr Christopher J Lourey, 43 Canadian Bay Road, Mount Eliza, Victoria, 3930.

MINUTES OF COMMITTEE MEETING

HELD AT: 25 Hastings Road, Frankston, Victoria on 26th November, 1980, at 2000 hours.

PRESENT: John Knight (President), Bill Hurst (Treasurer), Victor Brand, Beryl Turner, Chris Lourey (Secretary).

APOLOGIES: Darrell Wallner, Douglas Walker.

MINUTES OF THE PREVIOUS MEETING: R e a d and accepted as correct.

BUSINESS ARISING:

(1) The President tabled a letter written to FAUI regarding the medical evaluation of sports divers. This is to be promulgated in the SPUMS Journal.

(2) A protocol of management of diving accidents, as presented at the Singapore Meeting in June, 1980, together with the School of Underwater Medicine Emergency telephone number to be promulgated to -

(a) Safety Officer and National Director of Coaching, AUE.
(b) FAUI
(c) The Health Commissions of all States and to all Hospital Casualty Departments, with an accompanying letter.
(d) The Australian Resuscitation Council, with an accompanying letter.

The President volunteered to prepare this protocol with assistance from Victor Brand.

TREASURER'S REPORT:

The current Trading Bank balance as at 24th November, is $4,347.61. The fixed deposit stock as per the Annual Audited Report plus accrued interest.

It was noted that the cost of the Keynote Speaker/Guest Lecturer has been made good in previous years from consolidated revenue. The hazards of this were discussed and it was unanimously agreed that this cost should be paid from the Registration fee at the AGM. It was unanimously agreed that the registration fee for the 1981 AGM be $70.00.

CORRESPONDENCE RECEIVED:

(1) The South Australia Diving Death Report.

(2) Barologia.

(3) Dr Michael Strauss - The Chairman of the Annual Scientific Meeting of the Clinical Application Of Hyperbaric Oxygen. Regarding their meeting in June, 1981.

(4) Consultative Diving Report - "Health and Safety at Work" from the Diving Medical Sub-Committee - United Kingdom, forwarded by Dr Dick Adams.

BUSINESS ARISING FROM CORRESPONDENCE:

The Secretary to forward a copy of this report to both the:
(1) PDAA.
(2) The Diving Central Medical Registry.

SECRETARY'S REPORT:

The Secretary presented a report on the plans for the 1981 AGM/Scientific Meeting to be held at the Argao Beach Resort, Cebu, The Philippines. An invitation is to be sent to all the Philippine Diving organizations and Medical Practitioners inviting their participation and presence.

A report on the Secretary's address to the Executive in Athens was given - concise report was promulgated in the Secretary's letter to members. The 80's hopefully will see the development of fruitful exchange between the two societies.

Dr David Elliott has accepted the invitation to be the Keynote Speaker/Guest Lecturer at the 1981 AGM.

DIPLOMA OF DIVING AND HYPERBARIC MEDICINE:

Dr B Turner as Convenor of the Diploma Sub-Committee presented a Report on discussions held with the Commonwealth Institute of Health (incorporating the Industrial Health and Tropical Medicine School) and The University of Sydney. A separate report of this was tabled and accepted.

The dates of the Underwater Medicine Courses for 1981 were promulgated in the Secretary's letter to members.

THE JOURNAL:

The next edition of the journal to be published at the end of 1980.

FUTURE MEETINGS:

It is proposed to hold the next Executive Meeting, together with a One-Day Scientific Meeting at the School of Underwater Medicine. Dr Beryl Turner kindly agreed to organize this.

As per attached list (not printed)

GENERAL BUSINESS:

The President presented a report on a meeting with COMEX (13.11.80) held for the diving and medical communities.

The Meeting closed at 2300 hours.

AN EPIDEMIOLOGICAL STUDY OF FATAL DIVING ACCIDENTS IN TWO COMMERCIAL DIVING POPULATIONS

ME Bradley

US Naval Medical Research Institute

The distribution of fatal diving accidents in the commercial diving population in the Gulf of Mexico and in the British sector of the North Sea has been examined and the factors which influence or determine that distribution are discussed. Recommendations for safer diving practices are presented and areas where research is needed are suggested.

There are a estimated 905 commercial divers in the US who work in the Gulf of Mexico. From 1968 to 1975 there was an average of 2.25 deaths per year in this group of divers, an annual average fatality rate of 2.49 per thousand per year. About 700 commercial divers work in the British sector of the North Sea. From 1971 to 1978, there has been an average of 3.375 deaths per year in this group, which is a fatality rate of 4.82/1,000 per year. The incidence of fatal diving accidents for each year in these two diver populations is presented in Table 1. From this data it is apparent that commercial diving operations in the North Sea are more hazardous than those in the Gulf of Mexico. In the Gulf, the highest fatality rate occurred from 1968 to 1970. In the North Sea, the peak period was from 1974 to 1976. These periods correspond with the introduction of new diving techniques and heightened diving operations. It is noteworthy that in recent years there has been a substantial reduction in mortality in both areas.

TABLE 1

FREQUENCY OF FATAL DIVING ACCIDENTS IN COMMERCIAL DIVING

GULF OF MEXICO

Year	1968	1969	1970	1971	1972	1973	1974	1975
Deaths	4	3	5	1	1	1	2	1

NORTH SEA

Year	1968	1969	1970	1971	1972	1973	1974	1975
Deaths	1	1	2	5	6	7	3	2

Most accidents involve multiple factors that are mutually interacting. To understand the cause of accidents requires identification and analysis of interactions between variables that differ widely. One successful technique for analysing accidents is an adaptation of epidemiological methods. This approach analyses accident data in terms of interaction between “host factors”, “environmental factors” and “agent factors”. Host factors are the characteristics of the persons suffering injury; environmental factors refer to situational variables that predispose or contribute to injury; and agent factors are the agencies capable of producing injury.

HOST FACTORS

Age and experience

The average age of the divers who died in the Gulf of Mexico was 34.1 years with a range of 21 - 50 years. The mean age of the diving fatalities in the North Sea was 26.5 years, with a range of 20 - 40 years. Because the data was inadequate, the degree of experience could not be assessed for either group; however, the younger age of the North Sea fatalities in which 77% of the divers were between 20 and 29 years of age suggest a lesser level of diving experience.

Health of a diver

The nature of diving requires that divers be in good health. Nevertheless, a small number of diver fatalities occur because of medical conditions that contribute to the accident. In one (6% total) of the accidents in the Gulf and in two (7%) deaths in the North Sea, medical conditions that contributed to the fatality were present.

Behavioural factors

Behavioural dysfunction in diving is the major contributor to diving accidents in all diving populations. Behavioural dysfunction in divers may take the form of poor judgment. Anxiety and panic have been recognised as important contributors to fatal diving accidents. In 17% of the Gulf accidents and 15% of those in the North Sea, poor judgement or panic on the part of the diver was cited.

Summary of host factors

The “typical” commercial diver involved in a fatal diving accident is most likely to be in his mid twenties. He is in good health. He is probably somewhat inexperienced as a diver. Poor judgment on his part or panic are occasional concomitants to the accident.

ENVIRONMENTAL FACTORS

Environmental factors that can contribute to a fatal diving accident are varied. They include but are not limited to:

a) depth of dive;
b) breathing gas;
c) weather;
d) sea state;
e) current;
f) equipment failure;
g) capability of others;
h) narcosis;
i) clarity of water.

Depth of dive

In the Gulf, the mean depth of dive in which there was a fatality was 136 feet (range 0 to 340 feet). The mean depth of North Sea dives was substantially greater (223 feet, range 0 to 500 feet). The percent distribution of these accidents was according to depth is presented in Table 2. The majority of fatal diving accidents in the North Sea occurred during dives in excess of 200 feet. In both the Gulf and North Sea episodes of unexplained

diver unconsciousness or unaccountable actions have been contributory to accidents occurring during dives of 300 feet and greater.

TABLE 2

THE DISTRIBUTION OF FATAL DIVING ACCIDENTS ACCORDING TO DEPTH

Dive depth (feet)	Gulf of Mexico (%)	North Sea (%)
Surface	17	16
1-100	25	16
101-200	33	16
201 +	25	52

Breathing gas

Compressed air was the breathing was in use during the majority (67%) of fatal accidents in the Gulf. Helium oxygen mixtures were most commonly (63%) in use during fatal North Sea accidents.

Cold

Cold was mentioned as a contributory factor in 11% of the North Sea fatalities. It was not a factor in any of the Gulf accidents.

Sea State

Heavy sea states were considered to be a factor in 15% of the North Sea accidents; all of these accidents occurred on the surface. In none of the Gulf accidents were bad weather conditions considered to be a factor.

Equipment failure

Severed or fouled hoses occurred in 33% of fatalities in the Gulf and in 11% of the North Sea accidents. In 11% of the North Sea deaths, a diving bell was dropped; in another 19% of the North Sea fatalities there was some form of equipment failure, usually concerned with the underwater breathing gear.

Capability of others

In 33% of the Gulf fatalities and in 22% of the North Sea accidents, there was some form of judgmental error by the diving supervisor, tender or bellman.

Summary of environmental factors

There is a considerable influence of environmental factors in commercial diving fatalities. Deeper dives carry a greater risk. Cold and sea state contribute heavily in the North Sea. However, the most important environmental factors present in fatal accidents, are equipment failure and diver supervisor/tender error during the conduct of the dive. Improved equipment selection, maintenance and operation together with adherence to cogent, safe operating and emergency procedures, would appear to offer the greatest possibility of reducing accidents.

AGENT FACTORS

Agent factors are those agencies that constitute the direct causes of injuries. The distribution of agent factors in these two populations is given in Table 3. In both groups, drowning was the most common proximate cause of death. Decompression sickness/air embolism and asphyxia were next in order.

TABLE 3

THE DISTRIBUTION OF CAUSES OF DEATH IN DIVING ACCIDENTS

Cause	Gulf of Mexico (%)	North Sea (%)
Drowning	44	63
Decompression Sickness/air embolism	28	19
Asphyxia	17	7
Trauma	11	0
Other	0	11

SUMMARY

Commercial diving is a hazardous occupation. Nevertheless, the fatality rates are not as high as some other high risk occupations, such as anthracite mining in the US. In recent years, there has been a significant downward trend in fatality rates in the commercial diver populations in the North Sea and in the Gulf of Mexico.

The interaction of host factors, environmental factors and agent factors in commercial diving fatalities has been examined. The contribution of environmental factors to diving fatalities appears to be the greatest problem and the most amenable to change. Research into the cause of diver unconsciousness and inexplicable action occurring at depths below 300 feet is needed.

Acknowledgements

Naval Medical Research and Development Command, Work Unit No. M0099 PN.002.7062. The opinions and assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

REPRINTED BY KIND PERMISSION OF THE UNDERSEA MEDICAL SOCIETY FROM THE ABSTRACTS OF THE SEVENTH SYMPOSIUM ON UNDERSEA PHYSIOLOGY.

SEVERE ACUTE ASTHMA WHEN DIVING

An experienced 21 year old diver suffered a life threatening attack of acute asthma while participating in a FAUI diving school course of instruction. The incident occurred after a class devoted to practising the retrieval of a disabled diver from sea bottom, depth 15 feet. Due to the rare good luck of there being several doctors in the course, and the skill of the instructors present, the victim survived. The problem of deciding "Fitness to Dive" is discussed. This account is based on the reports of two of the doctors present, made to "Stickybeak" Incident Report Project.

The diver in question had been attending a diving school with the intention of obtaining a diving accreditation. His pre-dive medical examination had been carried out by a very experienced medico-diver, and the information obtained from the novice was that, prior to the instruction course, he had carried out some 30 dives to a depth of 130 ft. At the medical examination the diver was noted to be a confident extroverted personality admitting to a past history of asthma, for which he used Berotec and Becotide inhalers. At the time of the examination there was no clinical evidence of broncho-spasm. Vitalograph readings were Vital Capacity 4.6 litres, FEV_1 3.9 litres. These figures were without the use of a bronchodilator. There was normal ECG tracing and chest X-rays were also within normal limits. The medical advice given to the diver was that he would be fit to dive providing he was free of all asthma symptoms and had taken an inhalation of Berotec prior to his actual dive. This advice was significantly influenced by the alleged pre-examination diving experience of the patient and his statement that he had never been troubled by asthma symptoms during such diving.

On the day in question the external air temperature was approximately 16°C; the water was cold, with a slight sea, and a fresh breeze was blowing. The FAUI rescue and resuscitation exercises had just been completed by the group of six novice divers, under an experience instructor, and the weight belts retrieved from the sea bottom (5 m), when one of the pupils was seen to be holding on to the pier near which they had been diving. An instructor swam to his side and was informed that he was suffering from an episode of asthma and that a suitable inhaler to control his condition was in his car. The victim's buoyancy vest was inflated and he was assisted to the shore some 25-30 yards away. His gear was progressively removed during this time and one of the doctors told of the emergency. This witness noted that the victim was cyanosed during the return to shore, where he then sat just above the water's edge with his arms braced under his knees, wheezing on inspiration and expiration and passive while others removed his wet suit top.

Within a matter of a minute or so he suffered increasing cyanosis and dyspnoea and became unconscious. He was laid on his back with his head extended to maintain an airway, and while in this position suffered a tonic-clonic Grand Mal seizure. His airway was maintained clear at all times. Post-ictally, with decrease in muscle tone, mouth to mouth ventilation was instituted and he was covered with towels in an attempt to prevent chilling. After a minute or two he commenced breathing again and Berotec was administered. Five puffs were given, at successive inspirations, though the first two were probably not functional. Throughout this period of time bradycardia became pronounced, but there was not at any time cessation of his heartbeat. His respirations increased and the former extreme cyanosis started to diminish so it became possible to roll him on to his side in the coma position. At this time some oxygen became available and intranasal oxygen was commenced. His mouth was cleared of mucus, saliva and blood.

The blood in the mucus from his mouth caused quite some anxiety but was, it seems probable, the direct result of trauma to his tongue and lips witnessed during the seizure.

His pupils on first examination when he was conscious were fairly dilated, and in fact became very large during the subsequent hypoxia and seizure. They did not decrease in size until he regained consciousness some time later. Prior to being rolled onto his side it was checked that he was ventilating both lungs and that there was no clinical evidence of a pneumothorax. There were no signs of pulmonary barotrauma.

Shortly after this stage in recovery had been attained an ambulance arrived, and reliable oxygen and suction equipment became available. There was no evidence of inhaled mucus on sucking out his airways. This management was continued during the journey to hospital. His conscious state improved during this 15-20 minute ambulance trip and on arrival he was conscious and responding to simple verbal commands, but it had become apparent during transport that he was wheezing again, although no cyanosis or real respiratory distress was noted. On arrival at the Casualty department he was conscious and asking what had happened. He was therefore started on an intravenous drip with 250 mg of Aminophylline in a one litre flask, and an initial slow intravenous dose of 250 mg Aminophylline was given.

At this time the patient complained of being unable to see. He could not initially identify light or dark but said that, though unable to see, it was light. His vision progressively returned to a reliable finger counting acuity over the next 25-30 minutes. His BP on arrival was 165/95 and he had marked bradycardia, pulse rate about 60 per minute. His BP gradually settled to about 135/80 and his pulse rate increased to about 20 per minute over the first 20-30 minutes in Casualty. After the first half hour in Casualty he was still confused, somewhat disorientated, questioning but co-operative. While his fundi were visualised he had fairly continual eye movement, so fundoscopic examination was less than ideal but no evidence of abnormality was found. His co-ordination was grossly impaired.

His condition progressively improved, with dramatic improvement in his vision and

resolution of his wheeze. He was discharged the following morning, at that time there still being some blurring of vision which cleared on concentration or blinking. He had no memory of the episode other than of being short of breath.

On questioning him no past history of "fitting" could be elicited. He had a past history of asthma and in fact had suffered an attack four days previously and admitted that he had "not been 100%" since then. He usually had good control of his asthma with Berotec, he claimed. He also mentioned that he was allergic to Ampicillin, which luckily had not been used.

Neither his group instructor nor his fellow pupils had noted any evidence of illness or wheezing prior to the incident. He had appeared, in fact, to be enjoying himself immensely and looking forward to his 21st birthday the next day.

Later conversation with the victim confirmed the pro-dive psychological assessment, for he said, "She'll be right, jack, and in any case I am going to continue diving". Needless to say, his medical "fitness" has been withdrawn since this incident, but this will merely prevent him obtaining skilled instruction and, seemingly, not prevent him from diving.

Discussion

The asthma episode may have been triggered by the aspiration of a small quantity of water, the exertion, the cold water, or tension of the training situation, either singly or in combination. The pro-existing low-grade asthma over the four days before the dive was a contraindication to diving of which he had been specifically informed. He had failed to advise his buddies of either his asthma or his allergy, and in most situations this could have proved fatal to him. It is not known how reliably he represented his diving experience and his freedom from past asthma while diving, but his alleged decision to continue to dive suggests that he would be unlikely to supply information liable to disqualify himself from the sport on medical grounds. He would certainly be unwise to assume that all his future diving buddies will be as alert and skilled as those he was with on this occasion.

The question of Medical Fitness to Dive is certainly not a matter of clear black and white decisions in all cases. It is easy to have firm criteria but life often fails to conform to clear-cut categorisation, and our real documented knowledge of the significance of physical divergences from the perfect is slight and based on the few mishaps, ignoring the possibly vast number who suffer no ill effects. In this man's case the history of his having made a large number of uneventful dives made the condit*ional* medical approval not unreasonable, though it is not known whether the reason for such reservations in the supply of approval was put in writing. There is also the *de facto* situation that at the present time the applicant can go to any doctor for a "Medical", and the additional factor that medical checks may, on occasion, be undertaken *after* the course has been started (or even completed) at some diving schools outside the main Instructor organisations. The medical reason most commonly given for prohibiting diving by asthmatics is the risk of pulmonary barotrauma on ascent. In the few cases known to the Stickybeak Project, surface dyspnoea seems to have been the critical disability and the victims to have known of their disability and omitted adequate use of their medications. Personality factors seem to be critical in asthmatics, as they are in so many other circumstances. "Fitness" is still a debatable concept.

The incident confirmed the importance of wearing an adequate buoyancy aid and of being near your well trained buddy. It also highlights the problems which can arise in giving a well considered assessment of "Fitness" in a person already apparently demonstrating *de facto* fitness for the job situation under assessment.

Acknowledgements

The very full reports by two of the doctors concerned in this incident are gratefully acknowledged, and in particular their permission to publish this report.

STOP PRESS ADDENDUM

Since the above was written a fatality associated with an asthmatic attack while diving has been reported in another State.

NEW WATER SAFETY SYMBOLS

The Standards Association of Australia recently launched a series of five symbols designed to create a greater awareness of water safety. The signs cover swimming, surf boarding, water-skiing, scuba diving and fishing. It would be interesting to know who will have the task of placing the SCUBA diving warnings, as the present concensus is that scuba fatalities are related to the concurrence of a number of factors and only rarely to the innate danger of the locality. Any reader knowing how the signs are to be distributed is asked to communicate with the Editor.

SEVENTH ANNUAL CONGRESS OF THE EUROPEAN UNDERSEA BIOMEDICAL SOCIETY and SYMPOSIUM ON DECOMPRESSION SICKNESS

presented by
NORTH SEA MEDICAL CENTRE, GREAT YARMOUTH, UK

Churchill College, Cambridge, UK, 21-24 July, 1981

Enquiries to Clem Aidridge,
Administrator,
Norwich Union Insurance Group,
PO Box 4, Surrey Street,
Norwich, Norfolk.

NEAR DROWNING OF A DIVER

From the STICKYBEAK Non-Fatal Incidents File.

The victim was a healthy 17 year old youth. He was one of a group under instruction in Scuba diving from a qualified instructor and had, in company with the others, made two Scuba dives in fresh water before being allowed to make this first open water sea dive. Conditions at sea were calm, current less than half a knot and visibility over 60 ft, which was much easier than the current and cold of the freshwater dives. The dive boat was a 130 ft vessel and there was a 16 ft dinghy with twin outboard motors as safety boat.
The victim was the first to enter the water, a 10 ft jump entry. While waiting for his buddy to enter he hung on to a pontoon for several minutes. He was not wearing his mask and had neither his snorkel nor his demand valve in his mouth at this time. In fact his buddy never entered the water, for the victim was seen to float gently away on the surface for 40-50 metres and then heard to cry "HELP" before disappearing beneath the surface, the first indication that anything was wrong. The instructor immediately grabbed a mask, snorkel and fins and swam to the victim's last position, there making a brief 5-10 ft dive to see what had happened. Before ascending he was able to see the victim near the sea bed 60 ft below, without his tank and weight belt and with only one fin on. He seemed to be moving the leg with the remaining fin as if starting to make a free ascent. However, after taking another breath, he dived again and, found that the victim was no longer moving and was on the sea floor, so he continued his descent and brought the victim to the surface. There he started in-water EAR and attempted to feel the pulse while awaiting the (rapid) arrival of the safety boat. Reputable observers noted that there was less than a 2.5 minutes interval between the victim's submergence and his receiving CPR on the deck of the dive boat. On the boat it was noted that at 15 minutes the pulse could not be felt but at 25 minutes it was again noted, while breathing started again at 30 minutes. Much frothy fluid came from the mouth during resuscitation. There were no medical or paramedical personnel present but there were three experienced persons able to undertake and maintain treatment. The only occasion when the victim became cyanotic was when an inexperienced operator was performing the EAR.

After reaching shore the victim was flown by flying boat to a Base hospital. On arrival at Casualty he was unconscious and thrashing about in bed. He had grunting respirations, responded to painful stimuli with movement, but was not cyanosed. Pupils R=L, both reacting to light. His initial blood gases were adequate. He was transferred to the ICU for close observation, with a nasopharyngeal airway in situ. However, he developed marked respiratory distress and cyanosis, so was intubated and ventilated. A thiopentone infusion was commenced (as a brain-sparing device), also IV fluids, antibiotics and intensive physiotherapy.

The patient remained cardiovascularily stable and his neurogenic state improved. He was finally discharged from the ICU breathing spontaneously, talking nonsense and walking inco-ordinately. However, his condition continued to improve over the next few weeks with physiotherapy, OT, and speech therapy. Assessment by psychologists was that marked impairment of his visio-spatial cognitive abilities had occurred, as well as a milder degree of dysphagia. A Wechsler Memory Scale gave a Memory Quotient of 58, indicative of a significant memory impairment. There was also a marked tendency to confabulate, associated with this memory impairment. His attention span was also impaired. Follow-up a month after discharge from hospital showed that the mental state had much improved and the psychologist estimated that the various parameters of intellectual ability were all "within normal limits." It is believed that the pre-accident status was average, so no significant morbidity is now apparent by this testing.

COMMENT

This unfortunate accident illustrates the rapidity with which a serious incident can develop and the vital importance of immediate appropriate response. The Instructor's rapid response, his ability to freedive to 60 ft, the nearby surface cover boat and the skilled application of CPR saved the victim's life and brain function.

It is difficult to explain the exact sequence of events, not least because the victim gives a varying explanation of his initial problems, sometimes blame being put on sighting a shark or sting ray and at others a knock on the head from his tank being blamed. Possibly there was some aspiration of water while on the surface, panic and 'dry drowning' then occurring, for he appears to have never breathed from his tank or used his snorkel and he was not wearing his mask. Whether the equipment was dropped underwater while conscious or when acting unconsciously cannot now be known. He apparently wore a buoyancy vest but this was not inflated. The value of persisting with active resuscitation despite absence of consciousness is demonstrated, because return of cortical functions continued for several weeks after the anoxic damage occurred, a gratifying outcome for everyone concerned.

It is incidents such as this which underline the importance of having skilled instructors in adequate numbers present during instruction in diving, the speed with which appropriate action is taken being vital. It also shows the value of the 'simple skills' of breath-hold diving in an emergency situation. The Instructor is to be congratulated on his conduct of this lesson.

SPUMS 1981 SCIENTIFIC MEETING

Travel arrangements are in the hands of *ALLWAYS TRAVEL SERVICE, 168 High Street, Ashburton, Victoria, 3147. Telephone 03-258818.*

ANATOMY OF A NEAR-ACCIDENT

From the STICKYBEAK Non-Fatal Incidents File.

The writer of this Incident report teaches Marine Science and on this particular day had taken his students to a reef conveniently reached by a jetty from the beach. While giving them a pre-dive briefing at the end of this jetty he saw a group of five Scuba divers walk past. Only one of them wore a wet suit, two of them had no snorkels and none of them had a buoyancy vest. Their demeanour caused him to feel anxiety concerning their awareness of the need for adequate diving skills for diving here, so he went across to speak to them. The chap with the wet suit, but no snorkel or buoyancy vest, was local and the other four were visitors from New Zealand who claimed that they had all received Scuba instruction.

From the way they put on their gear, the veracity of this statement was doubted. The dive leader, the local man, jumped off the seaward side of the reef, with mask in hand (not on his face!) and drifted slowly out to sea while shouting instructions to the other four. They jumped in a few minutes later, and appeared to be fairly anxious. In fact, two seemed to be in mild panic and to be taking in water. The dive leader was now 30 metres out to sea and still drifting, still with mask (presumably) in hand.

"I shouted to him that he should come in closer to his group because they seemed to be in difficulties, and was told, extremely impolitely, to take myself away and keep quiet," the reporter noted. Meanwhile one of the three males now appeared to be in the initial stages of drowning on the surface. When asked if he was OK he made it quite clear that he was not, and that he needed help to get him out of the water as fast as possible, so the witness jumped in, retrieved him, and brought him onto the reef. It was not necessary to ditch any of his gear or weights because, despite the choppy conditions, it was possible to support him quite well with the aid of the rescuer's Fenzy.

No sooner had this diver been rescued than it appeared the sole girl of the four visitors was panicking, and possibly drowning, ten metres away. She was taking in too much water to answer questions, so she also was rescued. The remaining three of the group had meanwhile swum together and decided to submerge: their bubbles seemed to indicate that they were managing and in no difficulties. By this time the two who had just been rescued were observed to have re-entered the water, this time on the inside of the reef, and to be swimming off in different directions.

While his marine students were receiving their interrupted instruction on the inner side of the reef, he saw the girl diver frog-kicki*ng* and *breast-stroking,* in Scuba gear, nearby. This convinced him that the visitors surely couldn't have used Scuba before, so he told his students (who were all PADI open water Scuba divers) to continue their work while he once more set out to find the girl and her "buddy" (who was 40 metres away from her). They accepted his advice to go up on to the reef and give away any idea of further Scuba diving before they drowned themselves.

Meantime the three others had surfaced on the outside of the reef, the two visitors seeming to be in some minor distress. They too had decided that they had had enough. Speaking later to the dive leader, who was now quite subdued, it was revealed that he had taken them to a local dive shop (which has since then changed ownership and management) and there they had hired Scuba without having to produce any evidence of diver training. He still insisted that they had all been trained, but this seems difficult to believe on the evidence of the day's activities.

This popular diving area has had eight diving fatalities over the years and nearly added to the tally on this occasion. It is interesting to speculate whether ordinary swimmers, who would lack the benefit of wet suit buoyancy and Scuba air supply, would have survived the circumstances with as little morbidity. The fortuitous presence of skilled assistance stood between several of this group and death.

DISCUSSION PAPER

THE *HOW* and *WHY* OF REPORTING DIVING OCCURRENCES

Douglas Walker

Newcomers to diving may well assume that the reporting of diving incidents of any kind is an unnecessary activity. They may have seen those Bibles of the diving world, the Diving Manuals of the major naval countries and are certainly aware of the volume of instructional books which deal with the subject of diving. They may admit that the exotic world of Saturation Diving, mixed, Gases and HPNS, so well covered by magazines and TV reports, has some troubles, but that is not their scene at all. Experienced divers probably retain an initiate's trust in the truth of what they were taught many years before, though they naturally cut corners on the Rules of Safe Diving they subscribe to and support in public. They may fear that making an incident report will reveal their corner-cutting and sloppy methods, bringing forth wrath and retribution. Their other thought may be that to complain of any excessive fatigue after a dive, the cold, the mistakes others are making on dives where nitrogen narcosis "shouldn't" occur, or pains after "no decompression" dive schedules, will lead to comments on their lack of fitness, skill and toughness. Such views, though natural, are mistaken.

Diving is above all else an activity where morbidity has forced its practitioners, very reluctantly in most cases, to learn more about the rules for safe existence in the new

environment. Nobody foretold the occurrence of Nitrogen narcosis, Oxygen toxicity, Pulmonary barotrauma, Salt water aspiration syndrome or any of the other conditions now included in Diving Medicine and believed by many to have always been known and understood. Truth to tell, we do not really understand where the pain of the bends *originates,* let alone whether the "stops" should be depth or near-surface orientated.

In the early days of diving the diver was treated, to a greater or lesser degree, as a disposable instrument of little worth. The sufferings of lesser beings are easy to sustain, amelioration an unnecessary tenderness. With the increasing cost and technical complexity of diving equipment and the introduction of the concept of employer liability, this attitude has been markedly changed. Though the concept of "try it on Muggins" will never die, at least nowadays Muggins is likely to be a well paid volunteer of above the average health and skill. Should he suffer no significant morbidity the new Procedure will be let loose on everyone else, even though they not be the equal in health, skill or adequacy of topside supervision. There were plenty of "cowboys" on the North Sea rigs using advanced technology, it is now known. The entry of Pleasure divers has unexpectedly assisted the input of diving information, for whereas "real divers" will keep silent about the occurrence of episodes of unconsciousness, the amateurs are likely to seek to how why they get dizzy and deaf and have painful ears, etc., and if you have paid good money for air you are more likely to complain if it tastes "dirty" and gives you a headache. There are many examples of "real" divers using equipment or schedules they distrusted, lest they jeopardise their future prospects. Telling the boss that the equipment is crook is not a riskless procedure in either industry or the armed forces.

This tolerance of divers to minor morbidity and unsatisfactory conditions may demonstrate an admirable "Can Do" attitude but is a considerable brake on Progress towards a better awareness of the need to improve out methods, to rethink our assumptions. Without the stimulus of critical feedback there is a tendency for a Mandarin Complex to develop in the group of experts who calculate the Tables, to take but one example. They become so used to dealing with "half-time tissues" that one gets the impression that they come to believe such things can be cut out and exhibited just like the lungs or the heart. In reality they are only useful concepts which can hide the extent of our ignorance by sounding authoritative and should always be so understood. More accurate reporting in recent years has led to the recognition of the complex nature of decompression sickness, which some may feel can "forgive the wicked and punish the godly". There has previously been a comforting certainty that the human body obeyed the Tables and that ipso facto the bent diver had broken the rules. Nobody told the experts of the minor symptoms or that cautious divers added private safety factors, so how were they to know the limits of their theories? It has taken a long time for it to be accepted that the physiology of a woman was quite likely to differ from that of a young naval rating, though on a separate plane both of these groups were fully aware of the fact! As noted, without an input of reports there can be no effective check on the validity of our beliefs.

At the present time our concepts of diver fitness and of safe diving practice may require updating, a task made difficult by an almost complete absence of written evidence. On the basis of a couple of cases of pulmonary barotrauma in the Submarine Escape Training Tank during "free ascent" practice, everyone has to have a pre-ascent chest x-ray, but the incidence of detectable (and detected) bullae is not published. Although asthma is accepted as an absolute bar to diving, the only cases so far known to the Australian Incident Reporting Scheme1 have become dyspnoeic without having the confidently predicted pulmonary barotrauma. In diabetes, as in asthma, there is no information concerning the unknown number of divers who may be diving without disclosing their condition and without morbidity. Unknown because they are aware of the "certainly not" they would receive if they made their condition known to a diving doctor. It was diver determination2 not medical rehabilatory advice which broke the taboo on any diving activities by paraplegics. Our certainties may sometimes bear being tempered by the granting of special waivers to selected individuals. Only confidential reporting can hope to establish whether there are many "unfit on medical grounds" divers operating at present.

There are two major philosophical attitudes to reporting schemes. One holds a belief in compulsory reporting. This never works efficiently because only incidents which cannot be hidden are reported and then with the minimum of self-implicating details. The other approach depends on the assumption that if you can persuade the persons concerned of the value to themselves and others of the reports and reassure them that neither publicity nor retribution will result, they will co-operate. There is a necessary corollary to the institution of such schemes, that the results be readily and speedily made available to those interested and the implications be discussed. It must be made absolutely clear that at all times the identity of those involved must not be discernible except to those already well informed about the incident, a proviso already long accepted in relation to medical articles.

The aviation world has long recognised the value and indeed necessity of incident Reports in order to improve safety standards. The United Airline's "Non Punitive Reporting", NASA's "Voluntary Confidential Reporting System" and the British "Confidential Direct Occurrence Reporting" (CONDORE) schemes are matched here in Australia by the Department of Transport's scheme, which treats accidents and incidents as being of equal significance because it is recognised that very few accidents result from a single critical factor. Almost invariably, accidents evolve from a combination of adverse situations any one of which in isolation would have amounted

to no more than a simple incident. It follows that the elimination of any one of the links in the chain would have altered the outcome and therefore the identification of such critical items has great importance. Though the actual problems are different, the same principles apply concerning diving occurrence.

The fundamental objective is to promote safety, not to apportion blame or liability. The Australian aviation scheme contains a guarantee[3] that there will be no punitive measures upon any pilot who has asked for help or made a report on an incident unless it is apparent beyond doubt that persons or property have been exposed to danger because of a dereliction of duty which amounts to culpable negligence, or a deliberate or contemptuous disregard for the law by the pilot. This reservation is obviously necessary in order to prevent misuse of the immunity offer to escape the consequences of antisocial behaviour by pre-empting the laying of charges. Even the "Benefit of Clergy" in times past had to be circumscribed to protect the community. But misunderstanding concerning the application of this reservation may become an excuse for withholding of vital reports. Truthful disclosures are more likely if the person making the report is certain of anonymity when some "sensitive" matter is discussed. Sources may need such protection in regard to their employers, employees, fellow workers, a union, a government authority or lawyers. The last may prove the most difficult to achieve.

To report unsatisfactory equipment or routines may bring disfavour from others involved and no bureaucracy has ever said "welcome" to critical advice from low in the pecking order. A totally independent scheme is therefore a necessity, its success depending on the acceptance of the person receiving and controlling the reports as having integrity, experience of the matters involved, and a keen interest in the project. Dr Sem-Jacobsen[4] has been involved for many years in the USA in the field of aviation safety, and has recently become involved in a similar capacity with divers. He has reported that Mercury astronauts have supplied him with information they were unwilling to turn over to NASA directly, and pilots and other groups have similarly provided information under confidential conditions. This has been fed back to NASA and the aviation industry in a non-attributable form. Much of it would otherwise never be divulged, except as a result of difficult questioning at an investigation into some serious accident, which might get the facts but certainly not the truth "in the round". In the legal arena, in the game of "find a scapegoat", the whole truth is too expensive a luxury to be willingly used.

There are two major problems which require overcoming before the Commercial Diving Community give unhesitating support to complete-disclosure reports to persons or organisations outside their complete control. The first is the unresolved risk of a subpoena concerning such records. Although some smart lawyer might think to gain advantage from such a ploy, it would be a phyrric victory as henceforth there would be no "sensitive" reports written and all the old ones would be destroyed. Nobody in their right mind would put the whole truth in writing if it might one day be used, possibly in a selective and biased manner, against him in court. No reporting scheme would survive if the status of Privileged Communication were not to be granted to its files of information. As lawyers consider themselves responsible enough to have this protection vis a vis their clients they should be able to see the force of this requirement.

The second problem is the fear lest hard won information of possible value in the battle for contracts will leak back to rivals more readily than at present. Such problems can be solved with goodwill and commonsense for few if any serious misadventures or successes occur where total secrecy is vital. An exception would be should some illegality come home to roost, naturally. The efforts of the Association of Diving Contractors in the North Sea Oil Rig diving industry to set up an Incidents Reporting Scheme is a welcome step in the required direction.

As the intent is to improve both present and future safety, those receiving and examining the input must keep in mind the possibility that not only may the evidence enable a refinement of understanding of diving problems but it may disclose unsuspected problem areas or the unsatisfactory nature of present beliefs. As Sherlock Holmes impressed on faithful Dr Watson, we must remember "the curious incident of the dog in the night-time".

Suggested items for discussion:-

a. Are incident reports of value and what should be reported.
b. Should professional diving problems/ occurrences be collected by a scheme controlled by Diving Contractors and Sport/Scientific diving reports be recorded by the combined Diving Organisations, or should some independent body be set up.
c. Should a legally recognised status be declared for such a repository of information.
d. How should findings and provisional deductions be reported.

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1. Diving Incident: Severe Acute Asthma. SPUMS Journal. Jan-March 1981.
2. Flemming NC. *SPUMS Journal*. Jan-March 1977: 35.
3. Halton CC. Aviation Safety Digest Australia. No. 100, 1977.
4. Sem-Jacobsen CW. Address to Norwegian Society of Chartered Engineers. March 17, 1980.

For general reading see Incident and Fatality Reports this and past issues of the SPUMS Journal and other publications.

DISCUSSION PAPER

POST GRADUATE QUALIFICATIONS IN UNDERWATER MEDICINE AND RELATED FIELDS

Beryl Turner

The purpose of this paper is to act as a discussion/working paper to facilitate the development of Post-graduate qualifications in underwater medicine and related fields, including hyperbaric medicine and caisson medicine. The parties involved in this discussion are RAN, SPUMS, and the Commonwealth Institute of Health.

THE NEED

Australia is experiencing a rapid increase in diving activities, involving industry, commercial fishermen and sports. It is estimated that 10,000 new sports divers were trained in Australia in 1979, and the current increase in oil exploration is resulting in greater offshore diving activity. The need for medical support and informed medical advice to these activities has also increased concomitantly.

BACKGROUND

The South Pacific Underwater Medicine Society (SPUMS) was formed in 1972 and in 1980 has 280 Australian members and 80 other members in the South Pacific region. The society is comprised of medical and paramedical personnel interested in Underwater Medicine and provides for discussion between such people in seminars, conferences and the SPUMS Journal.

The Royal Australian Navy School of Underwater Medicine is an underwater medicine research, clinical and training facility and conducts courses for medical Practitioners, including civilians, each year. This course is conducted in 2 components, basic and advanced, each of two weeks duration. This is followed by a one week course in hyperbaric medicine at Prince Henry Hospital Hyperbaric Unit.

The Commonwealth Institute of Health was formed in March 1980 from the Institute of Occupational Medicine and the School of Public Health and Tropical Medicine. It is funded by the Department of Health, is situated in Sydney University Campus and has academic liaison with the University. A College of Occupational Medicine will be formed from within the Institute in 1983-4.

THE PROPOSITION

Underwater Medicine and related fields are probably best described as a specialty within Occupational Medicine. For the purpose of Post-graduate qualification it is not feasible to consider Underwater Medicine a separate entity necessitating a separate college in the long term.

It is proposed that: Post-graduate qualifications in Underwater Medicine and related fields be administered by the Commonwealth Institute of Health in the short term and by the College of Occupational Medicine in the long term.

To develop post-graduate qualifications in this field along the following lines:

1. Medical Examiner in Underwater Medicine. This would be a certificate level qualification issued on completion of a 4 week course in diving medicine conducted at the School of Underwater Medicine and a 1 week course in hyperbaric medicine conducted at Prince Henry Hospital. Both courses would qualify a medical Practitioner to conduct suitability and annual medicals for divers.

2. Diploma of Occupational Medicine. (Underwater Medicine). This would be a diploma level qualification issued on completion of both the certificate and the DOM which will be offered by the Institute in 1982 for the first time. This would be an academic qualification only and would not qualify the Practitioner to charge specialist fees under the terms of NASQAC.

3. FACOM. An underwater medicine practitioner would be admitted to the College of Occupational Medicine (when formed) as a Fellow if he was the holder of a DOM (Underwater Medicine) and had practised underwater medicine for a period of 7 years. The 7 year period is a standard time scale specified by NASQAC for admission to a College as a Fellow. This qualification would allow the practitioner to charge specialist fees under the terms of NASQAC.

TIME SCALE

Certificate	-	1981
Diploma	-	1982
Fellowship	-	1983-84

Dr Turner was, at the time of writing this paper, the Officer in Charge, RAN School of Underwater Medicine.

SOUTH AFRICAN CODE OF PRACTICE FOR RESEARCH DIVERS

The South African Bureau of Standards has published a Code of Practice and diver scientists are now able to register with the Department of Manpower Utilisation and entitled to international recognition by obtaining a CMAS Scientific Diver Brevet. They must first hold a CMAS 3-star diver certificate and complete an application form stating their scientific affiliation, with approval of a scientific diving association (eg. Barologia) and an establishment of learning or research (a nice distinction!). The Standard, as judged from the summary available, appears to cover both performance and organisation of all areas of diving, in all kinds of conditions. The publication consists of 160+ pages including figures, diagrams and tables, and is priced R20 plus 4% GST and postage. It may be obtained from the Scuth African Bureau of Standards, Private Bag X191, Pretoria, RSA. 0001

ALTERNOBARIC FACIAL PALSY FOLLOWING AN UNEVENTFUL DIVE

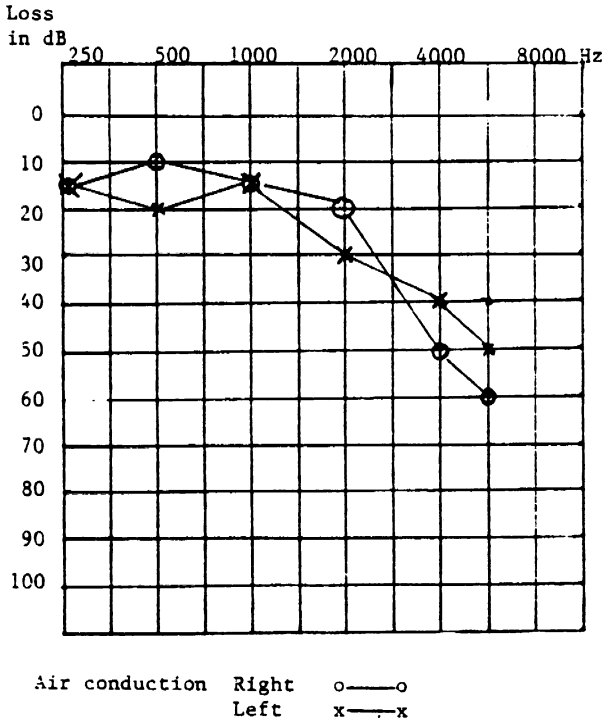
From the STICKYBEAK Non-Fatal Incidents File

A healthy 58 year old man suffered acute right ear pain and right facial palsy shortly after surfacing from a pleasant hookah dive at 43 feet for 75 minutes on an offshore wreck. Ischaemia of the facial nerve as it traverses the middle ear is suggested as cause. Resolution of the paresis may have been accelerated by hyperbaric oxygen therapy, which definitely relieved the severe ear pain. He was free from apparent symptoms on discharge from hospital the next day, though still presenting bilateral drum changes and post nasal drainage of blood stained exudate. Follow-up has revealed no residual hearing deficit, though decreased lacrimation of the right eye, thought to be permanent, troubles him.

Case Report

The victim was a 58 year old man, of good health history, who had received numerous physical checkouts before undertaking diving "to ensure safety". He attended an ENT specialist regularly and was known to have some bilateral loss of higher frequency appreciation (Figure 1). He had received certification in basic scuba diving about 8 months before the incident, though he had been diving for 18 months prior to this. It had been noted that he tended to be "air hungry" as a pupil. In the past he had encountered considerable difficulty in clearing his ears, and usually would find a small amount of blood in his mask after diving. He accepted this as a small price to pay for the pleasure of diving. He made it a habit to descend slowly and equalise carefully, ascending a short distance when he could not clear his ears immediately.

FIGURE 1.
AUDIOGRAM 14.3.80.



The dive site, a wreck, was about 2 miles offshore. There were three divers, one using scuba and two others by 20 feet hoses from a common twin-tank fed single hose. Dive bottom time was about 75 minutes, depth never greater than 43 feet, a safe non-decompression schedule. Although the water was cold at first, this was soon forgotten by the divers.

The dive was enjoyable, the victim feeling totally relaxed and at ease. On one occasion he yawned and allowed a small quantity of water into his regulator, but this was swallowed without any adverse symptoms resulting. The dive was terminated when the buddy noticed that the air supply was a little restricted, though the victim himself noticed no change. Ascent was slow, though the buddy made an accelerated ascent for the last 20 feet after inhaling a little water.

Immediately after surfacing, the victim felt a sharp, severe pain in his right ear, which became persistent and almost intolerable as be climbed back into his inflatable (Table 1). He then began to notice a strange sensation over the top of his left eye, a "prickly, numb feeling" of the forehead above the eyebrow. He mentioned this unpleasant feeling to his companions, who wondered whether his hood had folded over itself and caused a local restriction of the circulation. He doubted this as his left eye now felt heavy, as if it wanted to close itself. He also noticed a similar numbness at the base of his tongue on the right side, "like the feeling of a local anaesthetic received at the dentist", and he could barely control his bottom set of false teeth.

About five minutes later he noticed that his right eye could not be closed, although his left eye was now back to normal. The piercing earache continued and his tongue was still numb. They all discussed the problem and felt it was something to do with sinus pain or a middle ear problem. It took them 25 minutes to reach the shore, where the pain was so bad that he only wanted to get home.

He walked to his car and then realised that the entire right side of his face was paralysed and the right side of his mouth was drooping. He collected his diving gear from the boat and informed some friends who had just arrived that he intended to go home. During his journey he felt increasingly queasy and he was afraid that he would become violently ill while driving, although there was no dizziness. He therefore stopped at a relative's home and started to phone around for advice. By the time he had contacted a "diving doctor" and discussed his symptoms, he noticed that he was now able to close his right eye. It was decided that there had probably been middle ear damage and he was advised to attend the nearest hospital for several hours of oxygen therapy. It was now 70 minutes after the onset of symptoms. However, at this time, a diving instructor, one of those persons he had tried earlier to contact, phoned back. After a general discussion it was decided that he should go straight to the nearest large hospital, where hyperbaric facilities were available if required, driven by a friend.

TABLE 1

PLACE AND TIME	NUMBNESS/ PARALYSIS	EAR PAIN	DEAFNESS	TINNITUS	NAUSEA	DIZZINESS
Immediately after surfacing	Nil	Severe (right ear)	Nil	Nil	Nil	Nil
In boat, within minutes of surfacing	Numbness felt over top of left eye, above eyebrow	Increasing	Nil	Nil	Mild	Nil
In boat, minutes later	Base of tongue on right side, numb. Left eye wanted to close itself	Severe	Nil	Nil	Increasing	Nil
In boat, 5 minutes after surfacing	Right eye could not be closed; Left eye back to normal. Tongue still numb.	Severe	Nil	Nil	Increasing	Nil
On shore, about 30 minutes after surfacing	"Entire right side of face" paralysed. Right side of mouth drooping	Severe	Nil	Nil	Increasing	Nil
Driving home in car	Numbness decreasing	Severe	Nil	Nil	Near - Vomiting	Nil
Talking on telephone	Numbness decreasing	Severe	Nil	Nil	Increasing	Nil
At hospital before recompression	Paralysis subsided	Severe	Nil	Nil	Nil	Nil
During recompression and later	Nil	Nil, after 10 minutes.	Mild	Nil	Nil	Nil

In the hospital's ICU he was given Valium and placed in their mono-place hyperbaric chamber for oxygen therapy. He was taken to 30 psi gauge on oxygen, at which pressure all remaining symptoms disappeared. After 30 minutes at this Pressure he was slowly decompressed over the next 30 minutes. When he "surfaced", he noticed some right ear deafness but the ear pain had cleared. He was allowed to return home the next morning, residual deafness apparently being slight. The Hospital's Clinical Summary makes no comment concerning the appearance of the ear drums and the case was diagnosed as being decompression sickness.

Inspection on the second day revealed grade II (R) and grade I (L) ear barotrauma. Audiograms (figure 2) showed high tone loss, but this was a pre-existing condition. ENT specialist check on day 6 reported right haemotympanium, some blood-stained exudate in the left middle ear, and drainage of some of these exudates in the form of a dark, blood stained post-nasal discharge. It was not thought necessary, then or later, to perform either a paracentesis or insert ventilation tubes. His hearing has returned to pre-incident levels (figure 3).

Since this incident the victim has performed two problem free scuba dives, both in less than 30 feet of water and the second for about 90 minutes. However, he has been troubled by dryness and soreness of his right eye of a progressive intrusiveness. This ultimately forced him to obtain specialist ophthalmic advice. He was informed that the lacrimal gland was not functioning and that artificial lubrication (drops) would be required for an indefinite period. Although coincidence of an unrelated factor cannot be excluded, the condition may well be a consequence of damage to the facial nerve in the middle ear.

DISCUSSION

The history suggests that this man was one of the large group of divers who have equalisation problems with their para-nasal cavities. Such difficulties he minimised with careful attention to descent equalisation. It is possible that on this occasion the cold water, combined with some minor reaction in the post-nasal space from the small amount of water unexpectedly swallowed, disturbed a precarious balance of factors controlling middle ear ventilation. He had no warning symptoms of equalisation failure on either descent or ascent, which was unusual for him and no stress on ascent. This makes the sudden onset of bilateral middle ear barotrauma unlikely to be due to gross errors by the victim and more likely to reflect the existence of some significant anatomical variation from the average. The left-sided forehead symptoms may indicate frontal sinus dysbarism alone, but there is the possibility that the left facial nerve was malfunctioning.

FIGURE 2.
AUDIOGRAM 13.10.80

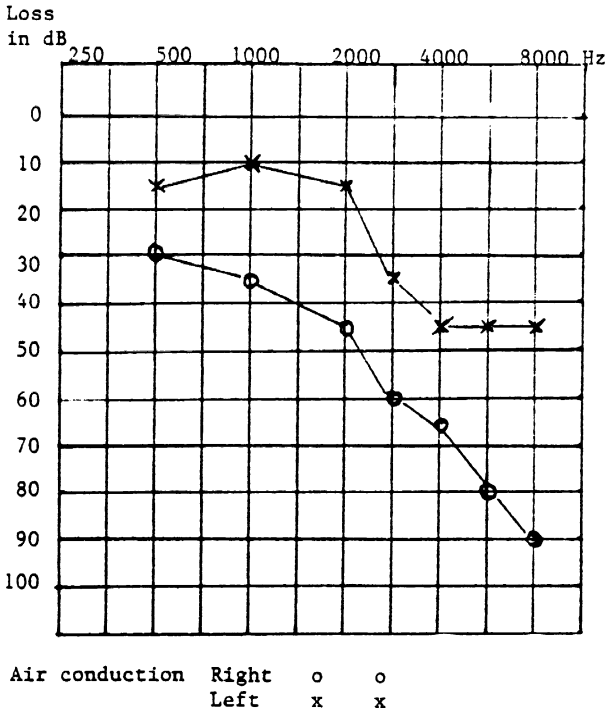
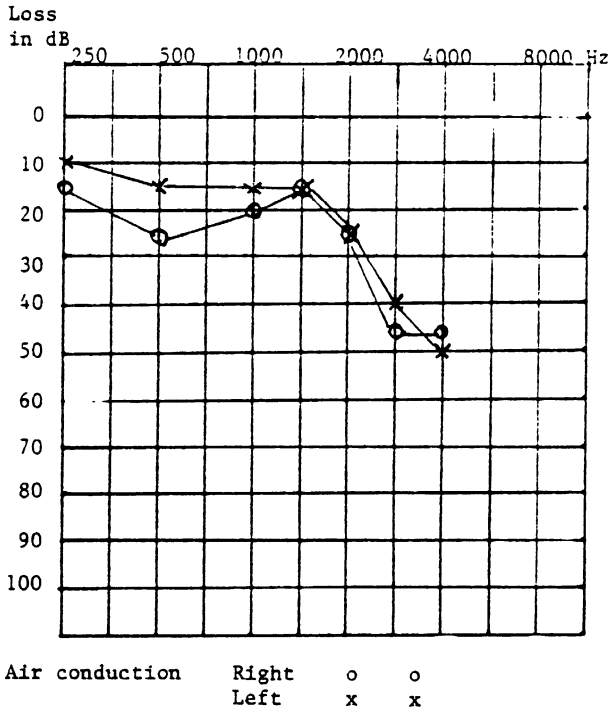


FIGURE 3.
AUDIOGRAM 31.10.80



The right-sided facial palsy is of the same nature as the cases described by Molvaer and others.[1]

In his paper he described the occurrence of dehiscence of the facial canal towards the middle ear, a condition said to have an incidence between 5 and 57%. The transient nature of the symptoms in this and other cases makes it unethical to test the hypothesis by surgical exploration and the fact that exposures to pressure changes are common but symptoms rarely point to the complex changes of events necessary before compression of the nerve occurs. The dysfunction of the lacrimal gland can reasonably be explained by damage to the branch of this gland from the facial nerve. it cannot now be determined whether this damage occurred at the time of the paralysis or was a secondary effect through some resultant damage to the vascular supply of the branch to the gland. It is known that this dive, to 43 feet, was the deepest dive he had made.

The diagnosis of middle ear barotrauma made by every diving orientated person involved in the case, was confirmed clinically. The use of oxygen was apparently beneficial, although the symptoms were resolving before this was initiated. Whether the use of hyperbaric oxygen was theoretically correct or not may be debatable, but it appeared to result in rapid and lasting resolution of the severe right sided ear pain. The use of a clinical diagnostic label of “decompression sickness” may indicate the need for any facility having a hyperbaric chamber to be better aware of the basic diving problems which may unexpectedly come into their care. The differential diagnosis of barotrauma and decompression sickness affecting the ear has been well described.[2,3,4]

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INNER EAR INJURIES IN DIVING DIFFERENTIAL DIAGNOSIS OF INNER EAR DECOMPRESSION SICKNESS AND INNER EAR BAROTRAUMA

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Persistent inner ear injuries in diving have been noted more frequently over the past decade and have been described in several publications. These injuries have been classified as follows:

1. Inner ear barotrauma and labyrinthine window rupture.
2. Inner ear injuries occurring at stable deep depths.
3. Inner ear decompression sickness or air emboli.
4. Sensori-neural deafness in relation to high background noise during diving conditions.

Inner ear injuries occurring at stable deep depths have been documented on only one occasion and occurred shortly after the beginning of breathing a different inert gas by mask while the chamber remained at a stable pressure, with the original helium oxygen atmosphere. Injuries related to high background noise have been suggested. The exact frequency of these injuries is not known.

Most divers who suffer inner ear injuries in relation to diving, have inner ear barotrauma and possible labyrinthine window rupture or inner ear decompression sickness. In some instances the differential diagnosis of inner ear barotrauma and inner ear decompression sickness is difficult. Some of the related dives are air exposures close to the no-decompression limits. Divers occasionally do not know when during the dive the symptoms began. Also, signs of middle ear barotrauma suggesting the possibility of inner ear barotrauma or signs suggesting decompression sickness may not be present. An accurate diagnosis is important, for the likely mechanisms of such injuries strongly suggest that recompression be an inappropriate treatment for inner ear barotrauma and possible labyrinthine window rupture and unnecessary delay in recompression therapy for those cases of inner ear injuries resulting from decompression sickness can increase the likelihood of permanent deafness. Therefore, the following review of current treatment recommendations and the differential diagnosis of these two types of inner ear injuries in diving is presented.

INNER EAR BAROTRAUMA

Inner ear injuries occurring after relatively shallow diving or with symptom onset during the decompression stage in deeper diving, have been termed inner ear barotrauma. Such injuries were first documented and named by Freeman and Edmonds in 1972 and have been related to labyrinthine window ruptures. Implosive and explosive mechanisms of such ruptures have been postulated. The explosive mechanism suggests that with inadequate middle ear clearing during ascent, intra cochlear pressure as well as ambient pressure increases, relative to middle ear pressure. With straining or a Valsalva manoeuvre, a further increase in this pressure differential occurs, with rupture of the round window or oval window membrane into the middle ear and the subsequent perilymph fistula. The implosive mechanism suggests that with a sudden Valsalva manoeuvre which does result in middle ear ventilation, the rapid increase in middle ear pressure results in rupture of the round window or oval window into the intra cochlear space. Simmons has suggested that such pressure changes may also result in membrane breaks within the inner ear. Which of these mechanisms is more often the cause of inner ear injuries during the compression phase of diving, as well of the overall frequency of such injuries has not yet been established.

Treatment principles for inner ear barotrauma include the following:

1. The best treatment is prevention. This includes the avoidance of descent or compression when the middle ear pressure equilibration problems exist and the avoidance of forceful Valsalva manoeuvres at depth.
2. Recompression therapy should be avoided since such therapy exposes the diver to conditions similar to those which resulted in the injury.
3. A complete otological evaluation by a knowledgeable physician should be accomplished as soon as possible.
4. Until such an evaluation can be obtained, and appropriate treatment measures initiated, manoeuvres which may result in an increase in cerebro-spinal fluid or perilymph pressure should be avoided; this includes the avoidance of coughing, straining or exertion. Bed rest with head elevation is indicated.
5. Drugs to supposedly increase inner ear blood flow are generally not effective and may result in a decrease in intracranial and inner ear perfusion from shunting of the axial circulation to other body regions. Anti-coagulants should be avoided, because of possible haemorrhage from traumatised tissues.
6. The need for immediate exploratory tympanotomy is controversial. Some authors have advocated immediate exploratory surgery in all suspected cases. Others have suggested reserving surgery for those who do not improve after a 48 to 72 hours of bed rest with head elevation. Singleton et al. in a review of 34 cases of labyrinthine window fistula, including some not associated with diving, noted better recovery with bed rest, head elevation and the avoidance of increased intracranial pressure, than with surgical intervention. Caruso et al. state that although the majority of otologic membrane ruptures may heal spontaneously, with conservative treatment, such treatment may be associated with progressive hearing loss. They suggest that when the diagnosis is fairly certain, surgery be performed without delay to prevent further hearing deterioration which may be permanent. We advise treating these cases conservatively and reserving exploratory surgery for those who demonstrate no improvement after 4 to 5 days and/or worsening in hearing after 48 hours of conservative treatment.

INNER EAR DECOMPRESSION SICKNESS

During the past decade isolated symptoms of inner ear dysfunction occurring during or shortly after decompression from dives in which decompression sickness is possible, have been associated with inner ear decompression sickness. Animal studies have demonstrated bubble formation and/or haemorrhage into the inner ear fluid spaces and human investigations have shown a significant correlation between prompt recompression treatment and recovery. This entity appears to be more common with decompression from deep helium oxygen exposures, especially those involving changes to air during latter stages of decompression. Cases

have also been noted to occur during or shortly after air dives requiring stage decompression.

The following principles of the management of inner ear decompression sickness were proposed in 1976 and thus far appears to be effective:

1. Vertigo, nausea, vomiting, tinnitus and/or hearing loss beginning, during or shortly after the decompression stage of dives in which decompression sickness is possible, should be considered forms of decompression sickness and recompressed promptly. Divers who experience such symptoms during or shortly after a switch to an air environment during decompression from a deep helium oxygen exposure, should be switched back to the pre-symptom helium oxygen atmosphere and recompressed promptly.
2. The optimum treatment depth or depth of recompression has still not been established. Theoretically, the optimum recompression depth is the lesser of the depth of relief, or the bottom depth. However, labyrinthine trauma resulting from inner ear bubble formation may result in haemorrhage or structural deformities and prompt relief will not be seen, even though an adequate depth of recompression to drive bubbles back into solution is achieved. Also, returning to the bottom depth in some situations may be hazardous or impractical. Therefore, we arbitrarily suggest that the optimum treatment depth in these situations should be at least three atmospheres deeper than the depth of symptom onset. Whether or not a lesser treatment depth will suffice has not been established.
3. Drugs which supposedly increase intracranial and inner ear blood flow are generally not effective and may result in shunting of blood to the peripheral. Also, if haemorrhage has occurred, anticoagulants may result in additional intra cochlear bleeding. Thus, these agents are considered potentially harmful and not recommended- Diazapam, 5-15 mgm, given intramuscularly, has been noted to result in significant relief of vertigo, nausea and vomiting during otologic decompression sickness. This agent can suppress the nystagmus, accompanying such injuries, and thus mask a sign of optimum treatment. However in many cases the symptoms are so severe that relief is desired. Fluid replacement is also indicated-

DIFFERENTIAL DIAGNOSIS OF INNER EAR BAROTRAUMA AND INNER EAR DECOMPRESSION SICKNESS

The most important factors in accurately differentiating inner ear barotrauma and inner ear decompression sickness, include the knowledge that such injuries can occur in diving, familiarity with the likely pathophysiological mechanisms and the obtaining of an accurate history and physical examination. Other factors to be considered in this differential diagnosis include the following:

1. The time of symptom onset is important. Divers who indicate that their symptoms started during compression, are certainly more likely to be suffering from inner ear barotrauma; whereas, divers whose symptoms start during or shortly after decompression are more likely to be suffering from inner ear decompression sickness.
2. Knowledge of the dive profile is important. Symptoms of inner ear dysfunction associated with shallows dives, which do not approach the no-decompression limits, and in which decompression sickness is unlikely, should not be suspected of resulting from decompression sickness. Inner ear barotrauma is certainly more likely in these instances. Also dives associated with rapid descents are more likely to result in inadequate middle ear pressure equilibration during compression, especially in inexperienced divers, subsequent inner ear barotrauma.
3. The presence or absence of associated symptoms should be noted. Divers experiencing ear pain or blockage or fullness during compression are more likely to develop inner ear barotrauma. Freeman notes that the common factor in his series of labyrinthine window ruptures in divers is difficulty in clearing the ears when descending. However, divers who note symptoms suggestive of decompression sickness involving other organs or tissues should certainly be suspected of having their inner ear symptoms secondary to bubble formation of the inner ear structures, and/or vasculature.
4. The presence or absence of associated physical findings are important. Divers who exhibit physical findings compatible with middle ear barotrauma, such as retrated, haemorrhagic, or ruptured ear drum should certainly be suspected of having a possible labyrinthine window rupture, as an explanation of their inner ear symptoms. Divers who exhibit other signs of decompression sickness, such as other neurological deficits, should be suspected of having their inner ear symptoms on the basis of inner ear decompression sickness.

An accurate differential diagnosis can be difficult in those cases in which inner ear symptoms are first noted, after no-decompression dives close to the no-decompression limits or deeper dives in which apparently adequate decompression schedules were followed and in which the divers cannot recall the time of symptom onset. In these instances, the other factors such as associated signs and symptoms, should be considered. Divers who have associated symptoms and/or signs of middle ear barotrauma, should be suspected of having inner ear barotrauma and possible labyrinthine window rupture. For divers without these signs and/or symptoms, additional factors to be considered would be the presence or absence of other signs or symptoms suggestive of decompression sickness or air emboli. If these are absent, and if none of the above factors are helpful in arriving at a diagnosis, the overall type of diving should be considered. Such cases associated with air diving in which proper decompression procedures were followed, are more likely to represent inner ear barotrauma, since isolated decompression sickness seems to be more common with deeper, helium oxygen exposure.

Fortunately, in most cases an adequate determination of the time of symptom onset, dive profile and the presence or absence of other signs and symptoms is possible and an accurate diagnosis can be made.

All cases of inner ear injury during diving should have a complete follow-up otoneurological evaluation after treatment. This should be done even though symptoms relief has occurred. Individuals who exhibit permanent inner ear deafness should not return to diving, since future injury especially to the uninvolved inner ear, is likely to result in significant permanent disability.

In summary, an accurate diagnosis is essential for the proper management of an individual suffering inner ear symptoms related to diving. Usually differentiation of:

1. Inner ear barotrauma and possible labyrinthine window rupture related to the middle ear problems during compression.
2. Inner ear symptoms associated with inert gas exchanges at stable deep depths.
3. Inner ear decompression sickness.
4. inner ear injury resulting from excessive noise exposure is not difficult.

However, confusion as to the differentiation of inner ear barotrauma from inner ear decompression sickness has occasionally occurred. In these instances, major consideration should be given to the depth of dive, rate of descent, the breathing mixture used, the time of symptom onset and the presence or absence of other associated signs or symptoms.

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DECOMPRESSION SICKNESS IN A COMMERCIAL DIVING POPULATION

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There are many different proprietary decompression tables in use in the UK sector of the North Sea. The vast majority of companies use tables of the US Navy origin. Others use tables derived from independent laboratories or produced within the company. There is considerable uncertainty as to the true incidence of decompression sickness amongst commercial diving population. However, many believe that the incidence is far higher than the 2% value frequently quoted for the US Navy tables. We have tried to obtain by means of questionnaire analysis some idea of the numbers of men who have experienced decompression sickness and to relate the pattern to the types of diving they have performed. This analysis is based upon the answers to 240 questionnaires received from divers who presented themselves for medical examination for fitness to dive in the UK Sector.

The mean age of the whole population studied was 30.1 years + 5.6SD. The whole population was divided into sub-groups according to the divers' experience of different modes of diving. It was found that the group who had performed air diving only, without surface decompression, formed the youngest group, with a mean age of 25.7 years + 3.7SD (n=32), whereas those with oxygen/helium experience were the oldest, with a mean age of 30.9 years + 5.6SD. 172 divers were included in this latter group. No significant differences were found between any of the sub-groups with respect to years of experience as a commercial diver. In an analysis of the oxy/helium experienced men, no correlation was found between maximum depth achieved during their career and their age or number of years as a professional diver.

Of the 32 divers who had performed air diving only, without surface decompression, only one had experienced decompression, a cutaneous manifestation. In a group who had performed air diving only, but with surface decompression procedures (n=63), 21 had suffered decompression sickness. The difference between the surface decompression group and the non-surface decompression group is significant, $p < 0.05$. Eight of the men in the former group had experienced skin bends, nine reported limb bends and eleven reported "niggles" and three men said that they had suffered Type 2 decompression sickness.

172 men studied had performed either oxy-helium "bounce" diving or saturation diving. 81 of these divers reported having had decompression sickness, of which 63 were limb bends. The incidence was correlated with maximum depth and their commonest diving depth. There is good correlation with maximum depth but no significant correlation with commonest depth.

TABLE 1
RELATIONSHIP BETWEEN COMMONEST DIVING DEPTH AND INCIDENCE OF DCS OF ANY KIND

Depth range (m)	Divers	DCS Cases	%
50 - 100	60	20	33
100 - 150	58	29	50
150 - 200	53	32	60

An analysis was also made of the number of Type 1 bends experienced by the men and it was found that this did not correlate significantly with either their age or the number of yours

experience as a professional diver. A study of the sites of bends showed that in all groups, the upper part of the body was more affected than the lower and also that the right side of the body was more commonly affected than the left.

TABLE 2
RELATIONSHIP BETWEEN COMMONEST DIVING DEPTH AND HISTORY OF DCS IN THE OXY-HELIUM GROUP OF DIVERS

Depth range	Divers	DCS Cases
0 - 50	74	33
50 - 150	88	44
150 - 200	9	4

Of the 172 mixed-gas divers, 60 had experienced niggles (35%) and of this group 28 admitting to not always reporting them. The above results suggest that the number of men experiencing decompression sickness in the UK sector of the North Sea, is greater than that one would have expected from the low reported incidence of decompression sickness on the US Navy Tables.

In particular, surface decompression appears to carry a significantly increased risk of decompression sickness. The correlation between the reported maximum depth dived and the history of having experienced decompression sickness supports the theory that the incidence of decompression sickness increases with the depth of the dive. The high incidence of men who consistently do not report minor manifestations of decompression sickness, suggests retrospective analyses of decompression logs may yield an artificially low figure for the true incidence of decompression sickness.

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THE PRESENT STATUS OF BONE NECROSIS RESEARCH

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At present, the MRC Decompression Sickness Central Registry in Newcastle-Upon-Tyne has the radiographs of the bones of about 4,600 professional divers. Of these persons, 8 are known to have juxta-articular (A) lesions with broken joint surfaces (the most serious outcome of bone necrosis). A further 44 have unbroken juxta-articular (A) lesions, which are potentially disabling and 126 more have the head, neck and shaft (B) lesions, which have not so far been considered to be of any significance to the health or efficiency of the subject concerned.

In addition, we have noted in our records that 39 divers have suspected juxta-articular lesions and 66 divers have suspected head, neck and shaft lesions. From experience, we know that some of these affected lesions will become definite in a year or so.

In terms of an overall problem bone necrosis in divers does not appear to be overwhelming. However, because the management of the condition is so difficult, it does seem to be important to try to understand why it occurs, and what its natural history is, so that we can either stop it occurring or select the optimum time for treatment.

Ultimately, the aim must be to avoid the condition altogether. Most decompression tables in use at present are presumably believed, as least so far as those who use them, to be satisfactory. This, I suggest, means that they will be safe for most (say, for example, for 99%), but not all of the population is at risk. It now transpires that bone necrosis can occur in the absence of previous attacks of decompression sickness, although a history of such attacks does increase the likelihood of bone necrosis occurring. It therefore now appears that there may be some additional factor independent of the decompression which makes a diver susceptible to bone necrosis.

Research into bone necrosis following hyperbaric exposure has been proceeding simultaneously along several avenues, and although at first sight they may appear to be unrelated they are in fact all directed towards the development of the integrated picture of the total problem.

EPIDEMIOLOGY

First I would like to express my thanks to all those radiologists from every part of the world, who have followed the MRC Decompression Sickness Panel's system of radiological skeletal survey and classification of bone lesions and who have thereby enabled us to build up a clear idea about the overall problem that would otherwise not have been possible.

In addition to obtaining some idea about the prevalence of bone necrosis in North Sea divers, it has also been possible to study the influence of:

1. The type of diving carried out (for instance, there seems to be a critical limit for combined depth and time short of which bone damage does not occur).
2. Decompression sickness.
3. Some personal factors, such as weight, on the prevalence of the condition.

The question currently being asked is whether or not the appearance of a (B) lesion is an indication that the individual is more likely to develop an (A) lesion if he continues to dive, than a normal person. This has proved difficult to answer. The crux of the problem lies in finding men with comparable hyperbaric experience. At the Newcastle Central Registry, we have recently and at long last found a way in which this difficulty can be solved, and the relevant figures will be presented.

ANIMAL MODELS

Bone necrosis research has proceeded slowly over the years, because it has been difficult to find a satisfactory animal model. Many laboratory animals can be shown to develop microscopic evidence of necrotic bone when examined after severe decompression but under realistic conditions of depth, and duration of exposure, only the mini-pig develops macroscopic lesions similar to those seen in man.

An interesting alternative model system which we have used successfully, has been the simulation in rabbits of bubble emboli by glass spheres. After these particles had been injected into the arterial circulation, the rabbits developed both shaft and juxta-articular lesions, which appear to be identical with those seen in man after hyperbaric exposures

THE DEVELOPMENT OF DIAGNOSTIC TECHNIQUES

One of the practical problems in dealing with divers is to relate any bone lesion which may appear to the causal incident. As diagnosis by radiography cannot be immediate, and usually requires a period of at least three months between the initiating insult and the development of changes sufficient to be seen on a radiograph, efforts have been made to seek more sensitive, but none the less practical indicators. So far the most encouraging and conveniently detected sign of incipient bone damage, appears to be a rise in serum ferritin level. This is of course a non-localising sign, and when positive, has to be followed up with a bone seeking radioisotope scan in order to identify the site of the abnormality.

This is a very sensitive technique, and one of the dangers with any such method is that it may be too sensitive and detect lesions which will in any case heal spontaneously. It is therefore important to gain more experience in this area before concluding that all positive serum ferritin results will necessarily end up as definite bone lesions.

A PRE-DISPOSING FACTOR

Bone lesions occur mainly in a few well known sites in the skeleton, as there is no absolute relationship between being treated for decompression sickness and subsequently developing bone necrosis, this raises the question as to whether there is some additional pre-disposing factor which has so far not been considered. Recently, we have been studying in animals the clearance of radioisotopes from bone marrow before, during and after decompression from simulated dives. As will be reported elsewhere in this meeting, it does look as though there are times when the marrow circulation is embarrassed and would be more than usually vulnerable to transient ischaemic episodes. Should the cause for this diminution in clearance rate be one which could be controlled, it might be possible to minimize the damage to bone marrow and bone during decompression.

TREATMENT

Unfortunately, the treatment for juxta-articular lesions once the joint surface has broken is unsatisfactory. Essentially, the choice lies between arthrodesis and the replacement of the damaged joint by a prosthesis. Whilst one or other of these options may be perfectly acceptable for patients at the end of an active life, neither is desirable in young and otherwise fit men.

Post-mortem studies of juxta-articular lesions have provided evidence that almost always the body makes a considerable effort to repair the damaged area of bone, but rarely succeeds completely. In most cases the healing process comes to a halt, just short of the articular surface, to leave a saucer of dead bone at the crucial point. It transpires that the explanation for this failure to repair totally lies in the fact that the repair process involves the deposition of new bone on the dead trabeculae. These eventually become so thick, that where they lie close together the spaces between them are occluded, and this results in the obstruction to the forward progress of the new capillaries and hence the blood supply to the tissues beyond. The repair process stops. Now that this mechanism is appreciated, possible ways in which the difficulty could be overcome are clear and can be tested.

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“VINEGARY” COMMENT ON THE LIGHT-FINGERED GENTRY

Recent press reports on the newly discovered value of vinegar in the treatment of “blue-bottle” stings and a subsequent revelation that members of the Surf Life Saving Association have to buy the vinegar for themselves as no funds are made available, have led to a public spirited firm offering supplies. The only present problem facing the Association in taking up the offer by Mauri Brothers and Thompson, is that of ensuring that the vinegar gets to the surf clubs without being “knocked off” along the way. Meanwhile, North Queensland lifesavers make their annual plea for old pantyhose, an effective protection against the “Sea Wasp” stingers which infest the waters around Cairns until April. It is not stated who repairs the panty-hose before it can be safely considered an effective protection.

NOTES TO CORRESPONDENTS AND AUTHORS

Please type all correspondence in double spacing and only on one side of the paper, and be certain to give your name and address even though they may not be for publication. Authors are requested to be considerate of the limited facilities for the redrawing of tables, graphs or illustrations and should provide these in a presentation suitable for photo-reduction direct. Books, journals, notices of symposia, etc., will be given consideration for notice in this journal.

SPUMS-COMEX MEETING, MELBOURNE NOVEMBER 1980

Dr Joel Griselin, Director of the Comex Hyperbaric Research Centre and Dr Maurice Comet, Operations Medical Officer for Comex Services, visited Australia in November 1980. A meeting was arranged at short notice to be addressed by Dr Griselin.

He gave a short presentation of what Comex is doing, mentioning all their activities. This was followed by a short question and answer session. After supper a film was shown which gave a good idea of the type of jobs Comex is involved in.

Dr Griselin first outlined the Comex organisation. The Comex group consists of the parent company called Comex SA and three sister companies which are Comex Services, Comex Industries and Comex Pro. These companies have different activities all related to underwater work. Comex Services, the biggest of the three, is mainly devoted to underwater work and services. Comex Industries manufactures heavy equipment for Comex Services and also makes equipment for the use of competitors and for the navies of different countries. Comex Pro, the smallest company, manufactures light equipment.

Slides were shown covering the activities of Comex Industries. One slide showed part of a hyperbaric complex with the two main chambers and the console units that had been made for the Argentine Navy. Another slide showed a number of chambers being prepared for off-shore work with Comex or other companies. Another line is small submarines, including lock-out submersibles with a compartment behind the atmospheric pressure sphere where up to four divers may lock out. These submarines also have a mechanical arm that allows manipulation underwater at great depths. They have built another type of submarine, a rather big one, for the Swedish Navy, to recover the personnel of military submarines which have sunk. This can operate in a depth of 600 metres.

Comex Pro manufactures light equipment such as a new helmet which can be fitted with a gas recovery system which can save up to 90% of the gas used by the diver. They also build small compact therapeutic chambers which are widely used all through the world.

Comex Services is the diving arm of the Comex Group. Comex operates all through the world but the general philosophy of the company is to have operational areas. These areas are the North Sea, France and the Mediterranean, Western Africa, the Middle East, Asian-Pacific, Australia, North America and Southern America. Comex tries to have the best co-operation possible with the local companies in order to bring all available expertise together. Comex in Marseilles, where all the information that comes from these areas is collated, is now much more a think tank where expertise is concentrated to back up the different areas. Comex performs between 15,000 and 20,000 dives per year. This is between 350,000 and 450,000 man hours under pressure.

The majority of Comex diving is surface demand bounce diving. If local legislation allows, wet bell bounce diving can be used to go down to 90 metres. For instance, this type of bell was used in the North Sea inside the protective wall that surrounds a concrete platform. The closed bell bounce diving method is used to 120 metres. If the conditions are right, Comex has used bell bounce diving to 240 metres for bottom times of up to two hours.

Saturation diving is used on construction jobs where divers may have to work up to 24 hours a day for many weeks, if not many months. A slide was shown of a huge saturation complex that was built in modules containing eight big chambers and eight small chambers connected together which allowed a crew of 24 divers to work continuously on a large construction job.

Another slide showed part of the control room of a big saturation complex. This showed all the different pneumatic controls that are under the supervision of a chamber operator as well as part of the atmospheric control terminal.

Comex has developed as an underwater constructor or entrepreneur for many years. For this purpose, Comex has developed a number of tools and methods which are not only used by divers. They have an atmospheric pressure bell which is a cross between a diving bell and a submarine. It allows people to go down to 1,000 metres. They are building one which will go down to 2,000 metres. These are mainly used in support of deep drilling operations. The atmospheric bell is equipped with large windows so that the occupants have good visibility. Television or movie cameras can be used through the windows. The bell has manipulators so it can recover all sorts of things from the sea bed or operate valves, etc.

Comex also has a fleet of submarines. They range from very small submarines to huge submarines. These can be built by putting modules together which means that it is relatively simple to produce a submarine for a specific job. It can be fitted with a manipulator, or with special tools designed just for the specific job. A slide was shown of one such submarine which can go to 400 metres. Comex Industries has sold three big submarines to different companies around the world. Some three weeks before the meeting, the deepest lock out ever done, at 210 metres, was performed from one of these submarines.

Comex Industries has built special tools for a given operation. They have constructed a

burying machine which can trench the bottom and bury a cable or a small pipeline at the same time. They have also developed a machine just to anchor pipelines on the seabed. This can fix up to 40 anchors on huge pipes a day.

To enable the firm to accomplish the diving operations and the subsea works requested throughout the world, Comex has a fleet of ships generally owned in joint ventures with ship-owners. Most of these ships have operated in the North Sea or in the Asia-Pacific areas or off Mexico or Africa. The French dynamically positioned vessel Talisman has been doing a lot of work in the North Sea, and was then working in the Gulf of Mexico. Besides small barges and small ships, Comex also works from a specially designed semi-submersible vessel called "Uncle John". This is at the same time a semi-submersible and a dynamically positioned vessel. "Uncle John" has been working for two years in the North Sea and it has been designated as the most efficient ship in the North Sea. Dr Griselin has seen the vessel work in rough seas, up to sea state 9 and 10. It is equipped with two diving bells and an atmospheric bell as well as many wet bells. A slide was shown of "Uncle John" using its capabilities of ballasting to lower a spool piece of 240 tons into the water.

One of the most important operations that Comex performs underwater is welding, either joining pipes or repairing structures. There are two situations where underwater pipeline welding is required. With new pipe, which is just dumped on the bottom, the two ends are sometimes very close together and sometimes very far apart. The operation is to do the "tie-in" of these two lines, which means binding the pipes, aligning them, bringing them together, making the pipe, fitting and welding it, coating it and taking gammagraphs and so on. The other operation is to repair a pipe which has been damaged in the middle of the line. The work is almost the same cutting out one piece of the pipe and replacing it with a new piece. To do this type of work Comex has designed a number of heavy tools. "H" frames which are able to grip a pipe, pull it up and to displace it sideways on the bottom, effectively walking with the pipe. Generally two of these are used in conjunction to roughly align the pipes. When the rough alignment has been made, a small alignment spread which contains the welding chamber is lowered. This alignment spread has two jaws on each side which do the fine alignment of the pipe. With this equipment one can align huge pipes from 36 to 42 inches to within two or three degrees. (Slides were shown of these various pieces of equipment).

Comex has developed two different methods of underwater welding. One is hyperbaric welding where the welders work in a bubble of gas, which is at the same pressure as the sea outside. Divers who are also trained as fitters and welders are sent down to work on the pipe, to align it and the pipe fittings and to do the chambers, one needs to have a very thorough control of the environmental atmosphere. Comex has developed methods so that the welders need not wear any breathing masks. They have developed a refrigeration system or an environmental control unit which can clear the lethal gases which are produced during welding. This unit has been developed as an easily attached and detached module. It can be sent down to the chamber and attached underwater and taken back to the surface if it is necessary to leave the chamber empty on the bottom to avoid a mis-alignment of the pipe when bad weather interrupts diving. The divers and pipe fitters and welders are sent down to these chambers by means of a diving bell. The refrigeration unit, which can be sent down or recovered, has all the energy and all the functions necessary for people to work in the chamber. (The film showed how such a chamber operates, with the people inside joining a pipe and welding). Having the environmental control unit as a module, Comex can build very small chambers or special chambers on request, with the provision for the costly environmental control modules to be attached.

The other method of welding is atmospheric pressure welding. This method has been developed so as to be able to go very deep without having problems related to hyperbaric physiology. A slide was shown of men welding in atmospheric conditions at a depth of 300 metres taken in actual conditions in 1978 in a fjord in Norway. To do such a weld at great depths at atmospheric pressure requires machinery to align the pipes to which is attached a working module which is normally filled with water. This can either be a module to cut the pipe or a module to weld the pipe. The atmospheric transfer module attaches to the top of the working module. Then the transfer module connects to the plexus stem, the working module is then pressurized with gas so that the water is forced out. Once it has been pressurized with gas at the same pressure as the one which exists on the bottom, the working module is then vented through a pipe to the surface so that the inside is at atmospheric pressure. The men can then enter and work in atmospheric conditions. Crews can work up to 24 hours a day on the bottom and they are transferred to the mother ship through the atmospheric transfer module, which may be either a submarine or an atmospheric bell.

Another field for Comex is a non-destructive testing. There are now a lot of structures off shore. Their safety depends on frequent regular inspection and sometimes repairs are needed when defects are detected. Divers use a water jet to clean the wall of the concrete platform just before taking any measurements or any pictures. Divers have to clean the metal of a structure very thoroughly to be able to detect any small defect.

In the field of non-destructive testing, Comex works with a number of techniques and in association with laboratories and universities.

Among the techniques used is the magnetic particles inspections (MPI) technique.

Among other tasks, Comex was requested to recover the cargo of a tanker which sank off the Western coast of France. They had to devise very rapidly a method to recover the oil that was inside the tanker. The problem was that they had many problems to solve at the same time. The tanker was in 100 metres of water, the sea state was very, very rough, the temperature on the bottom was around 6° C and the crude was almost solid at this temperature. They used a dynamically positioned vessel which was in fact a drilling vessel. They injected hot water through the drilling line into the oil tanks. Once the crude oil was liquified again it was brought back to the surface where it was separated and then burnt off. This was in 1978. Unfortunately, another tanker sank off the same coast in 1980. Comex once again has been pumping the crude out of that tanker.

Comex has been involved in deep diving for many years. In 1972 they went to 2,000 feet. Since that time they have placed much more emphasis on the working methods used in diving as well as safety, rather than in trying to go deeper. The Engineering Department, the Diving Method Department, The Medical Department and the Safety Department all work together in association with universities as well as with foreign laboratories. This work is mainly conducted in Marseilles at the hyperbaric centre.

Comex has a big chamber called the hydrosphere, 5 metres in diameter, which can be filled with water up to the midline. The water can be cooled to minus 10°C. The conditions inside this hydrosphere can simulate exactly those in the North Sea as a welding chamber, with regard to the humidity, the gas and the temperature. There is a huge double lock which enables them to take big pieces of pipelines up to 42" in diameter in and out of the hydrosphere. A slide showed another part of the hyperbaric centre, with the two deep spheres where most of the deep experiments have been conducted in the past. The third wet pot was not visible in this picture taken during the preparation for the Janus 4 operation. There is also another chamber which is rated to 1,200 metres and where Comex conducts a lot of experiments in physiology, mainly on monkeys. In addition, there is a big sphere rated for 5,000 metres which is used for experiments on equipment.

Most of the experiments conducted in the hyperbaric centre are physiological. Comex works with universities or with foreign laboratories. At the same time, Comex is developing methods which are to be used when diving, such as welding at 450 metres. During the Janus 4 experiment, men performed work at 160 metres and also went to 500 metres. This was an actual operation in the open sea. One of the tasks that they had to do was cut a piece of pipe and to make a connection with another piece of pipe. The working table was lowered down to 500 metres and the divers had to cut the pipe and make a connection. They had to do mechanical cutting, oxy/cutting, and some welding. Of course this was in-water welding and Comex was testing the ability of the divers to do the job and at the same time testing some pieces of equipment.

Question

Do you see hyperbaric welding in an atmospheric environment replacing hyperbaric welding in a pressurized environment within the foreseeable future?

Dr Joel Griselin

People are always asking if divers will be replaced in the future, if methods of working underwater at ambient pressure can be replaced by methods which can be done either automatically or by remote control or at atmospheric pressure. Without any doubt I think that in the future deep operations, common operations, will be done either by remote control vehicles or by automatic means and also at atmospheric pressure. But for a while I think that divers, as well as work done under pressure, will still remain a very good way and an efficient way and a cost effective way to do operations. We have been developing sub-sea wells and different systems which allow atmospheric intervention in these systems. I would say that very deep welding or deep welding on pipes will be done in the future at atmospheric pressure. I should also say that in the near future we will still stick to hyperbaric welding on structure repair but a little bit later we will have atmospheric welding on structure repair.

Question

What about the medical aspects of Comex research?

Dr Joel Griselin.

On our own or in conjunction with other laboratories, we are researching many subjects in physiology. One of the main subjects is research in the field of thermal exchange underwater. We feel that the thermal problem underwater, especially at deep depths when breathing helium, is a very big problem, and that perhaps it has not been looked at in the past and that one should have done it. So we are looking at this problem from the point of view of the physiology and from the point of view of the technical solution that one might use when diving at great depths and in cold water. Another subject which we are studying and which also pertains to safety, is fire hazards in hyperbaric environments. As more

and more welding is performed underwater in hyperbaric environments having an increased partial pressure of oxygen, there is a higher fire risk. We are performing some experiments on how to fight a fire efficiently and rapidly without putting the divers in danger from toxicity of the products that we might use to control the fire. A certain amount of research in pure physiology is being conducted on drugs and their efficiently for the treatment of decompression sickness. We are now at a stage where we are using rabbits and miniature pigs for these studies and they seem very promising.

We are also studying very deep diving. In order to have a systematic approach to deep diving, we are experimenting with monkeys. We are systematically studying all the parameters that might appear to have an influence on the high pressure nervous syndrome not only during the compression phase but also during the stay at pressure where some problems seem to appear during a long stay around or deeper than 1,000 metres.

Other research is being conducted in the range of 450 metres. At present Comex is experimenting with fast compression between 180 metres and 450 metres. The other research is mainly concerned with the effects of a long stay under pressure. We will have a dive in January 1981 where people who have been selected according to different criteria will be subject to thirteen days at 450 metres. There are other research subjects of less importance. During this 450 metre dive there will be neurophysiological research. Among other things we will be using electro-encephalography in relation to evoked potentials. Also there will be some research on other reflexes. There will be research on respiration, on the modification of the blood components as well as modification of the fine chemistry of the body. We have a large medical research programme during these experimental dives.

Question

What sort of therapeutic facilities do you have with each offshore set up?

Dr Joel Griselin

At each offshore set up we have at least a recompression/decompression chamber which is to be used as soon as possible when an accident happens offshore. That is the minimum equipment, but what is most important is the routine to be used. One must act very rapidly with the patient so as to put him in a situation where the effect of recompression, the effect of oxygen and the effect of drugs is as efficient as possible.

After supper, a Comex film was shown.

The film was about work on a pipeline in the North Sea. The situation was that there is a big gas line going from the oil fields to England. In the middle of this big trunk line there is a pumping platform, MCPO 1. An oil company (Occidental) wanted to flare gas from a field called Piper. However, the British government refused to allow an increased oil output unless the gas was not burnt. The gas had to be sent to the trunk line and so to England. So a line was placed between the Piper field and MCPO 1 to be fed into the big pipeline.
Comex was asked to make the riser connections. The line had been laid in 100 metres of water to the platform. Comex had to make the complete riser to the platform. One of the snags was that these big concrete platforms have anti-scouring walls. These are big walls. Also, inside these there is a wall with big holes in it at the surface to break the wave action.
The riser had to jump over those bottom walls, go along the outside wall of the platform, go through the pierced wall and then get inside the platform itself. All the pipe connections had to be done by hyperbaric welding. Two risers were prefabricated and brought to the platform. Heavy lift cranes were used to position the huge lengths of piping. One riser was installed within the perforated wall, the other riser was installed outside the wall down to the sea bed and connected to the pipe line. There were two hyperbaric welds to be done, one at 100 metres and one at 25 metres. The hyperbaric welds were done using a small welding chamber with the modular environmental control unit. On a number of occasions, the modular unit was disconnected when bad weather prohibited further operations, only to be rapidly reconnected when the weather improved. This allowed the pipe alignment to remain unaltered while not risking the costly environmental control unit with its umbilical connections. The film was made to show what Comex achieved. All this work was done on a lump sum contract. As one of the Comex representatives said, a lump sum contract has big advantages if the job goes well, cleanly and properly, then it makes money for the contracting company. If mistakes occur, the company goes down the drain!

DIVER SELECTION AND TRAINING, 1885

ZWS Moerkerk

This is extracted by kind permission of the Secretariat of the Safety and Health Commission for the Mining and Extractive Industries, from Mr Moerkerk's paper "Training the professional diver for inland-inshore operations", at the International Symposium, Luxembourg, October 1980.

They say that it all started in the era of Alexander the Great, who is said to have gone down in a diving bell around 330 BC to inspect the progress of his divers working in the harbour of Tyre (Lebanon). It was about 2,200 years later, in 1885, when the first diver went down in our company, then called WA van den Tak and now, Smit Tak. They were using the Siebe Gorman hard hat equipment and air was supplied to the diver by a hand pump. I can imagine that these divers at that time were observed in the

same manner as we observed Neil Armstrong when he touched down on the moon.

Salvage was already an established profession, due to the many groundings on the Dutch coasts, especially in the South-west, the approach to Rotterdam and Antwerp. It was here that the founder of our company, Mr Willem van den Tak, saw the advantage of men working underwater. He bought some hand pumps, helmets and diving dresses and looked for some volunteers from amongst his crew members to start diving.

These first divers, who in reality were all deckhands, skippers and the like, were all from the same family and up to a few years ago, we still had some members of this family working in our company. Over the years, as the company got bigger, more divers were required and diving went deeper. During and after the second World War, diving became a daily routine and international.

As already mentioned, the early diver had the function of skipper, deckhand or engineer and specialised himself as a diver for the occasion. Becoming a diver was a long process because firstly, the established divers in the company went down first when a job was to be done, in order to receive their extra payment of Dfl. 2.50 for six hours' diving, and secondly, there was little demand for diving work. Another important factor was the protection of the trade - if you did not belong to a particular family or at least come from the same island, it was very difficult to get yourself dressed in a diving suit for the first time.

Most of the time it started in assisting to dress the diver, keeping the signal line, cleaning the equipment and if you then after some years of deck experience had proved to be a capable hardworking "Jack of all trades" and had shown interest in being a diver (also the foreman had to be in a good humour that day, the job not too difficult, water not too deep), then you were allowed to make the first dive. Without payment of course: monies went to the diver whose turn it really was. Whenever the man diving for the first time was a bit scared to let go the grip he had on the rungs of the ladder, the older diver would step on his hands and the new diver was sea-borne. If this first dive was not satisfactory enough for the foreman, you could forget diving in the company for the rest of your life. It must be clear that this way of self-selection produced the best divers. This was in respect of their capabilities and craftsmanship in using their imagination and ability to improvise. They were hardworking, brave people and, of course, very healthy but had little or no notion of dangers, other than weather or currents. Safety precautions, doctors' examinations, decompression, etc., were subjects never heard of.

When I joined the company in 1954, we employed 15 men who, apart from being skipper, deckhand or motorman, practiced diving. The equipment was still the same as during the start 70 years before - Siebe Gorman hard hat equipment. The hand pump was still in use although most of them had been replaced by compressors. The diving telephone had been introduced, but because of the many failures which occurred, one had to rely on the signal-line system, which was much preferred, especially by the older men. Diving Tables were hardly heard of and the established divers thought of them as nonsense. There was no Dutch diving manual available, nor diving Tables except with the Royal Dutch Navy, so my first work was to partly translate the USN and RN Diving Manuals and to introduce diving Tables, in-water decompression and some diving safety regulations. I also started to send divers to the doctors for examination. If I compare this with today's medical examinations I wonder about the effectiveness of the examination in those days, but it was a start. The training continued more or less on the existing principle of "do it yourself" and was for the greater part based on the experience of the older divers and the fundamentals were grounded on facts of what to do and how to do it in practice, rather than theoretical possibilities and the physiology and medicine of diving.

In the early days of oil exploration and wild catting in the North Sea, a lot of wild catting also occurred in the diving industry. Many young men were put in sophisticated dresses, bells and mixed gas and quite a few of these men have never been able to tell anyone about their last experience. But now we have an almost ideal education program in order to maintain the high standard of quality divers and to keep accidents to a minimum, while using our divers in the most economic way, the intensive course of training culminating in an examination on all subjects, the diploma being also signed by the Inspector of the Dutch Department of Energy.

SPUMS ANNUAL MEETING 1980

Tuesday 24th June

SYMPOSIUM ON FIRST AID, TREATMENT AND TRANSPORT OF DIVING CASUALTIES

Dr Christopher Lourey

Tonight's theme is purposely very broad. It raises probably more questions than we can provide answers. In many ways it is rather akin to the sheik's problem in the harem. You know what is required of you, the problem is where do you start.

The best form of medical treatment is prophylaxis. If we can prevent the problem we will have a decreasing incidence of treating problems. A special tribute should be given to Douglas Walker, for his continuing analysis of diving fatalities and also non-fatal incidents in an attempt to make diving safer for everyone.

Throughout the world there is a continuing analysis of diving accidents and incidents and fatalities. I think the amazing thing, when one looks at all these statistics, is the similarity between nations of the percentage influence of factors involved. Going through

them very briefly, we can say that human error is responsible for about 50%, equipment failure in 30%, poor diving supervision in approximately 25%, inadequate training in changing surface interface conditions, as many would have appreciated today, in and inadequate medical supervision in the commercial situation in 4%, but in the sport diving situation it is considerably higher. These statistics provide an indication of the problems. They also give an insight into the methods available by which we could probably prevent and treat them. In essence, they can also provide, because of the problems of transport, bureaucracies etc., more questions than they solve.

In addition, I think each region, each nation, has its own specific problems. We will exclude the commercial Bass Strait situation from consideration. For example, I am sure that the Victorian members will appreciate that in the region where I come from there is among sports divers almost no incidence of decompression sickness. However, there is a rising incidence of problems of mild hypothermia, near-drowning and drowning. The rescue network is very good. We have a very efficient coastguard and police network, we have a Bell helicopter rescue network and we have a helicopter ambulance network. The problem often is that they take the victim to the first port of call, which is not necessarily where the expertise that the fellow needs is available. That is really what I basically want to say.

But there are a lot of questions to consider tonight. I think that there are problems of inter-referral amongst our profession, there are problems of transport there are also the problems of poor diving supervision, equipment failure and human error. These are the largest of the percentage in those statistics. How far and to what degree should we train individuals when they do their diving training? How much freedom of treatment should we give our diving supervisors and senior instructors? I think that all those with military experience will appreciate the enormous benefits that the paramedics give under the field conditions. In the development of the MICA (Mobile Intensive Care Ambulance) and coronary ambulance services, there is a continuing controversy about these non-medically trained individuals performing venesection, intubating etc. However, I think it is generally recognised that those paramedics have in fact contributed significantly to the treatment of severely ill people. Certainly they have the occasional problem, but the balance is beneficial.

Dr Michael Davis
I want to really take this chronologically if you like, or at least start the logical process. If we are going to talk about the evacuation of divers, then something must have happened to them. They may have required some immediate treatment at the site of the accident or injury, but even before that, something went wrong. And I really think we want to try to keep this oriented very much towards sport diving this evening. That is what a great many people are particularly interested in. Because of the type of practice they are involved in and their own sport diving interests, as a participant. One of the very interesting things to my mind about the way in which amateur scuba diving has developed in Australia and New Zealand is the total contrast between the way in which it is practised in Australia and New Zealand and the way in which diving was practised at the time that the British Sub-Aqua Club was first developed about some 30 years ago. In relationship to service diving, which was more or less, apart from hard-hat, all that was ever done then, the actual diving techniques were very different. If you learnt to dive in the services, you learnt to do things by numbers. In the navy there was an immense back-up to most diving operations in terms of the logistics that could be brought to bear and the actual diving techniques were very different because it was hard work.

I think it took the navies of the world really quite some time to come to grips with the concept that sport diving, scuba diving, was actually safe. You have only got to look at the record and compare it to other adventure sports to realise that really that is a true statement. Certainly there are fatalities, there are accidents, but it is a surprisingly safe sport. You know we have only got to go out here and think about some of the incidents that have already occurred in the past few days and think “Well, if something else had happened as well, maybe we would have had somebody in problems”. I think this is the whole point about why scuba diving is safe, it is the safety in depth if you like, pardon the pun. You can look at the way in which it is built up in a hierarchical format in that there is a definite training establishment, a training programme, supervision of that training so that people are taught basic techniques and skills. As far as the diving itself is concerned, you need to consider all those aspects of equipment and of diving techniques. All the little things, like carrying a knife with you, so that you, and I have not been in this situation, but I have been on diving trips where people have got caught in lines, can cut yourself free. When you think about all the little bits of equipment that we are taught to use. They all come into play at some time or another and there is always a back-up of some sort. If your regulator packs up you have always got a snorkel for the surface. If you were using some of the original equipment, the older naval diving gear with a full face mask, that sort of extra safety aspect was not available to you. All you had was a stop cock which opened to the atmosphere or opened to your re-breathing bag. And you can go on thinking about the techniques. Diving as buddies, having someone on the surface to cover you and so on. And the whole concept of dive planning, from right back to looking at charts, thinking about organising boats, knowing about weather, it all adds up to a very safe form of diving without there being an immensely structured aspect to it. One of the interesting things to my mind is that when things go wrong it is very unusual for somebody to get into serious trouble because only one

thing goes wrong. Most diving accidents are the result of a series of things which do not fit together properly and they build up to make things worse. An inexperienced diver with poor equipment, diving with somebody they are not familiar with, or in a diving site they are not familiar with and they do not know what the currents are going to do, the sea conditions change, they run out of air. You can think of a dozen or more scenarios and I think it is always worth remembering this, that it is a very multi-faceted thing. These sort of things gel together, unfortunately according to Murphy's law, when you least expect them and usually when you are least capable of coping with them as well. I think we have got to bear this in mind when we start to talk about sport diving accidents. So I think that as physicians interested in diving medicine, we also have to be interested in the whole philosophy of sport diving, training and practice. And I think we have to be prepared as practical devotees of the art, to express our concern, or comment on encouragement to lay divers, those people who actually run sports diving in different countries. I think we have got a real part to play in the prevention that Chris Lourey talked about and it goes right back to looking at these things that I have just mentioned.

The next big problem to my mind is what do you teach people in terms of coping with a diving accident? Who has actually been involved in a serious diving mishap? Either himself or with a group of divers out on a boat and have had to cope? Let us see just what our practical experience is, hands up. Well, nobody. So to my mind, the problem is equally relevant to a medical audience as to a lay audience. How do you react to this situation.

I have watched doctors in hospitals reacting to emergency situations and they do not always do the appropriate thing. So if that is the case, maybe we have got to sit down and think rather carefully about how we should react to this sort of situation. Then we have got to take it a stage further and think how we can teach lay people without medical knowledge to react correctly to an emergency situation.

What happens in fact is that you end up with a bloke on board the boat who looks bloody crook. Usually you have no idea what is wrong with him immediately. This is certainly true of the sport diver. We doctors tend as a group, because medicine is of necessity performed and practised that way, to be concerned with diagnosis and perhaps we are too concerned about diagnosis in this situation and we should be thinking more about immediate life-saving resuscitation. What are the most important things to deal with, right from stage one. Not necessarily teach people that there are a whole series of diving illnesses they need to know about, decompression sickness, air embolism, carbon monoxide poisoning and this, that and the other. We can go through the list and talk about each one separately. At present we say the symptoms to this are such and such and the treatment is this or that and so forth. A diving mishap does not present that way. People with air embolism, with early decompression sickness, problems from gas impurity, hypothermia, all kinds of things, one can go on making a long list, all tend to present in a remarkably similar fashion. They have a range of signs and symptoms which are on the whole, except for one or two exceptions, not pathognomic of a particular condition, headaches, unconsciousness, nausea and vomiting just to name a few, occur across almost the entire spectrum of diving problems, including those that we talked about last night. So I think it is very difficult for lay divers and instructors and so on to really appreciate the correct approach to emergency care medicine on a boat if they are taught it from the basis of a set of diagnoses, symptoms and then treatment.

I think we have to turn the whole thing around in much the same way as has been done with the training of para-medical people with the ambulance services, certainly in America and probably in Australia and as is beginning to happen in New Zealand. The way in which it has been done with cardiopulmonary resuscitation. You do not try to decide whether the man has got a myocardial infarct. Your prime responsibility is to provide emergency resuscitation both cardiac (circulatory) and respiratory. So one of the things that I would be very keen for us to talk about, to argue about, this evening, is the way we should be teaching people to cope with these situations. I have got one or two slides that we might put up as an arguing basis later. To go along with that, one of the most important things we should decide is what sort of equipment we should advise people to carry. There is an enormous variety of devices and bits and pieces that dive clubs and instructors and charter boats take out with them. Almost every group you dive with carries a different range of equipment.

The diving medical kit is something that maybe needs rehashing and re-thinking about as well. And finally on that sort of immediate care topic, should we be recommending people to purchase air vivas and other resuscitators, you name them, as their method of providing oxygen and resuscitation? My experience is that, unless you are an anaesthetist and are used to managing the airway, the majority of doctors and nurses are not capable of using these devices properly at all, unless they have had special training and regular practice. I think this applies even more to lay people. It certainly applies to the Surf Life-Saving Organisations and their members, who are taught to use this sort of equipment and go through a very thorough course. But it is not the sort of gear that any Tom Dick or Harry in a diving club can immediately use. So should we be encouraging dive clubs to use and to possess this sort of equipment? Certainly in New Zealand there are quite a number of groups, dive clubs, that actually carry this gear with them. If you go through it with any cross-section of the club, a vast majority of them have no idea what so ever of how to use it. They do not even necessarily know the basic principles of caring for the airway. So I think there are quite a few areas of concern for us to talk about, as far as the immediate care of diving problems goes.

Dr Tony Slark
I will just give you a few stories about various evacuations that I have been involved in and had to deal with the end products of. This is not a formal instructions in how patients should or ought to be evacuated from the site of the accident. I got to thinking about this matter some time ago, because my house is situated about equidistant from the airport that the helicopters take off from and the naval hospital where the patients may be landed by helicopters. I knew that accidents had occurred and I was asked about various matters of first aid. I was told that the patient would arrive in about an hour. So I made sure that I did not have any more grog that Sunday evening. It always is Sunday evening when these sort of things happen. So I got to know that it took very much longer than people expected for those helicopters to be flying past my house on their way to the other side of the Coramandel Peninsula or wherever it was that the diving accident had occurred.

Just recently this delay was emphasised by a diving accident which occurred on the Hauraki Gulf. Somebody had surfaced too quickly and had suffered an air embolism. The boat was well equipped and had a radio. They told the coast guard organisation that they had somebody who was obviously suffering a severe bend, he was very crook indeed and asked what they should do. They were put through to the senior sergeant at the police station who was in charge of search and rescue for that day. I do not how whether he did it regularly or even if he did it often. But he was certainly on call for that day. They asked the sergeant what should be done. They were told to stay where they were until a helicopter arrived. He telephoned through to Watsonville to check on the availability of a helicopter and he was told that one was ready and available. The crew was about, on two hours' standby. I expect that the sergeant did not really know exactly how long it would take to become airborne. But anyway, he told the boat that all was well. They should not move the boat. They were to keep the chap on the deck and keep him warm. The helicopter would soon be arriving for the patient, to take him to the naval hospital. He let us know of course that this was going to be happening, so we spent the next few minutes expecting to see and hear the helicopter come past us, as it would have to do, to get to the site of the accident. Well, two hours went past and I phoned him as I had heard nothing of the helicopter going past and I was told that it was going to be on its way fairly soon. Low and behold, two and a half hours later, the thing started past and I knew it was on its way. Three hours later it has brought the patient. He was landed on a playing field that is fairly close to the naval hospital and taken by ambulance to the naval hospital. We checked things out and it went on to the matter of recompression. The whole procedure had given us a fair time to get things organised for the arrival of the patient. Also plenty of time for getting the chamber flashed-up and the crew in and ready to work it.

However, this highlighted the whole stupidity of relying entirely upon a helicopter. Because in fact, the site of the accident is only twelve miles away. And had the boat turned tail and run straight into Auckland, he could have landed on the steps just below the naval hospital within about half an hour of his accident. It seems that everybody reacted with a complete lack of understanding of the time that various procedures may take. Although a helicopter may go fairly rapidly through the air, it does not necessarily get anybody back to the site of more definitive aid very quickly. It may be much easier and better judged to seek travel by ambulance. And there are a lot of difficulties with helicopters and using them in country such as we often have to cope with.

Looking back at some of the other stories, I remember a long time ago when the use of a helicopter was agreed to by the search and rescue operation people. Time passed as they got the crew together and then it was dark. So the patient had to be brought half way towards the helicopter over the hills. And then transferred to the chopper at the local racecourse on the other side of the hill. All the cars in the locality formed up to produce an illuminated landing strip for the chopper to come in on. The delays in that case were such that again it took just as long as if the man had in fact remained in the ambulance and had come straight to us.

I can think of another story, when there was an accident on board a boat off the Poor Knights, about fifteen miles off shore. There was a diving doctor and he diagnosed that this person had had an air embolism. And I am sure he was right. They rang through and got the helicopter arranged and it duly arrived. It took about two hours before it came in, and that was pretty good going. And it would have taken, I suppose, an hour to an hour and a half to get back once they had got the patient on board the helicopter. There was a strong wind blowing and the boat was anchored in the lee of a cliff. Over the top of the cliff, just at the level the helicopter was trying to station itself over the top of this relatively small launch, the wind was blowing and howling loud. Although it seemed very calm to the people in the boat, it was terrible on board the chopper. They winched a man down and he was swinging back and forth over the top of the launch. Wishing to be very helpful, the chaps on board that boat were all set ready to catch him, to grab him by the feet as he was swinging past them. He told me afterwards that he was absolutely terrified that somebody might catch him, because it seemed to him that he would be ripped in two. Anyway, they managed to get him down eventually without that happening. They winched the patient up to the helicopter, during which time he started to recover. And by the time they got him back to the naval hospital all his problems were over and he was very much better. He did not require recompressing although the incident suggested that he certainly had had an air embolism.

So helicopters are not always the answer. I think it is very necessary for people at the site of the accident to realise that seeking this sort of help is not necessarily wise. Everybody reacts with tremendous keenness and enthusiasm to help. The Air Force is very willing to put the choppers in the air and send them away. But they are not always readily available. Everybody wants to help. The senior sergeant who was concerned with search and rescue operations wanted to help, but he did not understand the situation. The flight controller will want to help, but he may realise that the weather is deteriorating and he may feel that it may not be wise for him to hazard a crew in the weather conditions that he fears may exist when the chopper arrives at its destination. This happened with two divers in the Royal Navy quite a long time ago when their back-up medical support was entirely by the supposed provision of choppers for taking away any person who had suffered an accident. In fact, when it did occur, the weather was too bad and the evacuation had to take place by sea, because the support from the air was unavailable. The rough weather had produced the situation that produced the rapid surfacing of the divers. As a result, they had inadequate decompression for the work dive they had done and the two divers required evacuation. But helicopters were not available due to the weather. So that the concern of the flight controller must be taken into account by those who are seeking the support of what is supposed to be a rapid form of evacuation. A chopper may be available within two hours. It is said that the crew of the helicopters that we have are available at twenty minutes' notice. But this is perhaps ideal and it might happen on a working day. But it certainly will not happen on a Sunday evening when most of these sort of accidents occur. In fact, most diving accidents that require recompression are likely to occur on the second dive of the second day of the weekend. So it is usually going to be Sunday evening.

When a rapid evacuation is sought, please think about the alternatives. Please think about the risks that your patient is likely to be put through in being transferred to the helicopter from the boat or from a larger boat to a smaller boat to get to shore to get to a landing space for the helicopter. And then by further transfer from the helicopter to an ambulance and so on to hospital and to the chamber. These transfers always take time and may reduce the speed of the helicopter to an item of no concern in the overall timing of the evacuation process. The turbulence of the helicopter can be very dangerous for somebody who is severely shocked. I have no doubt that although helicopter evacuation has great benefits in many circumstances, even the acceleration of the machine can be detrimental to somebody who is in severe shock.

Turning to other methods of evacuation. Light aircraft may be speedy, but they must fly over mountains and cannot fly through them. We always find difficulty at our diving sites where these accidents occur, because the light aircraft that are available more readily than a helicopter near the site of the accident, have to fly over a range of hills to reach Auckland and must climb at least 2,500 feet for safety and it is going to make the patient worse, undoubtedly. Now, even a helicopter winding its way along the road safely, in clear visibility, must go to at least 1,000 feet to get to Auckland.

Of course, if the patient comes by road the same effect is going to occur but will be more prolonged. And this again has to be considered in the evacuation. In other words, the terrain that exists between the site of the accident and the place where the patient is being taken to, will influence decisions about transport. We have had quite a number of patients who had a great deal of difficulty being got into a light aircraft, being got out of it again and then being put into an ambulance and being taken on another journey. So very often one gets back to the situation that the best way of evacuating the patient may be the ambulance that already exists fairly close to the site of the accident, or at least as close as the coast is to the site of the accident. In the ambulance there will always be some oxygen to give the patient. There will always be somebody to give the patient some oxygen. There will certainly be someone who is a skilled paramedic and thus better able than most people to deal with the needs of the patient during the evacuation. And when one considers all these sort of factors I have mentioned, this may indeed be the quickest sort of evacuation that can be possible for the patient.

I think I should just mention the use of oxygen here. We are finding with the patients that we are getting now that those who have been placed on oxygen that had been made available at an early stage on the boat seem to do very much better. And indeed, very often the symptoms seem to resolve more readily. If the patient has been on oxygen the whole time, by the time we get him it may make it less necessary to recompress the patient. The whole business of supplying oxygen is of considerable importance to diving casualties. I think the provision of oxygen facilities on large diving charter boats is a worthwhile safety aid and one we should learn to consider more than we actually do at the moment.

I should mention that if one has a diver who has suffered a diving accident and it seems that it is a case of decompression sickness, for goodness sake get his buddy back with him as well, in case the buddy is also developing decompression sickness.

Dr John Miller
One has to remember that particularly in the case of decompression sickness that a critical time period exists between the onset of symptoms and the development of the stable refractory lesion. Particularly when one is dealing with spinal cord decompression sickness. Decompression sickness is a whole body phenomenon regardless of whether or not the symptoms are restricted to pain only. When one is talking about a simple "bend" with pain only in a knee or elbow or something like that,

there is also gas formation in the circulation. Most times this does not cause very much of a problem, but one has to consider in all cases of decompression sickness, one is indeed dealing with a whole body phenomenon and therefore it is not too staggering to imagine the co-relationship between the development of pain-only symptoms and then subsequently a neurological lesion. The critical time period that is important between the onset of symptoms and the stabilizing of the lesion is somewhere in the region of four to six hours. This is because the mechanisms of some of the clotting factors, the platelet aggregation things, prostaglandin activity and all that sort of stuff mean that the reticulo-endothelial cells take that long to produce a stable rind of protein around the gas in the circulation.

It is obvious, particularly from what Tony Slark said, that in the majority of cases that we see at some place where we can treat a patient, that the transport time is frequently going to be prolonged. So that the patient is going to arrive there after the four to six hour period because, generally speaking, people do not get their diving accidents in the region of a recompression facility. When they do, the results are spectacularly good, with something like a 90% or 95% success rate with simple oxygen treatment and very little else. We are not talking about that situation. We are talking about the sort of situation that Tony Slark is talking about, where we have to consider the first aid management, and the transport.

Last year, at a workshop that we held at Duke on the treatment of diving accidents and their early management, Xavier Fructus of Comex presented the work of several of his colleagues in the south of France, in the area around Marseilles and Toulon. You appreciate that the terrain in the south of France and along towards the Spanish Riviera and the Italian Riviera, is in a sense similar to the sort of terrain that Tony Slark is talking about. There are narrow roads, high cliffs and frequently mountain ranges to be crossed. Therefore there are prolonged delays in getting the patient to a recompression facility and almost invariably in excess of six hours. These people started using a regimen that initially they felt was working. Then subsequently, they worked a semi-controlled series that was presented by Fructus and was shown to work very effectively. Fructus presented an evaluation of 97 cases of various diving accidents. They ranged from decompression sickness through to cerebral air emboli of which 67 had had this regimen of first aid. The regimen consisted of the immediate use of fluids as soon as possible after rescue. If the patient was conscious, oral fluids were given, usually starting with water and going on to something like fruit juice. Quite palatable sweat substitutes are now marketed in the United States, such as “Gatorade”. You can make up your own sort of thing if you have to. This was demonstrated by a Carl Moyer, who was a burns specialist, about 25 years ago. You take some lemon juice, a couple of teaspoons of sugar, a teaspoonful of sodium bicarbonate and a little extra salt and add to a pint of water. That makes a fairly palatable substitute for a balanced salt solution. Fruit juices are good because of their extra amount of potassium. Intravenous fluids should consist of a balanced salt solution also, and the quantity that they recommended was an initial load of at least a litre of this fluid. This makes a tremendous difference. This seems to be borne out by our experience and that of others in the United States. One of the features of decompression sickness is the development of a capillary leak and subsequent haemo-concentration. Consequently, what you are doing from the onset is something that is very simple, that can be done on a boat and that can go a great way towards ameliorating the development of the stabilized lesion that is going to happen later.

Then there was some debate about whether or not it is advisable to use various types of drugs. People in the South of France use large doses of aspirin and very large doses of steroids. We are not sure what the role of steroids is. So we are not sure whether or not it would be a good thing to use them. In fact, in order to get the platelet activation or deactivation mechanisms going in terms of drug therapy, all you need is two aspirin tablets. So that now we have a regimen that is based upon some kitchen type commodities that are available in the galley, a little bit of aspirin and the other factor, which is important in the drug therapy that Tony Slark alluded to, is oxygen.

Frequently, in an exposed situation the patient is going to be cold and therefore needs to be kept warm. I am not going to get into the problems of dealing with the hypothermic patient. I will just talk about maintaining an adequate homeostatic balance as far as warming the patient is concerned.

Now these patients as I said were transported for periods in excess of six hours. Almost all of them showed considerable improvement and many of them had complete relief of symptoms from this treatment. They were tempted not to recompress these patients because they had apparently got completely better and had lost all their symptoms during transport with this type of therapy. Thirteen of these patients who were not recompressed had a significant relapse and then turned out to be difficult to treat. So even if the patient is better, the idea that you give the patient something like one of the short oxygen treatments in the chamber.

The majority of patients will be transported by road and, as Tony Slark said, that is often quicker than air transport. We are finding the same sort of thing. We have virtually given up the use of light aircraft and only in certain circumstances do we use helicopters mainly when there has been an altitude decompression accident at one of the Air Force bases around the place. We have several Marine and Air Force bases within 200 miles of us and they invariably turn on their own transport. For long distances and the long distances that I am talking about in this situation is the

distance from the Caribbean or the Bahamas to Duke University Medical Center which is somewhere in the vicinity of 800 to 1,600 miles. Over those distances, jet air transport is very important. Jet air transport has some advantages as well. They are all pressurised. The only aircraft that have appropriate pressurisation systems that enable you to transport a patient at close to atmospheric pressure, are very expensive aircraft. At the present time in terms of the smaller commercially available aircraft, the best one is the Lear jet. The latest version of the Cessna Citation which will be coming out soon has a type of pressurisation system that enables it to operate at its most efficient altitude of 30,000 to 35,000 feet and at the same time transport the patient at a pressure close to sea level. Most aircraft cannot achieve this and are forced to operate at somewhere around 20,000 to 22,000 feet. This creates a double set of problems. It creates a very high fuel requirement because fuel consumption doubles in going from 31,000 to 21,000 feet. There are other problems from the reduced altitude. For instance, at the time of the Cuban crisis several weeks ago, one case that we had recently had to be transported from Grand Cayman Island, which is a little bit south and west of Jamaica, across Cuba. The aircraft had to cross Cuba at 22,000 feet which is below the normal jet route, which is protected by international law. The Cubans are quite happy about commercial aircraft travelling across at 30,000 feet. At 22,000 feet, they have that airspace covered by SAM 3 missiles. We had a major delay in being able to go and get this patient simply because of the diplomatic arguments involved in having access to that lower airspace. Indeed, when the aircraft turned up having picked up the patient, the Cubans tried to turn them back, then changed their minds and this went through several gyrations with continual warnings that they were violating Cuban airspace covered by missiles. So you see that there can be some problems with flying at 20,000 feet. Commercial aircraft are very reluctant to fly at those altitudes. Most commercial jet aircraft operate at cabin altitudes of around 8,000 feet with an operating altitude of 31,000 feet and 39,000 feet. If they are required to drop to 22,000 feet or 25,000 feet they too double their fuel requirements and that increases the cost of their operation enormously, because you are talking about an aircraft that costs about $1,200 a minute to operate. In the United States, and perhaps also in Australia, the patient can be expected to bear the cost of that. So that we find that the best method of transporting the patient over these sort of distances is to use a relatively small executive type jet like a Citation or a Citation Four or a Lear jet.

Because we have a small air ambulance group that has been formed by the local paramedics trained in handling these sort of casualties, we find it best to charter the jet by our own group. The time delay is considerably shortened because our group knows how to handle all the logistical problems of getting hold of an aircraft, all the communications, who to talk to in the government department when you have to go over someone else's airspace, all these sorts of problems are ironed out and can be rapidly dealt with. We have found that it makes the transport of these patients a whole lot easier. Also we found that other air operators have tended to charge the patient for the total round trip as though the aircraft had to travel at that lower altitude all the way. The patient only gets transported one way, so they tend to rob the patient. We no longer have that problem.

The sort of aircraft that we are talking about are executive turbo-prop aircraft which, in contra-distinction to most of the other light aircraft have considerably more space in them to do things. You can maintain an IV, you can maintain a patient on oxygen, you can get to him, you can monitor him. They tend to have somewhat better communications and better navigation systems as well and that also helps. We maintain the first aid treatment, fluids and oxygen therapy, maintain adequate body temperature throughout the whole transport period, no matter how short or how long and generally what we are dealing with, particularly with referred patients, are long transport periods.

One thing I did want to ask, there is a thing that has come out in the United States fairly recently. I do not know whether this has spread to this part of the world yet. It is an absolute requirement that all physicians nurses and paramedics have certifications in cardio-pulmonary resuscitation. And they must maintain currency in that. Has that sort of little device spread yet? It has good sides and bad sides you know. You have to show proficiency about how good you are on a plastic doll and then how good you are with the real person.

Question: Dr Nick Cooper
One subject that has been mentioned but not discussed that I think is of considerable interest for anyone handling diving accidents particularly in the southern part of Australia or in New Zealand, is the current management of hypothermia. I would very much appreciate the comments of the panel on how to deal with a hypothermic patient in terms of assessment, monitoring, rate of re-warming and methods of re-warming.

Dr Chris Lourey
I think how you handle the patient depends probably on the degree of hypothermia. Remembering that at the extreme end of the scale, that is profound hypothermia, the patient may appear to all intents and purposes dead. Here I think that one should continue intense cardio-pulmonary resuscitation until one gets to a unit of sufficient capability to intensively monitor all aspects and that includes blood gases and biochemical analysis and also has the capability of centrally re-warming the patient. At the other end of the scale and certainly in our experience on the Mornington peninsula, most of the patients we see are mildly hypothermic. I think that one of the problems that you have in this is an individual who is in the water, and for example had a near drowning situation, or has aspirated a considerable amount of salt water. There is no way you can adequately assess the pulmonary status of that individual without doing blood

gases. He is going to be blue. He is intensely vasoconstricted so you cannot assess that, but it opens a whole subject on its own which I think will be discussed in greater depth by John Knight in Singapore. I think that with a mild hypothermia that one slowly re-warms.

Question: What do you mean by slowly re-warming?

Dr Chris Lourey
Slowly re-warming, I think, is giving that individual intravenous fluids at body temperature and slowly re-warming to ambient temperature. I think that suddenly re-warming that individual by act of heating can induce problems on its own. I think there is one other aspect to mention, most boy scout organisations, most skiing places and mountain rescue teams, have these little aluminium space packs. That is fine if an individual is being transported to prevent cold. We have had a situation where we have had a patient transported in one of those shock packs. In essence, all it did was to keep that individual cold till he arrived. I think blankets and if he is conscious, warm fluids and the like all have a place. I am sorry to be brief, but it is going to be discussed in depth in Singapore.

Dr Michael Davis
Chris, I totally disagree with your management of mild hypothermia. There is really quite a lot of information about this that is about 25 years old. The thing that everybody forgets about mild hypothermia after immersion accidents is that the central body temperature goes on dropping. There have been many many people that have been recovered from the water in a reasonable state, who have subsequently gone on to die. If there is any way possible whatsoever of actively, rapidly, re-warming those people, peripherally then I reckon that that is the correct way. I do not believe that slow re-warming is the ideal choice in the acute immersion situation. If you have not got any other alternative, well, fair enough. There are plenty of things you can do even in an open boat to get people out of an exposure situation and at least reduce that after drop. You are never going to totally prevent it, the only way you can do that is by very aggressive central re-warming techniques. But if you have got any way of rapidly re-warming them then I reckon that that is the way to go. And I have had some personal experience of this. When I was keener and fitter and younger, I used to do a lot of long distance competitive sea swimming in the UK, and after six, seven and eight hours in the water, you were bloody glad to be put in a hot bath, I can tell you.

Dr Chris Lourey
One interesting case to show that hypothermia can present itself in an odd way. There were two chaps on a boat on the Mornington Peninsula about six weeks ago. A combined fishing-diving expedition conducted from a 12 foot dinghy. The fishing had finished and they were preparing for the dive. They overturned the boat. One was drowned and one spent eighteen hours in the water before he was found. When he was found he was transported to one of the more peripheral hospitals where he was warmed. He was transferred to us about twelve hours after that, anuric. We presume his anuria was due to the fact that after establishing an adequate CVP and after a questionable use of diuretics, he passed urine frankly myoglobinuric. We do not know whether it was due to the hypothermia and the intense shivering involved, or whether it was due to the repetitive trauma of hanging onto the boat during the night. So that the most simple case of hypothermia may in fact go on to other things.

Dr Peter Cohen
You made a comment that you wondered how or what the use of a diving club having an oxy-viva was. Well, I belong to a club. We have an oxy-viva and since I've been in the club there have been two episodes of bends on club dives. One was when the club president decided he would have a quick 45 foot dive on the way home with his spare tank. The oxy-viva was not used. I do not think that anyone in the club could use it.

When I became the Club Safety Officer I said "How does it work?" They said "I don't know, we have always had it in the club". The next time they were out was a deep dive, 150 feet wreck dive, and one of the chaps got his octopus regulator caught in his back pack and he did not realise that it was purging away the whole time. He should have done 10 minutes at 20 feet and 20 minutes at 10 feet on the way up and realised he was not going to make it. He signalled to his buddy that something was wrong. They all followed him to the top, climbed into the boat and made straight for Prince Henry's Hospital. But none of them used the oxy-viva on the way.

Dr Mike Davis
There are two aspects of this. One is the question of should clubs be encouraged to take oxygen on dives? The other aspect is should they have resuscitation equipment? Now, I would go along very strongly with encouraging all dive clubs to carry oxygen on club dives, on boats and so on. I always carry oxygen. The way we do it, virtually all the local clubs around Christchurch, is that we put an ordinary diving demand regulator on to an oxygen source. Every diver knows how to use of those, otherwise he would not be diving, or maybe that is why he got into trouble in the first place. But that is the simplest way of providing oxygen.

Now, when you are faced with an unconscious patient, there is no way that that will be ideal. Although, if he is still breathing theoretically you could probably still manage with a regulator. It is the unconscious victim that you need the resuscitation equipment for. Most people, divers, laymen, paramedics, doctors, are unable to use that sort of resuscitation equipment properly, and they would be far better off, in my mind, being taught to do mouth to mouth or mouth to nose, well, and being kept updated. As far as John Miller's comments about certification is concerned, I think that all club officers, all

diving instructors, all charter boat operators should be proficient. It should be part of the regulations. I do not necessarily believe that every single diver should have full CPR training and be updated every year. Maybe that is an ideal that we might achieve. It has got good points and bad points as John Miller said. I think that those people who are responsible for diving safety within any context should have that competence, and that it is a competence that I believe you can teach them.

I do not believe that the majority of people can be taught to use oxygen resuscitation equipment successfully. So the people that need resuscitation are most likely to have those around them that are least able to use a resuscitator. And thereby hangs the rub. It is fine if you or I are able to use oxy-viva equipment competently, but this would not be true of the majority, and this is the distinction that I think one has to discuss.

To my mind, if you are just going to provide divers with oxygen for the sort of transportation situation that we are talking about, you slip the mouthpiece into the guy's mouth. I recommend the simplest and most likely to be effective way of doing that is to use an oxygen tank with a diving regulator. Obviously, all the usual precautions that it must be correctly coloured, not just be any old aqualung. That actually happened quite recently when someone put the oxygen tank on his back and had a convulsion under water. It must be clearly labelled "oxygen cylinder" and the thing to do is to build a little rack and mount for it. And that's a great way of providing the wherewithal. One bends patient was transported on oxygen gear, initially their own with a demand regulator like this, and then subsequently using the ambulance equipment. By the time he reached us he was symptom free in the way that John Miller commented on. Despite that we did treat him on a short oxygen table.

Dr John Miller
I would like to make another comment. It really is very simple to make out a short protocol for handling this sort of patient based upon all these sorts of kitchen remedies. They are effective. Certainly, I find that the figures that Fructus presented at that meeting were extraordinarily convincing. They are very simple things that can be done, and do not need a great deal of high powered expertise.

If for some reason the patient cannot take oral fluids then you have the problem that you need to have intravenous fluids available. Chris has just raised the question of using Dextran. I am sure that over the years many of you have had dinned into you the potential value of using either Dextran 70 or Dextran 40. Now, the initial use or Dextran in diving accidents at least, was on a volume expander. When you give Dextran in high doses, it creates a series of problems. Someone who has a haemoconcentration due to a capillary leak is likely to become oliguric. When the patient becomes oliguric, having had a Dextran load, he is likely to develop Dextran crystals in his renal tubules. That will give him acute tubular necrosis and complete renal shutdown. Dextran 40 has got a very short half life and therefore has a greater tendency to do that than Dextran 70. Neither of them has, except transiently for something like half a dozen circulation times, very much of a hyperosmolar effect. So it is not going to pull all the fluid back out of the tissues when you have a capillary leak.

There is a potential role for the use of dextran either 70 or 40 in low doses because of its platelet coating properties. This requires approximately a litre in the first 24 hours. Dextran also has the disadvantage that it is expensive. In terms of plasma expansion, it would indeed be a very expensive substitute for salt and water and sugar solution. Aspirin in normally used doses, of something like two tablets, is fine. That is sufficient to produce a therapeutic effect for about three days.

Chairman: Dr Darrell Wallner
John Miller, I would like to direct a question to you. With oral fluids to this situation, I would be surprised, when you have got pain, fear, stress, that you would get any gastric absorption of oral fluids within four or five hours. Would you like to comment on that?

Dr John Miller
Those sort of factors are important but you do get some gastric absorption and certainly it is slowed down. For that sort of reason and for simplification in terms of developing further complications, I generally prefer an intravenous line. But going back to some studies presented by Carl Moyer, I guess in the fifties, resulting from some of the stuff that came out of Korea, there was the development of what was called the "Moyer Cocktail", which is basically a balanced salt solution and some substitute for Hartmann's or Ringer's solution, in fact. That solution was used effectively in burns in operational situations and used orally. There is no reason why one should not make these things up. It is a hell of a lot more effective than not doing anything.

One of the most important elements in any diving accident, as it is in any accident, is the reassurance of the patient. The patient feels a hell of a lot better if he feels that something positive is being done for him. So give the two aspirins with reassurance and explanation as a positive therapy.

Dr John Knight
My point is that they may be able to get oxygen into air cylinders in New Zealand but you will not get CIG in Australia selling you oxygen to put in anything except a pin index oxygen cylinder or a large oxygen cylinder. Now a pin index cylinder (C size) contains oxygen for about 20 minutes resuscitation, if you do not use it too much. It lasts for about 10 minutes

with an oxy-viva being used with one of those resuscitator heads that inflate the patient for you. So most diving clubs do not carry them because they are going to have half an hour to an hour and a half's boat ride to get home. Now, this short endurance is a problem. One solution is a closed circuit oxygen resuscitator such as the Komesaroff units used in the Victorian ambulances, which make a C cylinder last for a long, long time. But the snag is that you really need to be an anaesthetist to apply the mask, because if you have got any leaks the oxygen supply is insufficient. It can only provide 5 litres a minute maximum. Any of those power assisted jobs are going to provide you with gas at up to 60 psi, which I am quite certain does not do George any good if he has torn his lung on the way up.

The suggestion that I have is that you make up a suitable Magill type circuit with a clear resuscitation mask, so you can see his face. You put in on 14 litres a minute, which will make a C cylinder last for the best part of half an hour. You can watch him breathing because the bag goes in and out with each breath. At the moment, the CIG are busy selling us the Robertson resuscitator head, which if it is used each week, works. But if you put it away for a year it either jams on or off. It is a pressure cycled gadget. When it reaches cycling pressure it turns off. You have no idea, except by watching the victim's chest, whether gas is getting in or out. I am quite certain that what you need is something simple, so that you can detect it when it is not working.

Dr Chris Acott
This is a very funny but tragic story. I think any oxygen cylinder or set to be used by laymen should be labelled "Only use if the patient is breathing". I can remember when I was working as a medico in Bermuda. We had to go and retrieve all the rich Americans coming over for their second honeymoons. A lot of doctors have conventions there, and this particular convention of doctors were pathologists. One of their members unfortunately had a heart attack in the water, which is quite common in Bermuda with Americans.

I arrived at the beach after running down and found this team of American doctors, rotating around saying, "Oh, it's alright, doc, it's alright doc, we've been doing cardio-pulmonary massage on this fellow. We started as soon as he came out of the water". It was great. On him was plonked the oxygen mask running at 10 litres a minute and they were doing their cardiac massage. But when I went to incubate him I found that his whole mouth was full of vomit and nobody had attended to his airway whatsoever. So what did I do? I had to intubate him although the guy was dead. I think that oxygen equipment should be labelled "Only use oxygen if the patient is breathing".

Dr Mike Davis
That really backs up what I am saying and what John Knight has just said, you use the simplest device possible. It is all very well for us to talk about McGill's circuits and so on and so forth. The only thing divers know about is using a diving regulator. If they are unconscious, they cannot use it. That is why everybody who gets involved in diving should know how to do mouth to mouth. But one of the advantages of using a regulator in this way is that at least the oxygen consumption is only that of his minute ventilation. This is certainly more economical than oxy-viva equipment and all the other fancy types of gear. OK, I accept your point than if you were able to know what his minute ventilation was, you would be able to get the McGill circuit appropriately, but you do run into rebreathing problems.

Dr John Knight
I suggested 14 litres a minute, well above normal minute ventilation. So no rebreathing. This means that expired and fresh gas goes out of the relief valve. Even with that waste a cylinder will last 27 minutes.

Dr Mike Davis
Yes, well that is inefficient. A demand regulator is the most efficient way of using your oxygen supply. And it is the system that the diver understands, and the only one he understands, that is the point that I am trying to make. NZIG will not fill up any old cylinder either, but there are plenty of practical lads around who can knock up an adaptor any time they like.

Question: How much Stabilized Plasma Protein Solution should we use as a plasma expander?

Dr John Miller
I know this is a very controversial thing to say. For most situations in plasma expansion, particularly when you are dealing with fit, healthy people with normal serum albumens, then those are expensive substitutes for crystalloid solutions. Dear, basically. Later on there may be a case for getting into component therapy. Particularly when a patient with a severe diving accident may go on to develop a disseminated intra-vascular coagulopathy. Then you are using that for a component therapy on the basis of that symptomatology and not purely as a plasma expander. The simplest form of plasma expander is salt water. With a bit of sugar in it to help it along, provided that you do not put too much sugar in it and get an osmotic diuresis. I generally prefer to use a fluid regimen that gives you a urine production of 1 to 2 cc per kilo per hour. And we find that that has, well, we have not done controlled experiments so I should not say what I was about to say. We find, though, that that does not seem to prolong the effects of cerebral or spinal cord oedema.

Question: Dr Janene Mannerheim
How much time can elapse before it is not worth treating a person with an air embolism or decompression sickness?

Dr John Miller
I feel very strongly about this. In the last twelve months I have been involved with the treatment of five major cerebral air emboli that resulted from various forms of catastrophes in hospitals. One was a transbronchial biopsy, another couple were major pump catastrophes during open heart surgery, somebody else had 60cc of air inadvertently injected into his aortic arch. In all of those cases, there were prolonged delays, including one which was about 54 hours. Now all of those patients made improvements and all but one of them made a complete recovery. The last one had multi-organ disease and as he started to improve and perfuse his head he bled into an infarcted part of his brain and died. But the others recovered. I must admit to our surprise that the patient with 54 hours' delay after a catastrophic pump failure in the theatre, whose only activity before treatment was to seize on deep pain stimulation, recovered.

Characteristically, we find these people have about an 18-24 hour latent period, when you see nothing happen. Then at the end of that time, when you are about to despair, they start improving and over the next 6 to 8 hours they make dramatic improvements. That particular guy wanted his endotracheal tube out at the end of that time and then within a couple of hours he was on the telephone to his wife. We then managed him as a normal post-op heart and shuffled out of the chamber at the end of the treatment. So the point I am making is that the delay in getting the patient to the type of facility where aggressive, if necessary saturation treatment, can be performed, is a hell of a lot more effective than trying to rig up a series of make-shift systems to transport a patient. You are better off going through all the early regimen that I described, getting the appropriate type of aircraft, and getting to where the patient can be appropriately treated.

That obviously does not apply to the situation where you have a recompression facility that is reasonably right next to wherever the embolism takes place. But even then, that is not very effective as you know. The Royal Navy has had about three deaths in 50,000 submarine escape exercises, despite the fact that they have the full facilities there at the top of the tower.

Chairman: Dr Darrell Wallner
Any other questions? On this, or any related subject?

I would like to thank all our speakers for this information. Perhaps the executive might like to consider the questions we have heard. A group such as ours could well think about the educational aspects directing information towards the dive schools and instructor groups because many of them are keen to join SPUMS and are becoming members. A simple regimen of recommendations, if we could sort one out and publicise it through the various professional dive schools, would, I am sure, be welcomed and useful, because they must be just as confused as most of us. And we have the benefit of some degree of skill in this field.

SAY "FLY HIM" AND WE'LL STRIKE

Readers will be aware of the consensus of opinion among participants at the 1980 Pulan Tioman SPUMS conference concerning the relevance of helicopter or light plane use for most diving casualties. They felt that is was usually not the method of choice because of time, noise, space limitations and other factors. The use of rescue helicopters in certain sea and land situations seems a significant benefit, however. Readers may well be astounded to hear that New South Wales Ambulance personnel view the helicopter service as a threat to their future employment and have taken industrial action (which means inaction) to protect themselves. As the service is extremely costly compared with the alternatives and the time benefits are usually negligible in an emergency situation, their fears appear to be the result of the pro-helicopter PR Service "selling" the glamour too successfully. Possibly doctors are more at risk from the microchip Diagnostic Computers to a greater degree than the ambulance service officers ever will be from such a rival.

CLOSURE OF ROCHE INSTITUTE OF MARINE SCIENCE

The employees of the Institute at Dee Why (Sydney) have been told that it will close in June this year because of increased financial demands on the parent company in Switzerland. The Institute, which opened in 1974, has hosted a meeting of SPUMS members who were given a tour of the facilities and were greatly impressed by the equipment for the extraction of complex organic compounds from marine life. One critical factor leading to the closure has been its failure to win the jackpot by discovering a compound of commercial interest. Nature, red in tooth and claw, claims victims within the scientific community on occasion. We trust that those unfortunately displaced from their present researches will speedily find niches to re-establish themselves successfully.