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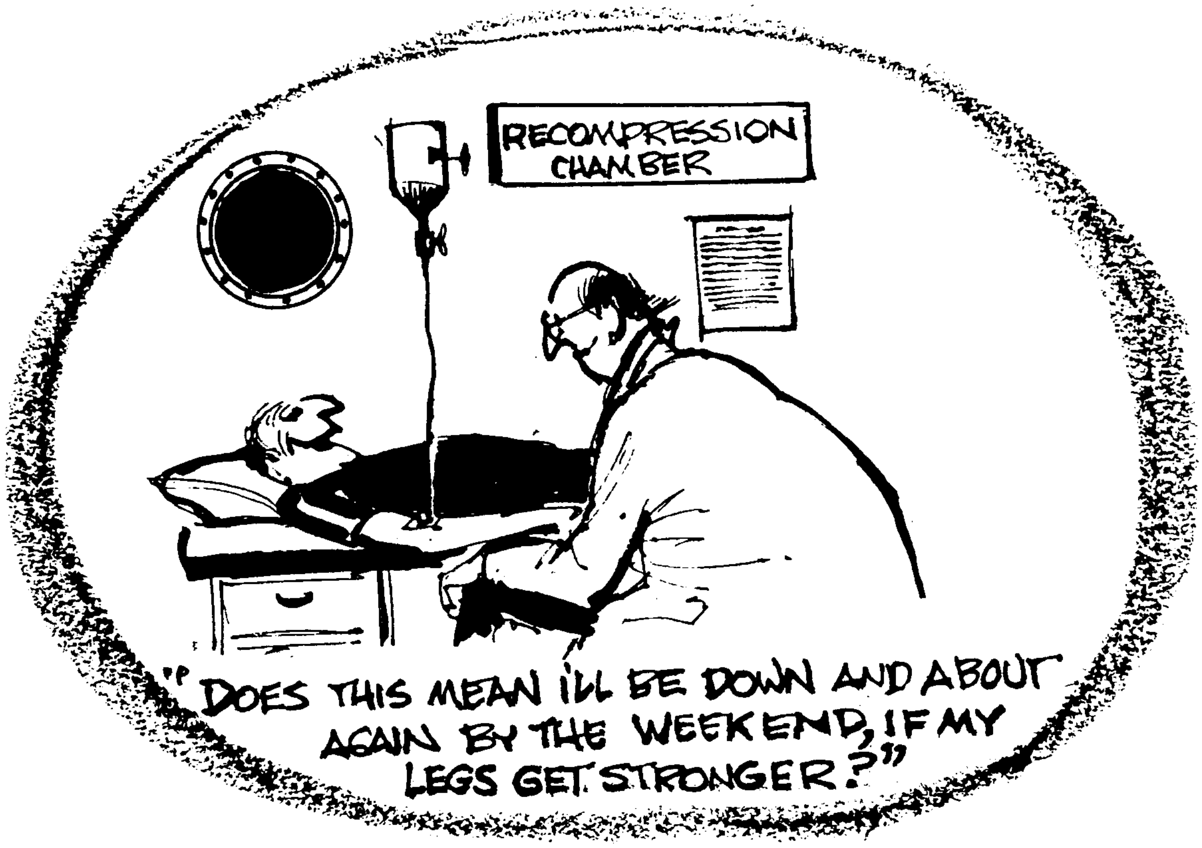

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Editorial

Convention permits, and may indeed require, that Editorials at this time of the year make reference to past events and future probabilities. A Whence and Whither discussion on the subject of Diving Medicine may indeed be both salutary and valuable, and even acceptable if presented in the guise of an end-of-year review.

Many of those who have recently discovered Diving Medicine, will be poorly informed of the genealogy of this branch of the medical profession. Rather than being the desired offspring of Medicine and Science, it was the result of the unplanned dalliance of Commercial Diving with Physiology, that poor relation of Real Medicine. With the passage of time this de-facto relationship was accepted as enduring and quasi legitimate, the obvious respectability of at least two of its offspring (UMS and SPUMS) tending to frustrate efforts to deny its right to a separate title and establishment, though many still apparently consider it has no right to mix with its social betters. This may explain in some small part the current attempts of the BS-AC to purify itself by eliminating its Medical Advisory Committee. One English king found, too late, that a living "turbulent priest" was less trouble than living with the problems elimination brought. It may even be advanced as a subconscious motive for the US Government's decision to cease funding of the National Underwater Accident Data Centre at the University of Rhode Island. As might have been said by a spokesperson: "One tiny saving for Government but a giant setback for Diving Safety".

To effectively counter voices critical of medical intervention in the Practical World of divers, if will be helpful first to recognise the divers' expectations of Diving Medicine. These come in three categories.

First, there is a requirement for a cheap, efficient examination to identify and exclude everyone with any condition even possibly disadvantageous in the diving situation, coupled with a compassionate approach concerning any minor flaws in the applicant himself. As a corollary, there is a growing expectation that those with obvious disabilities should be excepted from such unfair and rigid standards because it would be injurious to their self image if their ambitions to scuba dive were thwarted.

Second is the expectation that "they" should be able by now to provide a dive table which enables anyone of any build and fitness to dive as long, deep and repeatedly as he or she wishes and without any need for troublesome decompression stops. In return, the diver guarantees that he or she is totally immune to Nitrogen Narcosis, though possible other frail folk may, just may, suffer from the condition. It is gratifying to observe the brisk recent production of new Tables, all save one, (the Basset Tables discussed on pages 8-15 of SPUMS Journal, 1985 (2) April-June and on page 22 of this issue) aspiring to reduce significantly the unrealistic restrictions on divers of the older Tables, while still providing safety from Decompression Sickness. Some, unfortunately, do not include the phone number of DES (the Diver Emergency Service).

The third and possibly the most important service expected of Diving Medicine, is the ability to cure rapidly any problems which have, all too unfairly, affected the diver. Unfortunately, the experts have for far too long talked of Treatment as if it were the synonym for Cure, rather than for "attempting to achieve the best possible clinical result", which may be rather a different end point to the patient. Clinical Cure is a worthwhile thing, but retention of your previous health is even better. It is a whole new bubble game nowadays.

The papers in this issue bear witness to some of the very real uncertainties which may be encountered when treating a diver with symptoms, as the clinical picture is rarely as clear as text books claim, where even that infallible instrument for use on the cases of others, the retrospectoscope[ape, gives equivocal answers. The question of returning to diving after DCS is a matter with both financial and long term health connotations. The report by Khan and Jameel has not only its intrinsic value, also may serve as a timely reminder of how rarely information is available to us from that large proportion of the world which is not in the mainstream of the English speaking diving world. Such sources surely deserve greater attention.

While admitting that Diving Medicine presumes to intrude and does not always wait to be asked before offering advice to Real Divers, nevertheless, divers are fortunate indeed that its practitioners are curious people with an interest in trying to prevent Nature from playing the game of "trick or treat" on every dive.

SPUMS ANNUAL SCIENTIFIC MEETING 1985

HYPERBARIC OXYGEN TREATMENT IN HOBART

PW McCartney

I will start by describing the facility that is in Hobart, and then the work that has been undertaken in the last four and a half years.

The chamber is a standard "off the shelf" model as used on oil rigs for on-platform deck recompression of air, mixed gas, and saturation divers, and for short medical treatments of decompression sickness.

The chamber is 3.8m (12 feet 8 inches) long, comprising a 2.7m (9 feet) treatment compartment and a smaller access segment with an external door.

There is a medical transfer-under-pressure lock in the main compartment. This allows for drugs and equipment to be sent in and out of the chamber when a treatment is in progress. Large portholes allow for good interior lighting from an exterior source.

The air supply is from two compressors through a pressure reserve tank; in addition there is an ancillary air bank as a standby in case of compressor failure. On entering the chamber the air is ducted three quarters of the way along the entire complex and a silencer is installed in this system. This silencer proved to be effective in cutting down noise levels and is a valuable addition to the chamber as it enables easy conversion to take place in the chamber during treatments without raising voices. All efforts should be made to ensure as tranquil an atmosphere in the facility as possible.

Oxygen is supplied through two Scott duo-seal masks in the main chamber and an Airbox mask in the access chamber. The Scott masks have a demand valve on the oxygen inlet side and are sealed with a skirt to the contours of the patient's face; thus ensuring an atmosphere separate from the chamber air.

An oxygen overboard dump system is installed and used whenever hyperbaric oxygen therapy is being administered. This is very important both for chamber safety in respect of fire and explosion and for protection from oxygen toxicity in the medical attendant. The UPTD (units of pulmonary oxygen toxicity dosage) of attendants is very low and certainly well below 500 even after our longest treatments. Levels should be below 1,400 if pulmonary oxygen toxicity is to be prevented.

Chamber ambient oxygen levels have been monitored during treatments and the oxygen overboard dumping system works well. The levels of ambient oxygen being within the limits envisaged in the forthcoming standards requirements.

Two fire systems are installed, one entirely operated from outside the chamber. Considerable thought and planning went into the installation of this as it is necessary to pressure isolate the entire system from the hospital water supply.

Fireproof blankets are used, and temperature control has recently been made easier by using a ducted hot air system to heat the room where the chamber is installed.

TREATMENT

Over the 4 1/2 year period mentioned, a total of 242 separate treatments have been administered, approximately one per week for the period.

Table 1

Diagnoses, and number of patients treated

Decompression Sickness	18
Necrotising Fasciitis	2
Gas Gangrene	5
Refractory Osteomyelitis	2
Problem Wound Healing	2
Multiple Sclerosis	16
Teaching and Demonstration	19
Accidental Air Embolism	1

Overall
Youngest patient ... 5 yrs. Oldest patient ... 85 yrs 9 patients were females.

I will comment on some of these categories.

Decompression Sickness

This group comprised 15 abalone divers and 3 "industrial" divers. There were no sports divers in the group. Four had spinal bends and two of these were severely injured and were left with sequelae.

The remaining 14 cases of limb bends recovered uneventfully.

Necrotising Fasciitis

I presented these two cases at the Madang Meeting and they appeared in the SPUMS Journal (Oct-Dec 1982; 12(4): 8-10).

Gas Gangrene

Of our 5 patients, the most toxic case was an immunosupressed kidney recipient. The gravity of his condition made the clinicians consider the cessation of his immunosuppressants, thereby sacrificing his kidney, in order to save his life. This option was put to the patient and he indicated that he would commit suicide if this were done. This case was written up in the Australian Medical Journal, 12th June 1982. In all 5 cases the clinical results were satisfying, the tissue salvage was good and exceeded the expectations of the referring doctors. I feel that these results have made a positive contribution to hyperbaric oxygen therapy being used in Hobart.

Refractory Osteomyelitis

In both cases the wounds stopped discharging and antibiotics were stopped at the end of the hyperbaric oxygen treatment.

I have lost contact with one case but the second patient still contacts me from time to time and he is well after 2 1/2 years. He is an engineer and the success of his treatment has meant a great improvement in his life.

Problem Wound Healing

In both cases hyperbaric oxygen therapy effected healing after all other methods had been used without success.

Multiple Sclerosis

Strict guidelines are observed before a patient is accepted for treatment. Among the pre-treatment workup requirements are a detailed history of the disease profile, a neurophysician's comprehensive examination, and investigations, including audio evoked responses and visual evoked responses. These parameters are assessed by the physicians totally independent from the hyperbaric oxygen facility. After the course of treatment the same parameters are again measured. A full and frank explanation is given to the patients so as not to exaggerate their expectations, and they are asked to agree to the pre- and post-treatment measurements with the acceptance that this data is for research purposes.

Teaching and Demonstration

These have proven useful for a number of resident doctors and medical students, police divers, senior scuba instructors and the Australian Antarctic Division personnel.

Burns

I had to "knock back" the only patient with severe burns referred for treatment because he was too obese to fit through the door of the chamber.

I hope a larger facility will be available in the future as I feel that hyperbaric oxygen therapy has a role in modern medicine.

ENVENOMATION

CJ Acott

Over the past three years 30 suspected cases of envenomation have been admitted to the Intensive Care Unit (ICU) at the Rockhampton Base Hospital. Nine of these have required anti-venom. After studying these admissions I can state that the best time for touring Central Queensland is between July and September, if one wants to avoid the nasties.

Anti-venom for snake bites is the main use of anti-venom in Rockhampton. A third of all our snake bite victims have required treatment. Four sea snake victims have been admitted over the past 5 years. One of these has required anti-venom. This was a two year old girl who was bitten, savaged would probably be a better description of the attack, on her left foot and ankle. Poor first aid measures were used, and the child required intubation 40 minutes after being bitten. The snake was identified as an A*strotia Stokesii*.

Since then three other people have been bitten by sea snakes. One victim was snorkelling and thought the snake was a large piece of wood. I think he was rather surprised when the piece of wood turned around and bit him on the forearm and on the wrist. Another victim was walking in shallow water and felt something bite his foot. He lifted his leg out of the water, and there was a snake curled around it. Good first aid measures were applied immediately and he was brought into hospital.

One is always likely to see sea snakes off the central Queensland coast when diving and because of this and the four victims of sea snake bite I have developed an interest in sea snakes.

SEA SNAKES

The Hydrophiliae (true sea snakes) are recognised by their flattened paddle-like tails. They grow to variable lengths, some can be more than 2 metres long. They are mainly fish eaters, and are usually bottom feeders, however, the *Perlarmis Platurus* (Yellow Bellied Sea Snake) is a surface feeder. They are preyed upon by sea eagles, sharks and seals.

Lacking the ability to regulate their own body temperature, they are often found sunning themselves on the surface. This will only elevate their temperature slightly. They cannot breed or survive in water below 20°C, hence their distribution in tropical and sub-tropical waters throughout the Indian and Pacific Oceans.

The most widely distributed of all the species is the *Pel. Platurus.* Local distribution around any reef is patchy and is probably due to seasonal shifts which determine winds, currents and food supplies. They live in sea water, but captured ones have been kept alive in tap water. Some species of the *Enhydrina Schistosa* have been found in fresh water lakes of Cambodia and the Philippines.

There are strong evolutionary links between the Tiger snake and the Hydrophiliae. Baxter and Gallichio found that there was cross neutralization in vitro between some sea snake venoms and the Tiger Snake anti-venom. If no sea snake anti-venom is available, Tiger snake anti-venom can be used instead.

Sea snakes have one lung which extends into the abdominal cavity. This is divided into three sections, the two front sections are rich in blood vessels, while the posterior section acts as a gas storage organ, taking no part in gaseous exchange.

They are capable of diving to depths of 100 metres, and their maximum voluntary submergence time is two hours. Anaerobic metabolism is only used in an emergency. The sea snake's skin is unique. It has a respiratory function. Not only is a third of the snake's O_2 requirements taken up during a dive through the skin, but CO_2 and Na are eliminated.

Statistics of attacks and their subsequent outcome are difficult to obtain. There are probably thousands of attacks each year, the usual victim being fishermen in South East Asia.

Generally the species from Australian reefs are relatively inoffensive and only rarely will they attack when provoked. However catching, restraining or striking them may convert curious behaviour into an aggressive attack. Stay clear when they are feeding, or mating. If they are swimming in pairs, this usually indicates that they may be mating. Treat them with respect and handle them gently if you have to. Application of commonsense often prevents trauma both to you and to the snake.

The bite is usually painless, the victims hardly realizing that they have been bitten. Defensive bites rarely release venom. In the envenomating bite most venom seems to be released at the first bite. The *Astrotia Stokesii* (Stoke's Sea Snake) can inject large amounts of venom in each of seven successive bites. After their venom stores have been depleted it takes seven days for the supply to be replenished. The venoms of sea snakes are interesting. Fish and mice are susceptible, as well as man, but the reef eel is not. Broadly speaking they have either neurotoxic or myolytic properties or a combination of both.

Sea snakes can open their jaws wide enough to inflict a good bite. Their fangs are small and fragile and often break off and remain in the wound.

Reid pioneered the study of sea snake envenomation while working in Malaya in the 1950s and 60s. Fifty per cent of his patients died, while the remaining victims took up to two months to recover. All deaths were due to respiratory failure, renal failure (from myoglobinuria) and hyperkalaemia. Reid developed his “2 hour rule”. This differentiated envenomated cases into ‘serious’ and ‘non-serious’. Serious envenomation was indicated by myalgic pain (especially the neck muscles), ptosis, ophthalmoplegia, myoglobinuria and a leucocytosis of greater than 20,000 developing within two hours. Serious cases usually needed 3,000 units of anti-venom statim and up to 10,000 units in all. Non-serious cases usually required 1000 units statim and up to 3,000 units. Each ampoule of sea snake anti-venom contain 1,000 units.

LAND SNAKE ENVENOMATION

Case 1

A 74 year old man was bitten on his middle finger. The bite site was extremely hard to see. The medical registrar, an Englishwoman who had only just started work at the hospital, was summoned to Casualty. She took some blood, put in an IV line and then went to ring someone for advice. No first aid measures were applied.

I heard on the grapevine that there was a snake bite victim in Casualty, so I wandered down there. By the time I arrived the patient was drooling, dyspnoeic and had ptosis. His IV line site was bleeding profusely. A crepe bandage was quickly applied to his arm and the contents of one ampoule of polyvalent anti-venom was given.

The venom was identified as that of the Taipan. His coagulation profile was grossly abnormal and this was used as an indicator for our anti-venom therapy. He required two further ampoules of Taipan anti-venom. He returned to the ward after two days in ICU and went home three days later. He still had a residual ptosis at the time of discharge, which subsequently recovered.

Case 2

A two and a half year old boy was bitten by a brown snake on his left foot. There was a large area of swelling and bruising around the site. The bruising and swelling became worse over the next 24 hours. He was also complaining of pain in his calf muscles. There were no signs or symptoms of systemic spread of the venom although local reaction to the bite was severe.

The brown snake is a very venomous snake, and after lengthy telephone conversations with Dr Struan Sutherland we decided not to give the child any anti-venom despite the severe local reaction. This was the correct decision as by the third day the local reaction had subsided.

It is of interest that after the child had been bitten his mother applied a very firm crepe bandage. Perhaps the immediate application Of the bandage and splint localised the venom and prevented its systemic spread.

Case 3

A four year old girl was on a ventilator when I first saw her. She had been found, one morning, unrousable in her bed. On admission to hospital she was drooling, had ptosis, and a flaccid paralysis with rapid shallow respiration. There were two small fang marks on her left foot. She was afebrile. She had had a viral-type illness two weeks prior to admission. She had been well the day before.

A battery of various tests was sent off, including a venom assay on both blood and urine. However no swab was taken of the bite site. All the results were normal (including the venom detection), except for her liver function tests. All the liver enzymes were elevated, but she was not hypoglycaemic, nor did she have a raised blood ammonia level. Her respiratory status deteriorated and so she was intubated and put on a ventilator, when the epiglottis was seen to be normal. It was noted that she had a palpable liver after ventilation was commenced, this had not been noted before. A provisional diagnosis of Reye’s Syndrome was made, and a liver biopsy contemplated, but thank God not done.

I first saw her two days later after admission. I was not very happy with the diagnosis. The fang marks on her leg worried me, as well as other aspects of the history and examination that had been overlooked. She had been noted to be passing dark brown urine, this was thought to be traumatic haematuria because it followed the insertion of a catheter. Her renal function had dramatically deteriorated over the 48 hours since admission (renal failure is not a feature of Reye’s syndrome). The lack of hypoglycaemia and hyperammonianaemia did not support the diagnosis. I had CPK levels done on the blood samples taken on admission and I contacted Dr Struan Sutherland. He advised swabbing the bite site even at this late hour, because there might be some residual venom still present. The results were amazing. The bite site was positive for Taipan venom, the CPK levels were greater than 46,000 both on the day of admission and the day I first saw her (the normal in our laboratory is up to 200). I telephoned Dr Sutherland again and he advised giving 2 ampoules of Polyvalent anti-venom. The child was awake and responding six hours after the anti-venom had been given. She was off the ventilator within the next 48 hours. She went home 96 hours after the anti-venom had been given. A truly remarkable recovery from Reye’s syndrome!

Hypoxia and hypercarbia were the probable causes of the raised liver enzymes. I cannot explain the negative result from the venom detection kit (VDK) on the blood and urine samples, except that I regard all results coming from our laboratory with a high degree of suspicion unless they correlate with what is happening clinically to the patient.

Case 4

A 28 year old female was hanging out her washing and felt something bite her foot. She saw a tail disappearing into the scrub. No first aid measures were applied. She was brought into hospital, where no swab of the bite site was taken but a VDK test was done on her urine!

On admission she had severe abdominal

pain with palpable lymph nodes. She had also vomited and was extremely sweaty. I thought she had signs and symptoms of systemic envenomation so one ampoule of polyvalent anti-venom was given. This all occurred within 40 minutes of her being bitten. During the next 30 minutes all her signs and symptoms disappeared. All the investigations that were done were normal. She left hospital 48 hours later.

THE NATIONAL SAFETY COUNCIL OF AUSTRALIA, VICTORIAN DIVISION AND THE UNDERWATER TRAINING CENTRE

Ken Heynatz

The National Safety Council of Australia, Victorian Division, (NSCA) is the only organisation that I know of that offers both a retrieval service and hyperbaric treatment for patients. This is an overview of the operations of the NSCA, so that you may understand how we can offer this unique service. Those of you who have heard past presentations and read any recent writings, count this as an update, and please bear with us.

The National Safety Council of Australia, Victorian Division, is an independent, non-government, non-profit organisation, whose charge is to promote safety in all walks of life. To fulfil this charter, the NSCA, Victorian Division, provides vital services over a wide range of specialised areas at the highest possible professional standard at the lowest possible cost. The general membership of the Victorian Division, consists of public bodies, companies and private members. Some of these members are elected to the State Council, which is an honorary group of 31, who meet annually or as required. The State Council elects an executive committee, who, through the executive director and deputy director, pursue the goals of the Council with the various facilities at their disposal. The NSCA is a company limited by guarantee, with a turnover now exceeding $16 million, generated almost exclusively through the fees for the services provided. The Victorian Government grant for safety and the membership fees, account for less than 2 per cent of the annual income.

The company employs over 180 people to cover the diverse range of services to industry, government and the community. The consultancy services offered from our Melbourne Head Office cover occupational health and safety in many industries. The consultants are highly qualified in occupational medicine, business administration, mechanical and civil engineering, ergonomics and fire prevention, etc. The staff are also trainers and educators. To assist in this area, video technology has been incorporated into the training services as well as on-site cameras for training. We have developed a sophisticated audio-visual production and post production centre at Morwell.

On the more active side, the Council is engaged in provision of industrial emergency services in the power stations of the LaTrobe Valley. We maintain a 24 hour a day, 365 day a year presence, to help with first aid, fire protection, fire prevention and emergency services. To maintain a call-out ability for the many varied emergencies that we are confronted with, requires a large variety of support vehicles. These include rescue trucks, fire-fighting vehicles, personnel carriers for all sorts of terrains. We maintain and replenish various caches of stores and equipment throughout Victoria, which may be needed in times of emergency. Most of our ground support vehicles, support plants and equipment are fully maintained and serviced in our Morwell workshops.

The resources available within the Underwater Training (UTC) for use in training and emergencies, include a 52 foot Randal diving craft, currently being leased in conjunction with a sports diving organisation, for standby and rescue operations in Bass Strait, a 47 foot diving craft equipped with high pressure (HP) air banks, compressors, mixed gas banks, lifting arms, cages, and whatever is necessary for deep diving as well as numerous small craft, from a 24 foot aluminium jet boat down through semi-inflatable boats and zodiacs, the small “rubber duckies” that we use in diving operations as safety craft.

Training and diving includes the whole gambit of equipment. Air scuba used by the sports diver and the shallow commercial effort. Oxygen rebreathers used by our para-rescue unit. Kirby Morgan band masks and helmets which are used for surface supply diving. We have mixed gas helmets and rebreathers for bell diving as well. We carry a complete range of tools, both manual and hydraulic, which are used operationally and in the training realm. Underwater cutting and welding equipment, non-destructive testing inspection, underwater video, are just a few of the other sidelines. All diving is carried out to Australian standards, using Royal Navy tables and USN tables as appropriate and, so far, without any incidents. We safely train for, and work up to deep diving. We maintain an operational diving team, capable of diving to most depths using Drager FGG3 mixed gas equipment and Kirby Morgan with surface air supplies. We have two deck decompression chambers and a bell simulator. Again, all our equipment, whether for working dives or for training is maintained at our centre at Morwell.

We have a 10 metre diving tank for initial dives. This is also used with our ditched helicopter simulator for underwater helicopter escape training. This course, where trainees are strapped into the simulator and rolled over underwater, is designed to give confidence and understanding to those people who fly over water in a helicopter and who, one day may be unfortunate enough to be involved in a ditching and have to find their way to the surface. We also run survival courses for those who find themselves under the surface, regardless of how or why they got there.

To assure them that all these activities are medically sound, we have a highly skilled and well organised medical section, with three doctors, a fully trained nurse, one part-time psychiatrist and one full-time physiologist who cater for in-house medical needs, all training requirements and all forms of emergencies including hyperbaric treatments.

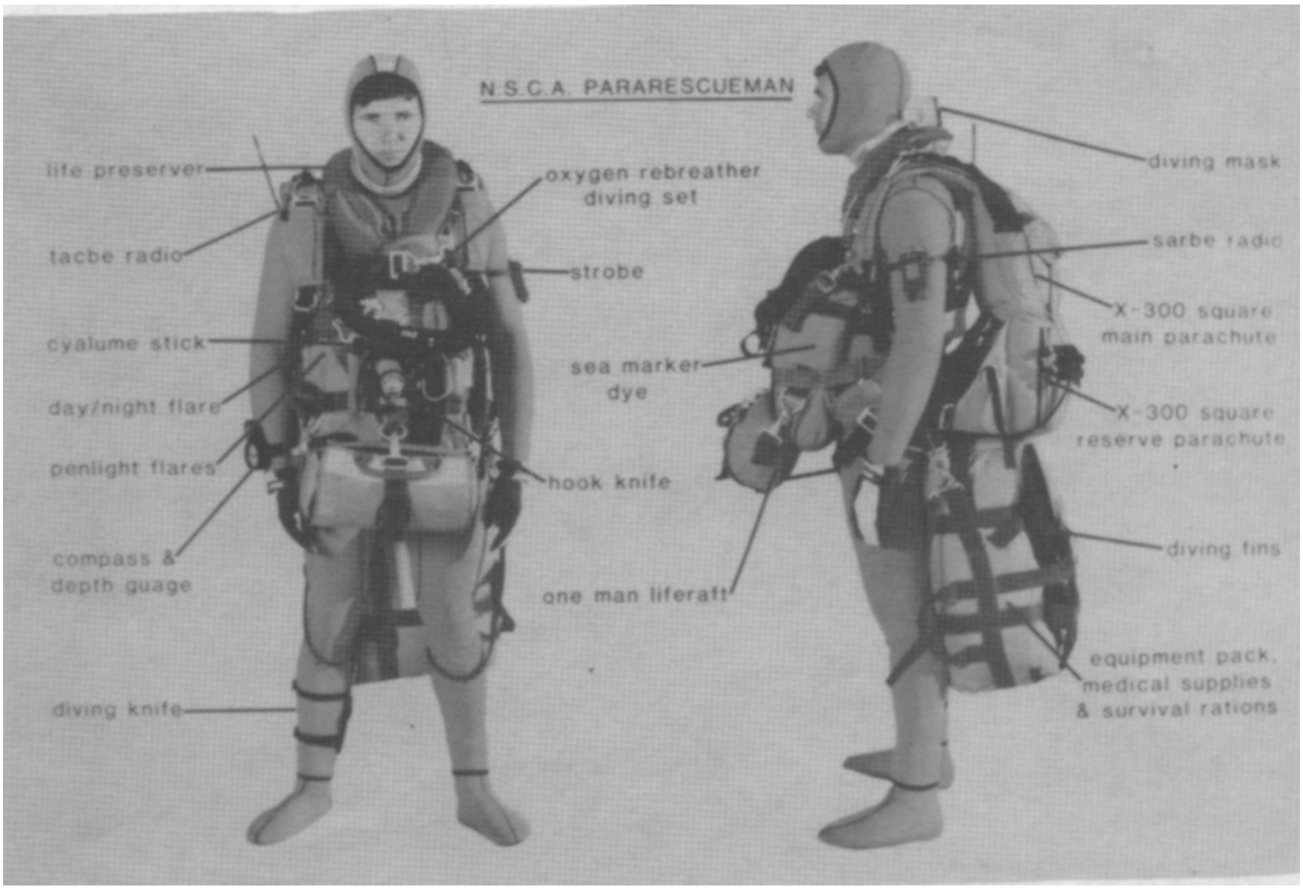
With all this equipment comes our mobile decompression chamber. This unit is totally self-sufficient and has a transfer-under-pressure (TUP) capability with our Drager DuoCom chambers. It consists of a prime mover, compressors, air banks, filtration banks, power generators, living quarters, supervisor’s and operator’s position in addition to the chamber itself. Currently this unit is located on a semi-permanent basis at the Royal Adelaide Hospital, together with one of our company operators and maintainers.

We have two Drager DuoComs in Morwell, one in Woollongong and one in Townsville. They allow for the transport of the patient and an attendant. For those who have not seen or used one before, and intend to in the future, the attendant slides in first and sits in an upright position and the patient lies on a stretcher and ends up between his knees. They are also in use by commercial firms worldwide. The West German Navy, the Canadian Navy, and I believe, the Israelis have some as well as the Swiss Air Rescue. In Carl Edmonds' own words, "If there is nothing else available, and the DuoCom is available, what would you use?" While these units are great for transport, they really are not suitable for carrying out treatments. So they must be capable of being mated with a deck decompression chamber for a transfer under pressure into a larger chamber to be used effectively. To this end, we have provided a TUP flange to the Royal Australian Navy at HMAS Penguin for use at their hyperbaric facility and also one to the Australian Institute of Marine Science (AIMS) in Townsville, for use with their chamber. We have now received another modified DuoCom that allows greater access by the attendant to the patient by increasing the width of the vertical component.

Naturally, our own decompression chambers are fitted with TUP facilities and can accept our DuoComs. The two chambers are rated as 8 and 12 bar respectively, for 10 trainees or one or two patients or one or two saturation divers. Transfer under pressure is effected through the AKZ chamber in the front. We are in the middle of an upgrading program with our chambers, which has recently seen the installation of new low pressure air supply systems, complete with catalytic conversion, air purifiers, air cooling and heating, oxygen analysers, and carbon dioxide monitors. The chambers are wired for video and sound monitoring and recording. Soon they will be fitted with multi-parameter monitors, for both treatment and research, and an improved suction system for emergency treatment. There is a new high pressure air and mixed gas supply system being constructed and upgraded. An overnight patient-observation room has been established. To back up our systems and allow programmed down time for maintenance, we are currently negotiating with Drager for a six man chamber as well.

Having served in several of the other hyperbaric units in Australia, I think we can be justly proud of the facilities in the NSCA

The UTC runs a number of courses. On the diving side, there is orientation to commercial diving down to 20 metres, restricted air diving to 30 metres, basic air diving to 50 metres, bell diving to 100 metres. Miscellaneous courses include non-destructive testing, helicopter underwater escape training and survival courses, assistant life support technicians. Of more interest to this gathering are the medical courses which are, Emergency Medical Technician Part I, a medical course aimed at the sports diver instructor, or dive leader; and Emergency Medical Technician Part II, aimed at the commercial diver.



This picture of a pararescueman was kindly provided by the National Safety Council of Australia, Victorian Division.

THE NATIONAL SAFETY COUNCIL OF AUSTRALIA'S AVIATION FACILITIES

Ian Millar

The National Safety Council of Australia (NSCA) Aviation Facilities include the areas of most dramatic growth within NSCA over the last few years, and are important in the diving context, as they are a useful resource for diver evacuation, in co-ordination with the treating facility. They also represent considerable manpower, material and expertise to back up the Hyperbaric facilities.

The Aviation Emergency Services started with a Hughes 500 helicopter serving as the first Latrobe Valley District Ambulance Service helicopter ambulance. This small but versatile aircraft was soon requested by other agencies for both fire-fighting and rescue applications.

The principle of cost-effective aviation emergency services supply on a multi-user, non-profit basis by NSCA became firmly established. Since then the fleet has grown considerably to meet requirements, particularly those of the Department of Aviation and Transport (DoA) as part of the upgrading of Australia's offshore search and rescue capability, and those of the Victorian Department of Conservation, Forests and Lands for airborne scanning and firefighting.

At present, three main bases are established, in Townsville, Wollongong and the Latrobe Valley. All have both fixed and rotating wing aircraft, available for search and rescue, air ambulance, fire-fighting or other public safety roles at the request of the appropriate official agency.

The Helicopters in use at present are the size of the familiar military "Iroquois", with as a guide only, a maximum passenger load of 13, or a 1.5 tonne cargo lift. This is however, reduced in many of the aircraft by long-range fuel tanks, etc. Bell 412 and 212 (four and two bladed rotors) helicopters are twin engined, instrument flying helicopters, set up primarily for offshore work, although suitable for ambulance work and capable of carrying the Drager DuoCom portable decompression chamber. They are fitted with radar, emergency radio beacon direction finders, forward looking infra-red units and powerful searchlights for night work, a 270 kg capacity winch and advanced navigation and radio communications equipment. These serve as the primary search and rescue (SAR) helicopters at all bases.

In addition, single engined Bell 205 helicopters are used primarily for mountain country bushfire fighting. Fitted with a 1400 litre belly tank, these machines can self fill via a hydraulic snorkel pump within 60 seconds whilst hovering over any water source greater than 15cm deep. This load is then released over the fire. NSCA has also been pioneering "heletak" operations, in which a team is abseiled into the forest from a helicopter to cut a firebreak, control a spot fire or lightning strike, or cut a helipad in the bush, allowing other helicopters to ferry larger numbers of firefighters in to otherwise inaccessible areas. These techniques were well tested and proven in last summer's Bright bushfires, when up to seven NSCA helicopters and eighty personnel were involved in the massive firefighting effort there.

This picture of a Drager Duocom being loaded into a King-Air was kindly provided by the National Safety Council of Australia, Victorian Division.

The NSCA fixed-wing fleet is led by, at present, four Beech Super King-Airs. These versatile aircraft are large enough to carry the DuoCom, a full search load, or a comfortable patient (diver!) evacuation configuration, yet can land on relatively small airfields. They are twin turbo-prop pressurised aircraft, cruising at about 250 knots, with a range of up to 1800 miles. For the search and rescue role these are specially modified with in-flight opening door, bubble search windows, smoke flare tubes and other equipment. When offshore survivors are found beyond the range of helicopters, a sea rescue kit can be dropped. This is a string of life rafts and supply containers, connected by lines, dropped to form a horseshoe around those in the water. A NSCA team working on behalf of the Department of Aviation, is currently training a number of aircraft operators up and down the East Coast of Australia in the use of this equipment, as well as search techniques, so that the General Aviation aircraft often needed to assist in major searches may be better fitted for their task.

These techniques are however, dependent upon survivors being able to use these bundles from the sky, which may not be possible if injury, hypothermia and weakness have taken their toll. Pararescue has been developed over the last eighteen months as a result. This involves highly trained and extremely fit young men parachuting into the water with equipment which includes wetsuit, liferaft, lifejacket, harness, diving apparatus, radios, flares and a large equipment pack containing medical and survival equipment. All of this is suspended under an oversize “square” parachute, which glides forward as it sinks, attaining controllable , horizontal speeds of 25 knots and more, allowing accurate landings in the water in winds in excess of forty knots.

The diving apparatus is necessary as a surface swimming breathing source in rough conditions, or if caught under a parachute. A closed circuit oxygen rebreather is used at present, this being the lightest chest mounted unit suitable for parachuting. A chest mounted, long duration air set is being developed, but at present, any diving operations planned would use air dropped, conventional scuba gear if possible. A wide range of backgrounds is represented in the present team, including doctors, professional divers, mechanics, shipwright and many others, all of whom can be deployed anywhere within the range of Australia’s suitable civil and military aircraft.

One of the King-Airs is fitted with multi-spectral scanning equipment that is the tool of the other rapidly growing section, Remote Sensing. Both visible and infra red pictures of the landscape are digitally recorded in the aircraft. A quick print of this can be made and dropped to ground crews for analysis. In the case of fire mapping this enables an accurate picture to be obtained at night or through dense smoke, giving fire controllers better information to plan deployment of resources than previously available.

The digital recordings can also be manipulated by the Morwell computer to provide accurate scale maps with very wide applications, as details are shown that are not apparent from aerial photographs. Vegetation types, crop diseases, resources surveys, pollution spread, water temperature and fire damage are some of these. Recent upgrading of the remote sensing computer has also given NSCA the capacity for fairly large scale data recording and analysis, and discussions are well underway with Dr D Walker, the Navy and other groups concerning the potential use of this computer to extend and enhance the functions of Project Stickybeak, allowing for instance, direct data entry by diving accident treating facilities, and easier statistical analysis, whilst of course retaining the necessary confidentiality by appropriate security systems.

NSCA has a policy of maintaining and supporting all of its own operations, and thus aircraft and electronic engineers are on staff with all necessary equipment for most repairs, modification and maintenance work. A twenty-four hour operations room has the necessary staff on call via pagers, with telex, radio, facsimile and multiple telephone links to provide co-ordination of all services. The emergency direct telephone number of this Latrobe Valley Operations Room is (051) 74 9922, which can be called direct by Victorian divers requesting assistance, but otherwise will only lead to a turn-out of equipment and personnel if called by the appropriate authority for that problem (eg. Police, Ambulance, DoA, RAN etc.).

These resources are being widely and increasingly used, and continue to be upgraded and to expand as invitations to augment already existing services arise. In association with the NSCA hyperbaric facilities, they offer an important part of Australians developing diver evacuation and treatment network.

GADGETS AND GOOFY IDEAS

Carl Edmonds

Washerwoman’s Skin

One of the things that I encountered in Sydney a little while ago, was a great idea from a young resident at the Sydney Hospital. He got involved in an underwater endurance record.

People who go into those futile gestures often have no concept of the physiology they disrupt. The diver came out of his underwater endurance after about 36 hours and his main symptom, apart from the odd hallucination, was extreme pain in his hands and feet. They were waterlogged (Figure 1). Everyone recognises this “washerwoman syndrome”, we have all had it to a greater or lesser degree. But this was to such a degree that it was very painful. The pain was the pain of arthritis as well as in the skin, and he could hardly move his hands because of the pain associated with this movement.

The young resident rationalised that “because you’ve soaked up a lot of fresh water into your tissues, we will now bathe your hands in hypertonic saline”. This he proceeded to do and got excellent results after 10 minutes. The hands cleared up nicely and the pain went away!

I had never heard of this treatment before. It makes sense doesn’t it?

Jackpot

The next smart idea I wish to present is referred to as “the Jackpot” (Figure 2). It is very small it stands about 10 cm, and is a mini wet compression chamber, made for me by a couple of entrepreneurs in Kempsey so that we could test decompression meters. Well, it was too small for the meters but it is just the thing to test depth gauges.

FIGURE 1

Diver's hand after 36 hours in fresh water.

It is now well accepted that depth gauges are fairly unreliable. They are unreliable because, as they are used more frequently, they develop faults which progress, and they can err in either direction.

Looking at surveys of depth gauges you realise how incorrect they are, and often how incorrect they are when bought brand new from the dive shop! The US Navy did a comprehensive survey on this. Anyone who dives with a depth gauge and believes it, has got to be fairly gullible.

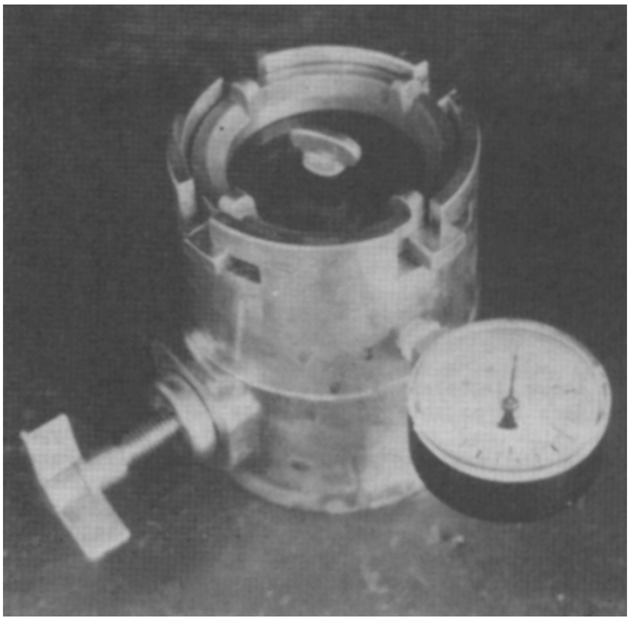
No pressure gauge is of any value (apart from the capillary gauge) in the first 10-15 per cent of its range, and in the last 10-15 per cent of its range, so there is no point in trying to use depth gauges for your decompression stops.

To use the "Jackpot", one puts the depth gauge inside the little water chamber, puts a plastic lid on the top and screws it down to make it watertight. Because there is only water inside it, the little screw on the side acts as a screw plunger to elevate the pressure. There is no great danger involved such as with an air compression chamber which could burst. It uses hydraulic pressure and if it bursts, the water simply squirts out.

In the "Jackpot", the shallow depths are checked against the capillary gauge inside the plastic top. Greater depths are checked against the main gauge, which has to be calibrated regularly.

It takes 5-10 minutes at the most to check a depth gauge. You will notice that when Cindy or I descend, we have on our gauges a waterproof correction scale on which the true depth can be ascertained from the depth on the gauge. We use capillary gauges to know what the genuine depth is, in the top 10 metres.

FIGURE 2



The Jackpot.

PANDORA'S BOXES

Nature

Some interesting things happened in one of my recent scientific expeditions. We dived the Pandora, and it is a fascinating wreck. The Pandora carried the mutineers of the Bounty with intent to bring them back to England. It was wrecked only 100 miles off Thursday Island, and that is a very inhospitable area. Quite a few people died in the accident and after it was recently discovered, it has continued to cause problems in the form of quite a few bends cases.

Some museums are now combining to explore the wreck and they are doing it in the most methodical and brilliant manner. I went there with David Flatman, the documentary film maker and Walt Deas, the underwater photographer. We were rewarded with the spectacle of wildlife on Pandora Cay where we saw the greatest number of turtles we had ever seen. It made Raine Island look deserted! By about 4 pm one could see the turtles invading the beach. By 8.00 pm you could not move on the island without stepping on turtles. Turtles were digging and destroying other turtle eggs with great abandon. After one turtle had laid her eggs, she would head off and another would come and take the vacated spot.

On another occasion, whilst travelling with two companions in a rubber duckie, we saw a small whale shark, 4 metres long! It came up alongside the rubber duckie, and literally pushed it aside. As I was the only one dressed for diving, I rolled on to the top of the whale shark, and for the next half hour had the most superb underwater encounter I have ever experienced. Everyone and their dog ended up getting onto the whale shark. It will be coming out in a rather spectacular movie sequence later on, courtesy of David Flatman Productions.

The shark obviously wanted to be with us, as he kept coming back. He did not appreciate us hanging on to his tail so much, for after a few minutes he would shake the hitch-hiker off. We could not go too deep because we only had snorkels and eventually we had to return to the surface. He would then turn around, have a look, and come back to collect us again. He would come right up, face to face, then glide over the top of the divers, and it is all captured on film!

Seasickness

A look at some of the research we did. Because we were going out on a boat, and into very rough seas, I thought this would be an ideal time to test some of the new approaches to seasickness. One is the use of ginger. I would appreciate it if anyone could give me some of the original literature on this.

I finally found an old record of its use in a book called "Sod's Law of the Sea". It is an exciting book about an old seaman writing to his nephew. In one of his letters, he pointed out that seasickness was a problem that was only averted by not going to sea, or not going to land. His suggestion in this book was that ginger biscuits were very good. He was not sure whether they were good treatment for seasickness, but he was sure that they made the boat go faster. That is the only reference I can find for ginger in the literature. On our controlled trial, it did not work. The ginger takers had to move on very rapidly to the more genuine anti-seasickness drug treatments, which worked very effectively.

Most people would accept that if you are going for an early morning dive, something like Phenergan (promethazine) can be taken the night before, with the sedative effects wearing off in the morning, and with the anti-seasick and electronystagmographic effects still very pronounced during the dive. Basically, we still rely on the antihistamines, which with a stimulant supplement is absolutely unbeatable for yachtsmen (but not for divers). That is the most effective regime, and I thoroughly recommend it.

There is, however, a more fashionable treatment called "Sea Bands". It is used by people as an acupuncture type mode, wrapped around the wrists, and the little button must cover the correct area. It must be very lucrative treatment for the people who initially promoted it. The main problem is washing the vomit off the material.

If you dive in the afternoon, of course, you cannot rely on Phenergan (promethazine) the night before, as it would be wearing off by the next afternoon. If you are prepared to take one of the short action antihistamines, like Marzine (cyclizine) four hours before the dive, the sedative effect will be wearing off, and the anti-seasickness effect will still be present. You must limit your dive to 10-15 metres less than you would normally dive. I think most people would accept that as being reasonable. Stimulants are not acceptable for divers.

Flares

Another very important development happened while at the Pandora. We were diving in areas which had very strong currents. I think that whenever one dives in an area that has strong currents or an irresponsible boatman (and I think that covers the whole Indo-Pacific region), the chances are that sooner or later you are going to get lost. Then the boatmen, belatedly, go into a panic. The people who up till then appeared strong, reasonable, secure type folk in whom you had enormous confidence, suddenly throw a tantrum, and zoom all over the Pacific in a frenzy looking for divers. The divers may be lost because they went with the current instead of against it, or it may well be that the boatmen up-anchored and left to pick up someone else.

Because I think it is very important to be found while still alive, I carry a day/night distress flare (Figure 3). It is about 12 cm long, and one end will give a remarkable amount of orange smoke that will be obvious for miles. It is preferable to discharge it when the boat is heading in your direction. I carry it in the little pouch where I also keep all the Spanish Doubloons that I salvage. I have it tied into the pouch with some fishing twine so it is easy to snap off.

FIGURE 3

Waterproof distress signal suitable for divers.

There is a problem with the flares. If you open it whilst peering at it, it can discharge in your face. Direct it elsewhere. On the other end, it is especially designed to draw attention during night diving, and has a brilliant flare system. I may add that it is pressurised and proven to 240 feet.

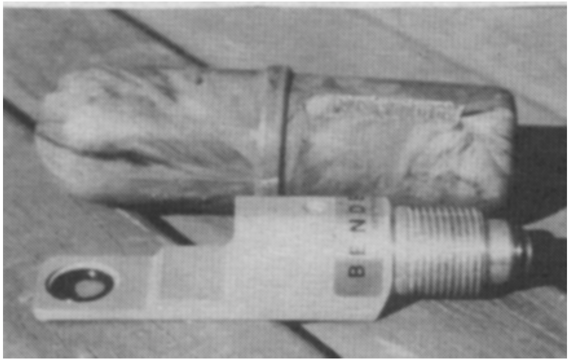
Bendeez

Another gadget that was used in the Pandora quite a lot was the Bendeez (Figure 4), which is just an adaptor to give oxygen via a normal scuba demand valve. It is a very simple system for divers. It allows the use of a large oxygen cylinder with a clean demand valve which should be used for nothing other than oxygen. The reason we needed it on the Pandora was that people were doing quite worrying sort of diving. They were going down to 110 feet twice a day.

They started off doing no-decompression dives twice a day, but fairly rapidly had to move on to decompression dives twice a day. It was a worry, because we were putting down 24-30 divers a day. It was a very bends producing profile in an area in which there was no recompression chamber, and in which the seas could be foul. The dive leader made the decision, even though he had no categorical basis for it, to give the divers oxygen for a short time, to get rid of nitrogen, between dives.

Because of the logistics of that area, it would be difficult to get from the dive site on to oxygen within ten minutes. As soon as practicable, the diver would go on to oxygen breathing even if only for a short time. That, at least probably eliminated some nitrogen and avoided a lot of the early intravascular bubbles. I cannot remember the statistics exactly, but there have been over 1,000 dives on that wreck. There have been three or perhaps four cases of very minor decompression sickness, joint bends only, and that is a good result.

FIGURE 4



The BENDEEZ adaptor for administering oxygen through a diving regulator. It is supplied in a plastic protective case.

It is really similar to the abalone divers who are now often using oxygen between drops. They do their dive, come up, go on oxygen for the 20 minutes it takes for them to get to the next drop site. But it would be dangerous if someone lit up a cigarette or if the oxygen "exploded". This happened recently when someone turned on an oxygen cylinder connected through a small home-made adaptor to a commercial regulator, and it burnt out immediately. He had flames coming out of his demand valve! That is not healthy if you are breathing from it. (This incident was described in the SPUMS Journal, April to June 1985; 15 (2): 31-32). I do recommend that you turn on the cylinder slowly, and that you do not have the demand valve in your mouth at the time, and that you extinguish your cigarette before doing anything.

Decompression Sickness

They used quite a few fudge factors. Firstly, they increased the duration of stoppages that they would do from the US Navy tables. Secondly, they reduced the ascent rate to 35 ft a minute but left the bottom earlier to achieve the same overall duration from surface to first stop. Thirdly, they extended their allowable surface interval, their surface time was predetermined but they spent a little more time than required on the surface. The fourth was the use of oxygen. So they added those four fudge factors in, but remember these people were diving very hard dives, twice a day. The length of time they stayed on oxygen varied, depending on who was on deck at the time, but it was usually only a matter of 5-15 minutes.

Diving in remote areas, as we were, required us to improvise with our personal oxygen system. We could not take a large bottle of oxygen with us, so we took an underwater oxygen set, the AEUR. It is quite different from most other underwater oxygen sets in that it does not require a gas cylinder, and thus, it can be taken on planes, without any problem. It also has an advantage over most oxygen rebreathing sets. These are recommended in the new US Navy diving manual for underwater oxygen treatment, but I am not happy with their use otherwise by most scuba divers. They have caused death, especially amongst untrained divers who have no knowledge of rebreathing sets, mainly because of dilution hypoxia. If you do not exhaust rebreather sets of nitrogen and clear your lungs of nitrogen, the chances are you could end up breathing just nitrogen.

The AEUR unit, has the advantage of supplying more oxygen than the carbon dioxide absorbed. In this chemical production of oxygen, superoxide combines with water, it also combines with carbon dioxide, and in both cases it produces oxygen and the chemical lasts about five hours.

Mask Squeeze

One diving accident we noted while on the Pandora was a new cause for mask squeeze, and we saw it in very experienced divers. One diver had been diving for 40 years, and he never previously had a face mask squeeze, but up there he produced the most beautiful face mask squeeze. He could not understand why, but I can. One look at his face mask (Figure 5) and the answer was obvious. It was the new type of mask that is flooding the market. The mask has been converted into a rigid structure, and so continuous equalisation is needed to prevent a "squeeze".

The reason people did not get face mask squeeze more often in the past, was because masks were very flexible so that when Boyle's Law had its effect, the mask would be sucked in, and it would accommodate for Boyle's Law. With this new mask, there is only a small possibility of flexibility in the silicon around the forehead where it makes the seal, and the mask is mainly made of rigid material. A stupid bit of equipment to sell on the open market, but they are coming out in pretty colours and you have always got to be wary of the dive equipment manufacturers. They will sell anything without thinking about it, or testing it first.

AIR EMBOLISM

Taking A Definite Position

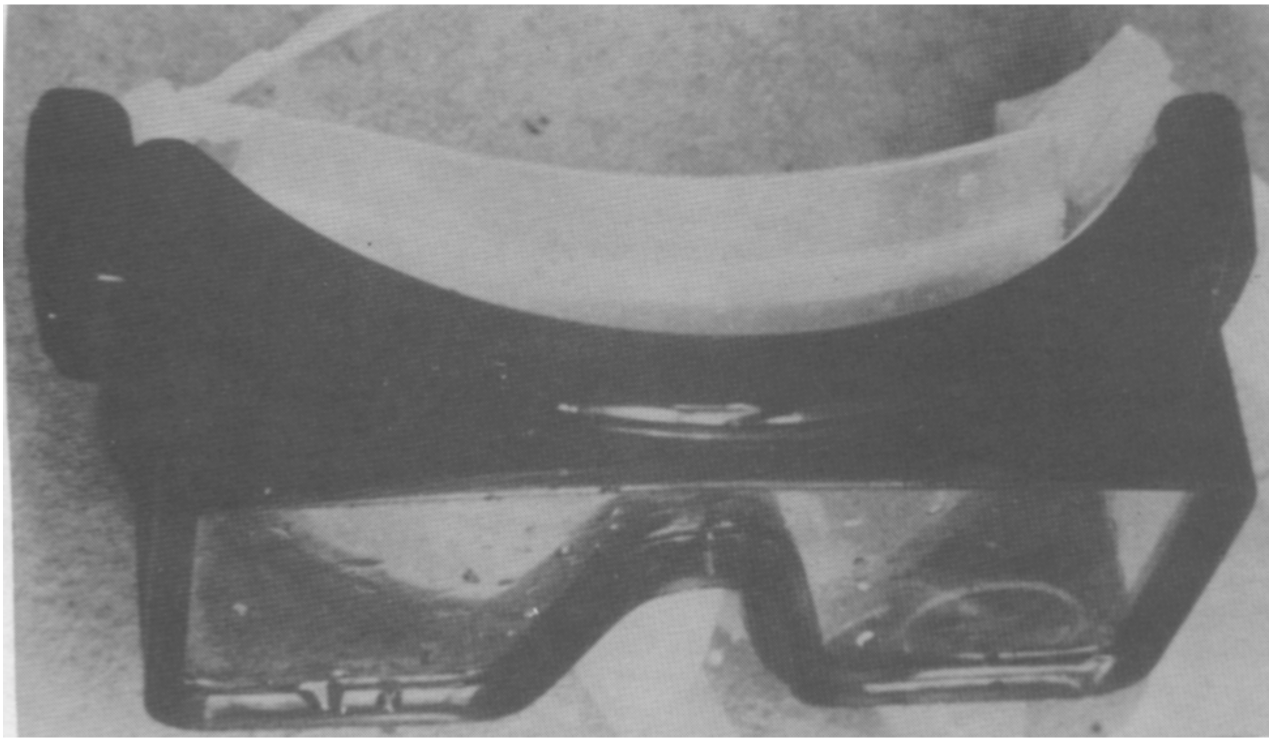
I guess that I average about one lecture a week to divers on the management of diving accidents. Unfortunately, there are some questions which are asked regularly, but which continue to stump me. One is the importance of the position of the patient during the first aid management of pulmonary barotrauma (burst lung) with air embolus. Everyone seems to have the answer, except me.

From Van Allen, in 1929 and onwards, it seems as if the horizontal position is to be avoided because gas follows the buoyancy principle and rises to the top of the aortic arch, thereby allowing a large amount of the gas to travel into the early branches from the aorta, the innominate and the left common carotid arteries. With the passage of gas emboli into these arteries they are then likely to reach the cerebral circulation which is what we are all worried about.

This terrible chain of events can be made worse if the patient is in the upright position. The headup position is, however, the way of preventing the bubbles getting into the coronary arteries. Oh well, you win a few and you lose a few.

If we are to lie the patient with the head down, gas will collect to some degree in the left ventricle, and when it is

FIGURE 5



Modern diving mask made almost entirely of hard plastic. It is an older diver's mask as there is a small reading correction glued to the left side of the glass.

gradually dissipated, it will presumably pass to the higher part of the aorta and thus be disseminated to the body and lower limbs, in preference to the brain and upper limbs.

Thus, there seems to be a good theoretical argument for the patient being, to a degree, inverted. Not a comfortable position to take, but preferable to having air bubbles in the brain.

Anatomy confuses me, especially if discussed in three dimensions. All my learning comes from the flat pages of a book. For simplicity's sake, let us presume that the head down, feet up position is the correct one. There are some variations on which we could now ponder.

The correct treatment is recompression therapy, although we may argue regarding the exact pressures and gas mixtures to be used. Between hauling a burst lung victim from the water, and putting him in the recompression chamber, I am sure that there are few who would object to the use of 100 per cent oxygen either as a supplement to his normal respiratory efforts, or to actively ventilate him if there is no spontaneous respiration, while in the head-down position.

Which Head-Down Position to Use?

The question is, which head-down position? There are two major contenders. I get the impression that, until the last decade or so, the left lateral or decubitus position, which is moderately comfortable and easy to obtain even with the body inclined downwards, was the one of choice. I have always felt this to be a fairly logical position to take, but of late there have been a number of proposals to place the patient on his back, supine, but with the head down and the feet up.

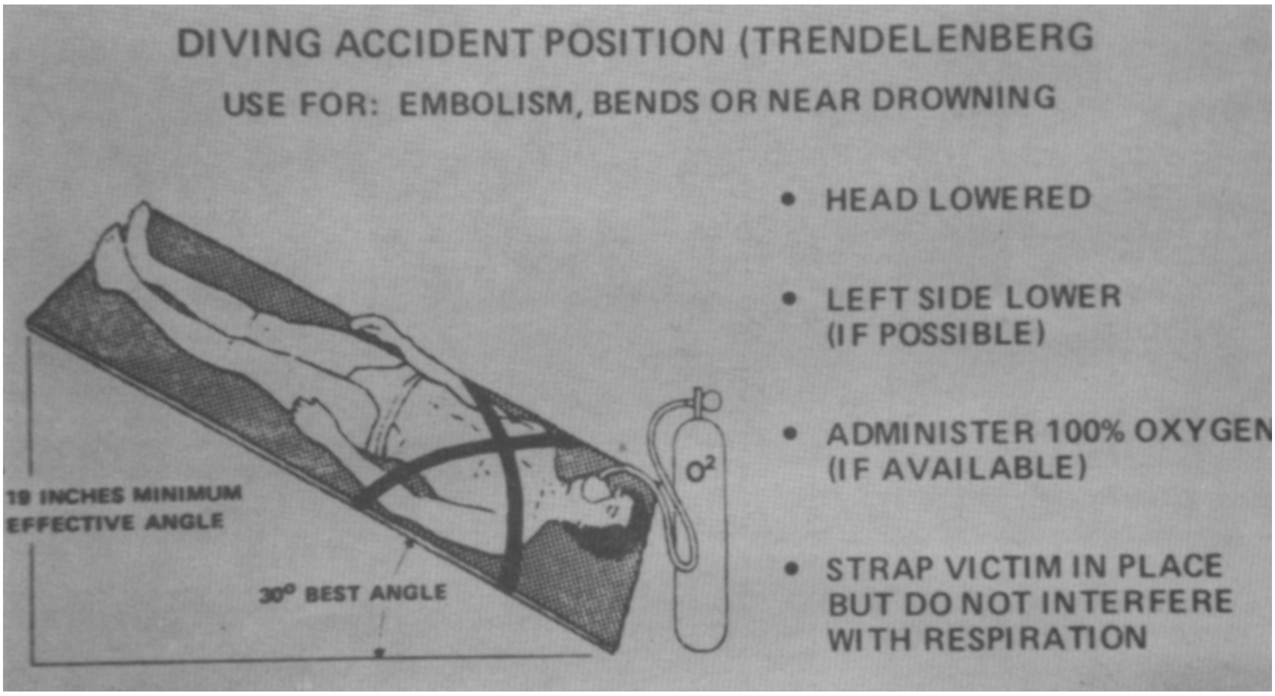
The first time that I saw this demonstrated was at a diving medical conference in 1975, and the demonstration was carried out by one of our more eminent diving clinicians. He demonstrated how the patient could be held in this position by putting him on his back and lifting his knees up in the air. This, we were assured, was the correct positional treatment for the first aid management of an air embolus. Most people would recognise this as a type of modified Trendelenberg (the formal Trendelenberg position requires the legs and feet to hang over the end of a table elevated to 45 degrees).

On seeing this I was amazed that anyone with any degree of respiratory impairment, or indeed any reduction of consciousness, would be put in such a position. It is almost guaranteed to produce an obstruction to the airway, with the tongue falling back into the oropharynx. It is also a position in which vomiting, if it does occur, will produce severe and inevitable aspiration. Not a good position for an unconscious patient, unless there is a cuffed endotracheal tube inserted. The modified Trendelenberg position on a patient without any respiratory depression, and with a well maintained endotracheal airway, may work. Without this, and if he has been recovered from the ocean and therefore likely to have swallowed some sea water beforehand, it would seem to be a disastrous position to use. Anyone who has treated cases of near-drowning would appreciate the enormous likelihood of vomiting and aspiration. This could be a danger with any neurological disorder, and air embolus certainly falls into that category.

Imagine my perplexity on seeing (Figure 6), in a recent edition of a respected diving manual, the suggestion that the Trendelenberg position be used for "embolism, bends or near-drowning". Yet they also advised not to interfere with respiration. I cannot think of a more effective way to obstruct respiration than the Trendelenberg, without an endotracheal tube.

Any doubts about the clinical significance of this were soon allayed after seeing some fascinating work being performed by Dr Des Gorman, a diving medico in the Royal Australian Navy. Des has spent a considerable time in developing an animal model in which the cardiopulmonary systems are not involved, but with the injection of air into the femoral artery. With the animal positioned 45 degrees to the horizontal, head upright, it is spectacular to observe the embolization in the cerebral vessels, followed by movement of the emboli minutes later and then re-embolization, even though only one amount of air was injected.

FIGURE 6



This position, taken from an American Diving Manual, almost guarantees obstruction of the airway in an unconscious patient, and death in the event of that patient vomiting. IT IS NOT RECOMMENDED. USE THE HEAD DOWN LEFT LATERAL POSITION

I am not suggesting that the left lateral position is any more beneficial in preventing air emboli reaching the cerebral circulation than the supine position. As long as the head is down then the body is up, such advantages are probably equal. The supine position is nowhere near as safe for the maintenance of a clear airway and respiration as is the left lateral. This is basic clinical medicine.

If one were to project theoretically what could happen in the different "inverted positions", then presumably the gas bubbles that get into the aorta while the patient is lying in the left lateral position would be likely to run along the concave wall of the aorta. If some were unfortunate enough to get into the innominate (the first major artery that they reach), the likelihood would then be that they would go into the right subclavian more than the right common carotid.

Recurrent Embolization

Does the position matter once embolization has occurred? The literature suggests that air embolus is not an instantaneous thing, but that air pockets do accumulate, depending upon the position of the body, and that recurrent embolization occurs.

Interestingly, re-embolization can occur over a period of 5-10 minutes. Another interesting aspect is the effect of oxygen. The amount of air required, in this particular model, to produce death is 10 ml injected over one minute. If the animal is breathing oxygen, then the amount of air injected needs to be increased to 25 ml. If oxygen is injected in an oxygen breathing animal, then 60 ml are required.

Because of delay in the effects of re-embolization (perhaps we should call it subsequent embolization, as it is obviously a different mass of gas), the immediate administration of oxygen after an accident may be of considerable benefit. Des is now evaluating the relative merits of oxygen and carbogen on the reactivity of the vessel adjacent to the embolus, and the redistribution of the bubble.

It is unfortunately impossible to draw conclusions from the small number of patients treated in various surveys. In fact, many patients who have clearly suffered an air embolus with unconsciousness have apparently recovered fully before they have received treatment. At this stage, Des, like Van Allen and others before him, has verified the enormous value of any head-down position in reducing the damage from air embolus.

In summary, I would recommend that the Trendelenberg position be reserved for the gynaecological and obstetric work for which it was introduced. The left lateral position should be used for the purpose for which it was designed, the maintenance of an airway in an ill patient.

SNORKELS

Darrell Wallner

Once I used to do a lot of swimming with a snorkel. At times during a difficult swim on the surface, and probably every snorkeller has had this problem, I would develop dyspnoea. The snorkel was obviously not supplying my ventilatory needs with any degree of comfort. I was in fact generating large driving pressures in my airways to get anything like the required gas flow. One tends to forget that there is considerable resistance to breathing through a snorkel during quiet swimming.

Recently I took a selection of the snorkels on the market and assessed their resistance. I assessed the resistance by using a system that delivered a known gas flow and seeing how much the flow dropped when a snorkel was attached to the system. I used flow rates of 200, 300 and 400 litres per minute (lpm) which approximate to the peak flows required during increasingly energetic exercise.

The system consisted of a large rotameter capable of measuring 400 lpm and a reverse-cycle vacuum cleaner to provide the high flow rates needed. As the vacuum cleaner could provide more than the required flow I fitted a three-way tap at the inlet to the rotameter so that part of the gas flow could be vented. This allowed us to set a steady flow rate on the rotameter. With the chosen setting flowing through the rotameter we attached a snorkel to the outlet tube causing a decrease in flow which gave a measure of the resistance of the snorkel. The apparatus is shown in Figure 1.

Resistance, as well as being related to the length of a tube, is inversely related to the fourth power of the radius, so we measured the cross-sectional areas of both' the mouthpiece and the end. Measuring the cross-sectional area of the end was easy, Measuring them at the mouthpiece was more difficult. I made moulds of the mouth orifice and then worked out the cross-sectional area. The results appear in Table 1 along with the snorkels used and the results of the flow rate test.

Some of the snorkels appeared likely to generate turbulent flows due to their shapes. Laminar flow causes much less resistance and so is to be preferred. The results showed that the snorkels which looked as if they would provoke turbulence did have higher resistances.

I tested the Dacor Turbo-vent, three Tabata snorkels, the 140, the 150 and the 160, two Nimrod snorkels and a Perry and Skinner snorkel. The snorkels are shown in Figure 2.

The Dacor came out best with a drop in the rotameter bobbin of 4 lpm at 200 lpm (-2%), of 16 lpm at 300 lpm (-5.4%) and of 20 lpm at 400 lpm (-5%). It is a snorkel with a wide cross-sectional area at the mouth (6.15 cm^2) and a below average one at the end (2.83 cm2}. The average end cross-section is high due to the large size of the Nimrod 1 (5.06 cm2). If that is excluded, the average drops to 2.78 cm^2. The Dacor Turbo-vent besides having a moderately large diameter has a particularly straight tube with the mouthpiece slightly offset. It does have a drainage port, a valve that lets water drain out so that one does not have to blow against the hydrostatic pressure of its length, but it is almost in line with the tube and is placed in such a way that it is unlikely to cause turbulence. It had an internal volume of 170 ml.

The next best performer was the Nimrod 1 which has a mouth cross-section of 6.15 cm^2. The bobbin dropped 4 lpm at 200 lpm (-2%), 18 lpm at 300 lpm (-6%) and 22 lpm at 400 lpm (-5.5%), One would have expected the larger end diameter of the Nimrod 1 to enable it to outperform the Dacor. Perhaps the reason is because it is not a smooth tube. One side of the tube is flattened. It is just possible that there is turbulence where the flat side meets the curves. With this extending the full length of the tube perhaps the turbulence is defeating the large bore. Like the Dacor, it has an internal volume of 170 ml.

The Perry and Skinner snorkel was the simplest of the lot and came third in performance. The bobbin drop was 14 lpm at 200 lpm (-7%), 18 lpm at 300 lpm (-6%) and 26 lpm at 400 lmp (-6.5%). The mouthpiece cross-section was above average at 5.06 cm^2 while the end cross-sectional area was 3.14 cm^2 which is

FIGURE 1

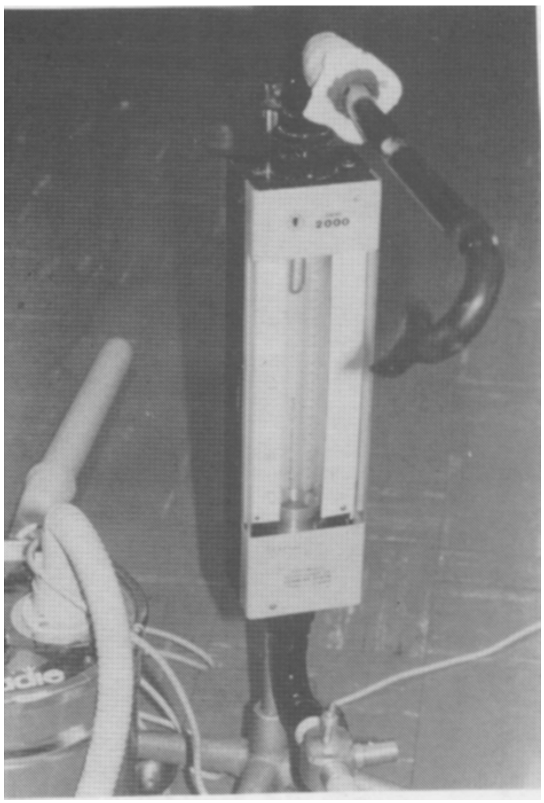
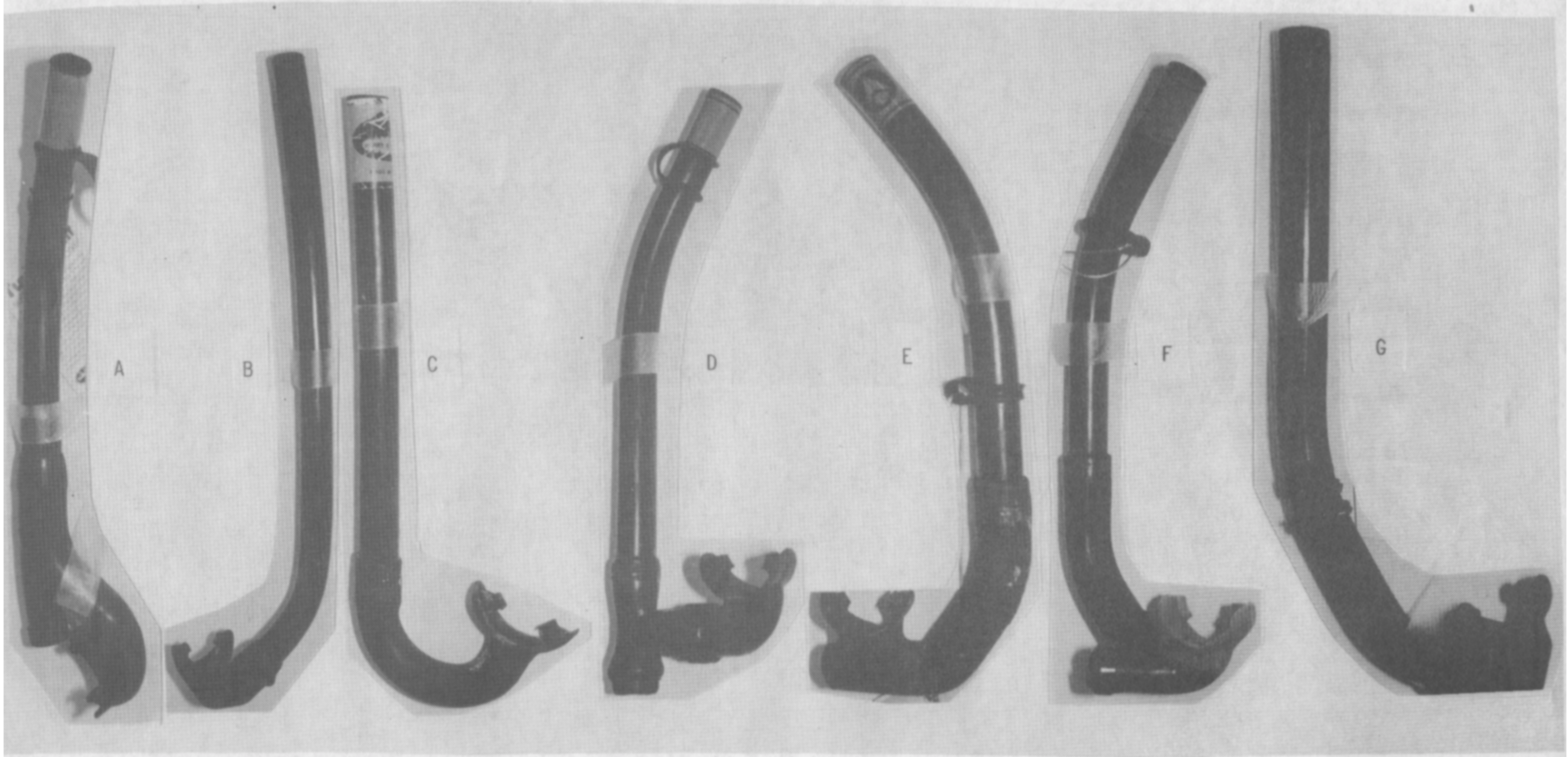


FIGURE 2



A = Dacor Turbo-vent. B = Nimrod 1. C = Perry and Skinner. D = Tabata 140. E = Tabata 150. F = Tabata 160. G = Nimrod 2, note the flat side on the inner aspect of the tube.

TABLE ONE

BRAND	CROSS-SECTIONAL AREA MOUTH	END	FLOW RATES 200L	%	300L	%	400L	%
DACOR	6.15	2.83	196	-2	284	-5.4	380	-5.0
NIMROD (1)	6.15	5.06	196	-2	282	-6.0	378	-5.5
PERRY AND SKINNER	5.06	3.14	186	-7	282	-6.0	374	-6.5
TABATA 140	3.79	2.54	178	-11	278	-7.3	370	-7.5
TABATA 150	3.79	2.54	182	-9	270	-10.0	370	-7.5
TABATA 160	3.79	2.54	180	-10	268	-10.7	365	-8.7
NIMROD (2)	4.40	3.14	170	-15	260	-13.3	358	-10.5

almost exactly the average of the seven snorkels. However it is 0.36 cm 2 larger than the average when the Nimrod 1 is excluded. It has a gentle, smooth curve to the tube, which one would expect would favour laminar flow. This snorkel had an internal volume of 140 ml.

The three Tabata snorkels all had the same mouth cross-section (3.79 cm^2) and the same crosssectional area at the end (2.54 cm2). However, they had some structural differences which probably explain their different performances. The Tabata 140 produced a bobbin drop of 22 lpm at 200 lpm {-11%), of 22 lpm at 300 lpm (-7.3%) and of 30 lpm at 400 lpm (-7.5%). This snorkel has a right angle in it and a constriction. I could not measure the crosssection of the constriction, Then there is a drainage port positioned to encourage turbulence. The internal volume was 145 ml.

The Tabata 150 produced a bobbin drop of 18 lpm at 200 lpm (-g%}, of 30 lpm at 300 lpm {-10%) and of 30 lpm at 400 lpm (-7.5%). It has a drainage port and a number of sharp bends in the tubing. The internal volume was 150 ml. I presume that the numbers of these snorkels is supposed to be the internal volume. This was the only one which corresponded.

With the Tabata i60, the bobbin dropped 20 lpm at 200 lpm (-10%), 32 lpm at 300 lpm (-10.7%) and 35 lpm at 400 lpm (-8.7%). Again there were sharp bends in the tubing. The internal volume was 155 ml.

The worst performer was the Nimrod 2 which had a mouthpiece cross-section (4.4 cm^2) larger than the Tabatas. It also had an end cross-sectional area larger than the Tabatas at 3.14 cm^2 and the same size as the Perry and Skinner. However, the bobbin drop was 30 lpm at 200 lpm {-15%), 40 lpm at 300 lpm (-13.3%) and 42 lpm at 400 lpm (-10.5%}. The explanation of the poor performance is probably its length and a sharp angle at the mouthpiece as it had the smallest internal volume of 133 ml.

Theoretically, one could say that the larger the snorkel diameter the less the resistance and therefore a better flow is possible. So a wide short snorkel should be the ideal. But there is a minimum length needed to get the snorkel end out of the water and to keep the waves from slopping in. Breathing through a snorkel increases ones dead space, and increased dead space can lead to rebreathing expired air. The result is a lowered oxygen partial pressure in the lungs and a raised partial pressure of carbon dioxide. To check the effect the snorkels have on rebreathing, I carried out a simple test. Using an end-tidal CO_2 sampler, I breathed quietly at rest, not exercising, for a while until the result was steady. This gave a figure of 4.8%. I then breathed for six minutes through each snorkel. When the figure was steady for 8 or 9 consecutive breaths, I took it as the end-tidal result for that snorkel. The figures, with the volumes of the snorkels, appear in Table 2. At rest there is no significant change, regardless of the volume or diameter of the snorkels. I have not tried them under exercise conditions to see what happens to the endtidal C02. However, it is likely that when one is breathing at near capacity, as swimming in bad conditions, the end-tidal C02 will rise.

TABLE TWO

BRAND	VOLUME	END-TIDAL CO_2 % (CONTROL 4.8)
DACOR	170 MLS	4.9
NIMROD I	170 MLS	4.9
PERRY AND SKINNER	140 MLS	5.0
TABATA 140	145 MLS	4.9
TABATA 150	150 MLS	5.0
TABATA 160	155 MLS	4.9
NIMROD II	133 MLS	5.1

When selecting a snorkel, one needs to have a wide bore. > 2 cm in diameter, with a smooth tube, no sharp bends or constrictions and a large mouthpiece. Keep the length reasonably short.

Dr Wallner's address is 114 Vasey Crescent, Campbell, Australian Capital Territory 2601.

A CASE FOR DIAGNOSIS
DECOMPRESSION SICKNESS OR MIGRAINE?

Chris Lourey

A 39 year old male, an ex-professional diver with 20 years experience, so-called, presented at Casualty after a dive complaining of blurring of vision, pain and skin rash in the epigastrium, lethargy and dizziness. He had focal but resolving right sided neurological symptoms and signs. These were pain, paraesthesiae and weakness of right arm.

He confidently stated that he was in Casualty only because of his wife's insistence, and that he had suffered two episodes of skin rashes after diving in the past and that this was all due to a migraine. He has 4 to 6 migraine attacks a year.

At all times until discharge the patient maintained an aggressive and at times paranoid mental state. There were gross discrepancies in data and detail between his diving buddy, the patient and his wife's testimony.

His diving profile, psycho-social-physical status and clinical management make for interesting discussion.

THE DIVE

He dived approximately half a mile east of the Nobbies in Bass Strait, using compressed air from a compressor to dual hookah hoses. He wore a 5/16th inch wet suit.

The visibility was approximately 8 to 10 ft. The water temperature was such that both divers felt colder than usual. There was a 15 to 20 foot swell. The depth was said to be 10 to 50 ft. However the relevant charts show bottom depths up to 80 ft or more in this area.

On the evening before the dive and just before the dive he had taken two "Orthoxicol" capsules for a head cold.

He entered the water at 1100 and did bottom sweeps till 1145 when he surfaced with a bag full of fish. From 1150 till 1230 he performed more bottom sweeps. He left the water at 1230. From 1235 till 1300 he had coffee and a few cigarettes. He re-entered the water at 1300 and performed more bottom sweeps until 1430 when he returned to the boat, without decompression stops. He then had lunch of beer, coffee and sandwiches and cigarettes.

At 1515 he noticed a headache, fatigue and blurring of vision. An hour later there had been no change in the symptoms. However he had now developed a rash which was more extensive than when he appeared at Casualty. By 1645 he felt giddy and disorientated. The blurring of vision increased. He lay down in the cabin and noticed weakness of the right arm with paraesthesiae and pain in the right elbow.

After approximately 60 minutes the paraesthesiae abated slowly, but the weakness and blurring of vision, although resolving, remained until approximately 8 hours after admission.

CLINICAL MANAGEMENT

Condition on arrival at hospital

On admission he had a generalised rash, particularly on the trunk and torso. His blood pressure was 150/90 lying, and 80/60 standing. His pulse rate was 96/min. There was no cranial nerve deficit nor any nystagmus. Tests of vision and visual fields were normal as were the fundi. Cerebellar function was normal. There was a very mild weakness of the right arm, but no specific neural deficit. The plantar reflexes were normal. Clonus could not be elicited. Otological examination was normal except for bilateral exostoses. Auscultation of the chest was normal except for occasional mild basal wheezes. He had no difficulty in voiding. No other specific abnormality noted.

His concentration was poor.

Investigations

Chest X-ray was normal except for mild hyper-inflation. There was evidence of mediastinal or subcutaneous emphysema.

Blood gases were done while breathing air. The results were pH 7.39, PO_2 77mmHg, PCO_2 36mmHg, HCO_3 22, Base Excess -2.

A full blood examination was performed. The results were Hb 17gm%, PCV 0.55, WCC 16,300, Platelets 80.3 x 10^3.

The electrolytes etc. were Na 141, K4.3, Urea 4.9, Glucose 4.8.

Fibrin degradation products were not tested as there are no facilities for this at Frankston Hospital.

Cardiac enzymes were within normal limits and remained so.

ECG showed first degree heart attack with ST elevation in Leads II and V6. The T wave in V1 was greater than in V6, ie. evidence of pericardial and/or epicardial injury pattern.

A CAT scan of the head and cranial region to C5 was normal.

An EEG was not performed.

Diagnosis

The diagnosis was obviously decompression sickness with skin, pericardial and possibly epicardial involvement and neurological manifestations.

Migraine as the aetiological factor of the waning hemiparesis and visual disturbance was also considered.

Myocardial infarction was considered and investigated.

He was treated with

1. IV-fluids were started with 3 litres of Balanced Salt Solution over 3 hours then maintenance therapy. This regime was empirically based as a CVP line was not inserted because of the low platelet count.
2. 100% oxygen was given for 6 hours then 35% was given for 48 hours with 6 hourly periods of 1 hour on 100% oxygen.
3. Dexamethazone.
4. Salicylate therapy was started with 600 mg of aspirin stat, then 300 mg daily for 4 days.
5. Routine oral antacid therapy.
6. Continuous ECG monitoring and serial enzyme assays.

The National Safety Council of Australia, Victorian Division (NSCA. (Vic)) at Morwell were phoned after instituting 1 and 2 above, for possible transfer for recompression and hyperbaric oxygen (HBO) therapy. However they considered as there had been neurological improvement, migraine was the likely aetiological basis for his transient visual disturbance and hemiparesis, and that the transfer of 130 kilometres at midnight not warranted. It was recommended that if any deterioration occurred he should be transferred to Morwell for recompression.

Treatments 3, 4, 5 and 6 were then instituted. He gradually improved over the next 24 hours, but his lethargy and minor degree of mental dullness remained, and improved slowly, over the next 3 days.

His ECG returned to normal within 48 hours. One's "gut" feeling at the time was that recompression and HBO would have been worthwhile, particularly in view of the slow resolution of his mental dullness.

He failed to appear for the scheduled follow up which was to include EEG, neurological and psychological testing!

PSYCHO-SOCIAL-PHYSIOLOGICAL PROFILE

He is an ex-professional diver of 20 years experience who reluctantly admitted to previous incidents of decompression sickness. He has had migraine for more than 10 years. He is prone to extreme swings of mood. He is a heavy smoker and heavy drinker who is currently on wife number three. He has had many motor vehicle accidents (MVA) and has written off three cars. The last MVA was one week before this dive.

His diving behaviour and knowledge was at variance with safe diving practice despite his professed experience.

It is tempting to categorise this individual as a "punch drunk diver".

SUMMARY

A 39 year old male diver who presented with skin rash, epigastric pain and resolving hemiparesis.

The conservative therapeutic approach taken invites comment as does the problem of migraine and diving.

I would dispute the statement made earlier that aspirin has NO place in the treatment of DCS. However is it not a panacea. I believe that it has a role in association with the appropriate adjuvant therapy in certain clinical situations, eg. remote geographical situations.

DISCUSSION

Chairman: Dr David Brownbill

First I would like to emphasise that when central nervous tissue is damaged and dies it is not replaced. There is no repair. So when you are looking at something that may involve death of neurones you are on a downhill slide, there is no way back from that death. When observations of neurological symptoms change then that indicates that there is a pathological occurrence which may be reversible. It may not be serious but there is a pathological occurrence. One has to assess whether that occurrence is incidental and reversible such as migraine or whether it is a potentially destructive thing such as decompression sickness. In that situation one must be considering all the time the risks of missing something that is potentially dangerous as opposed to the risks of instigating the appropriate treatment, here it would have been recompression, for that condition. What is the risk of recompressing a patient with migraine as opposed to leaving someone on observation only, who may have on-going damage to cerebral structures. I think that is fundamental in the assessment of this case report and I would like to hear a lot of discussion about the approach to not what is definitely decompression sickness, but what reasonably might be.

The prime treatment for decompression sickness is recompression. The indications for treatment of central nervous system decompression sickness is not only the diagnosis of established CNS decompression sickness, but rather the diagnosis of what might reasonably be CNS decompression sickness. It is better to find that one has recompressed unnecessarily than to have sat on neuronal damage, which at first may have been reversible.

Dr Chris Lourey

I would like to ask others their thoughts on salicylate therapy. My belief is that it is used in neurological disease. In a situation such I was faced with I would still maintain that you would use it until there was properly documented data that suggests that you do otherwise.

Chairman: Dr David Brownbill

I also subscribe to the view that until something that is not dangerous is proven to be totally ineffective, then consideration should certainly be given to using it. There is no doubt that one's clinical experience, eg. in transient ischaemic attacks, that low dose aspirin is of benefit in sometimes turning off showers of transient ischaemic attacks. There is benefit in preventing the extension of problems with established embolism. Whether overall statistically aspirin is of benefit, we do not know at the moment. We will not know the answer to this until the international survey comes through. But we do know that there are specific incidences where it seems irrefutable that it has helped. On that, I would subscribe to the idea that aspirin is worthy of consideration. I know Carl Edmonds says that the person who was the protagonist of aspirin for decompression sickness is now unhappy. I do not think that the use of aspirin in neurological conditions rests with that gentleman. It has extended across the world in other neurological areas of investigation and management, so it would seem to me that there is a case at the moment of considering its use.

Dr Carl Edmonds

The man had an obvious bend. He was badly treated and you were fiddling around with aspirin and the poor man needed oxygen and a chamber. The fact that he was aggressive means that he had brain damage. It is tragic to me that he was not recompressed.

Dr John Hayman

I would like to make a plea that when we do blood tests on such patients we should also include a coagulation profile. We should be doing things like the partial thromboplastin time and fibrin degradation products both in urine and in blood. Then I think we have got some background as to what is going on and we can see the effects of aspirin and any other anticoagulant on these parameters.

Chairman: Dr David Brownbill

Here we have a story of the subtler changes of cerebral function, that is cerebration. That raises another question, whether subtle changes in mental state should not be indications for recompression. Ian Millar has a story to illustrate this point.

Dr Ian Millar

This case report concerns a patient who presented quite a diagnostic dilemma. We believe the results of her test of recompression indicate that she was suffering from cerebral decompression sickness and that this case reinforces the value of treatment upon suspicion.

A thirty-five year old experienced female sports diver had undertaken repetitive dives to 75 feet for 40 minutes followed several hours later by 30 feet for 40 minutes. That evening, along with three of her colleagues, she had suffered nausea, stomach cramps, some diarrhoea and a generalised skin rash which was thought possibly related to some seafood eaten on the dive trip. Upon her return home she felt more tired than usual, somewhat “off colour” and had a persisting skin rash. She presented to her general practitioner late the following morning with a quite obvious blotchy skin rash and significant oedema. She felt unwell and a little dizzy. She was slightly ataxic. Her GP also noticed her to be dull, quiet and not her usual self.

She had been treated with hydro-cortisone and promethazine by the time I was contacted, and her oedema and rash had settled. She had also had some oxygen over about one hour. Her cerebration was still not quite normal however, and after some deliberation she was referred down to us. When I saw her, she seemed quite a reasonable person who stated that she felt something of a fraud presenting for treatment. She was, however, rather “slow”. Not having met her before, this could have been interpreted as her normal mental state, however, I had been informed that this was not so. She had very objective findings apart from poor balance with inability to maintain balance with her eyes closed. After 20 minutes at 18 metres on oxygen, her personality changed completely from being a rather dull woman with a very flat effect, to one of the brightest personalities we have had in the chamber. It became a most entertaining treatment from then, with the repartee passing in and out of the chamber. She had changed personality completely and maintained that change back to what all her friends and her doctor said was her normal self.

Dr Carl Edmonds

There is available to people who are amateurs in diving medicine a very professional service run by the Royal Australian Navy. It is called the Diver Emergency Service. It means that anyone who is an amateur medico in the field of diving medicine can phone up and speak to a really good professional and get help and advice. The number throughout Australia is 960-0321 and it is available 24 hours a day. It has been there many years but at least now it has been made widely known. I think, in the future, that will seem a sensible number to anyone, even those who are professionals, to use.

On the subject of permanent damage from CNS decompression sickness, there is a fascinating case of the man who had a very slight weakness in the left leg. He had a little pain around the back, very little, and I think that was all. He was treated very effectively in one of the Royal Navy’s chambers with oxygen and recovered completely. He walked out of his house a day later and was shot dead. The neuropathology showed lesions throughout both the brain and spinal cord, even after such minimal signs.

I would like to mention something else that people may not know. About 5 years ago there was a whole series of US Navy Tables, Tables 5, 5A, 6 and 6A. Nowadays almost all treatments are with Table 6.

Chairman: Dr David Brownbill

It would seem that people who have had a central nervous tissue hit really should be considering seriously not diving again because even though there appears to be complete clinical resolution, it has now been established that pathologically this is not so.

Question

When you say there is damage done, 24 hours later, what are you looking at? Are you looking at things like congestion and oedema or are you looking at something which indicates that you should be treating these people longer? Or are you looking at something that is a permanent damage?

Dr Carl Edmonds

In that particular pathology, it was autopsy pathology and largely brain and spinal cord. As to whether you should treat people longer, nowadays, in Australia anyway, people do not have just one treatment. They have many treatments for decompression sickness. In the old days one did not do that, one sent them out after 24 hours on oxygen. Nowadays we tend to do a number of treatments. Whether this is of value or not, I do not know. Whether or not one is going to show an enormous amount of pathology eventually when someone, like that guy, coincidentally dies, we are going to have to rely on people like John Hayman.

Dr Mary Novak

Was your patient’s labile blood pressure due to fluid depletion?

Dr Chris Lourey

My estimate is that it was a combination of the dehydration of cold diuresis with the diuresis of immersion with extravasation of fluid due to endothelial disruption that was responsible.

Question

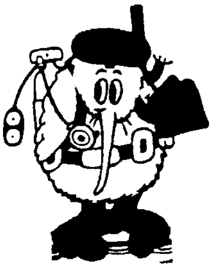
Did the ECG changes revert to normal?

Dr Chris Lourey

The ECG eventually did return to normal over the next 3 days. The ST elevations gradually resumed their normal profile. The only thing that did not return to normal was that he had a first degree heart block. We were hoping to look at that at a later stage. I would also like to stress that at no stage were his enzymes elevated, which I think is a consideration in a 39 year old individual who has an exhausting dive and who comes in with upper abdominal pain or chest pain.

Dr Ian Millar

Diving Emergency calls to NSCA are now referred to one of our three full-time diving medical officers. We have developed a close relationship with the RAN School of Underwater Medicine and quite often consult them concerning difficult or unusual cases.



DIVING KIWIS

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

DIVING FATALITIES IN NEW ZEALAND 1982 - 1985

RM Fraundorfer

Accident Recorder
New Zealand Underwater Association

SUMMARY

There have been 30 diving fatalities investigated by me in the three year period November 1982 to November 1985, 9 snorkellers and 21 Scuba divers. Twenty nine were male, one female. The average age was 32. Pre-existing medical conditions which should have precluded diving, either permanently or temporarily, were present in 56 per cent of the snorkellers and 29 per cent of the Scuba divers. Lack of training and/or inexperience was a significant factor of 33 per cent of snorkellers and 52 per cent of Scuba divers. Inadequate equipment was also a significant feature, particularly amongst Scuba divers. Failure of the buddy system, either by separation or diving alone occurred in 78 per cent of the snorkellers and 95 per cent of the Scuba divers, whilst identical percentages of divers in the two groups died with their weightbelts on (78 per cent and 95 per cent). The cause of death was as follows:

	Snorkel	Scuba
Drowning	7	10
Asthma	1	1
Cardiac	1	2
Air embolism		5 (?8)
Trauma		1
Unknown		2

Further statistics and analysis of these diving deaths will be presented at the Scientific Meeting of the New Zealand Chapter of the South Pacific Underwater Medicine Society on 7th November, 1985.

SIGNIFICANCE OF HAEMOSTATIC INVOLVEMENT IN THE PATHOGENESIS OF DECOMPRESSION SICKNESS

Abstract of a paper given by JF Cleland to a Meeting of the South Pacific Underwater Medicine Society, 8th November 1985.

Following investigative work in the 1960's and 1970's reviewed extensively by Philip in 1974, it was generally accepted that the haemostatic mechanism is activated with the formation of intravascular bubbles in decompression sickness (DCS). It was believed that this might play a significant role in the pathogenesis of the protean manifestations of DCS, and might be responsible for the individual and temporal variability of response to a single dive profile that is so characteristic of the disorder. If the role of the haemostatic mechanism is significant it would have three main implications:-

1. For drug therapy of clinical DCS.

2. Drug prophylaxis.

3. Recognition of divers with higher risk for DCS.

With a further ten years of diving experience and related biomedical research, shadowed by significant advances in the understanding of haemostasis, particularly the role of the platelet, these clinical implications are re-examined.

It is concluded that there has been little further advance in our understanding of the role of the haemostatic mechanism in DCS and knowledge of this role has not been translated into practical benefit for divers. However, in spite of the lack of adequately controlled trials of drug therapy, there is a significantly broadened theoretical base for the recognition of divers likely to be at higher risk. Reports on the use of newer drugs, such as Prostacyclin with its potent inhibitory action on platelet aggregation coupled with vasodilation, which may be more encouraging, are awaited.

RESPIRATORY ASSESSMENT OF INTENDING DIVERS

AG Veale

SUMMARY

History

To identify those disorders likely to lead to pulmonary barotrauma, or to limit exercise.

Examination

Chest wall deformities or scars, auscultation particularly on forced expiration and following hyperventilation.

Investigations

Chest x-ray PA Inspiratory and expiratory. Identifies "silent" areas of airtrapping, such as cysts.

Peak expiratory flow meters - useless unless the result is abnormal.

Spirometry FEV, FVC. Good at assessing structural disease. Useful in variable disease (asthma) only if abnormal.

Pulmonary physiology work-up. Adds little to spirometry in terms of normals. Is much better at assessing severity.

Histamine challenge (cold air and exercise testing have been abandoned). Identifies those with bronchial responsiveness whom I believe should be excluded. Should be performed in all intending divers with history of asthma at any time, in all those with history of cough after exercise or at night, or prolonged cough after respiratory infection. It is not complicated and can be an office procedure (resuscitation facilities should be present).

PERSONAL ACCOUNT OF DIVING DOCTORS IN NEW ZEALAND WHICH HAS CULMINATED IN THE FORMATION OF A SUB-GROUP OF SPUMS

Allan Sutherland

Like many doctors practising medicine on Auckland's North Shore, I was influenced by both the location and contact with New Zealand diving elder statesmen, Tony Slark and Rob Stephens. I did a dive course at a local Dive School, and groups of us, Medicos, Dentists and others, organised our own dive trips. Chronologically, these were held at the Poor Knights, Mercury Islands, Mokohinau Islands, the Bay of Islands, and more recently, the Poor Knights again. The last two functions included some clinical content relating to Diving Medicine. The 22 doctors who attended the Tutukaka (Poor Knights) weekend were unanimous in asking that a Steering Committee be formed to unify the standards of diving medical examinations and co-ordinate the treatment of diving emergencies. That Steering Committee was to include

Continued on page 24

THE FUDGE FACTOR TABLES MORE ON THE BASSET TABLES

John Knight

The Bassett tables set out for repetitive diving were presented at the Annual Scientific Meeting at Bandos Island. They were published in the SPUMS Journal (1985; 15(2): 8-15). The final paragraph mentioned that a commercial version would soon be on the market. This version, reproduced on the page opposite, was presented, in the interests of safer diving, at the meeting of the New Zealand Chapter of SPUMS.

With three safety factors (a shorter bottom time, a slower ascent rate, and a safety stop on all dives below 9 metres or 30 feet) built into the first dive and five (using the total time underwater to calculate the repetitive group at the end of the first dive, subtracting the USN residual nitrogen time from the Bassett bottom time to give the time available for the repetitive dive, a shorter bottom time, a slower ascent rate, and a safety stop on all dives below 9 metres or 30 feet) into the second dive they can be dived as they are written with a very low chance of decompression sickness.

To use the table, find the depth of your dive in either column 1 or 2 of Table 1. Column 3 will give you the no-decompression time for that depth. *The rest of Table 1 is for finding the repetitive group at the end of a dive.* After the dive, run your finger across until you reach your total time underwater and then run your finger down that column to the letters below. Find the same letter on the right of table 2 and run your finger horizontally to the left until you come to the time interval since your last dive. Then run your finger down that column into table 3, stopping when you get to the chosen depth of your next dive. Your finger is on the maximum bottom time available for the repetitive dive to take you to the Bassett limit for that depth.

On the back of the card there are the instructions for using the tables. There is a modified decompression table, which adds the safety stop time of 5 minutes to the USN decompression times, for those who accidentally exceed the no-decompression limits, and there are instructions, with an example, for calculating the repetitive group at the end of a repetitive dive. This allows a diver to have a third dive if he wants one.

The Australian Underwater Federation wants safer tables (page 36) but will have to wait for at least five years and probably longer for the RAN to produce new tables.

The sports diver needs a safer table than the USN one now or, at the latest, before his or her next dive. Safer tables, the Bassett tables, are now commercially available.

The tables are printed in waterproof ink on flexible plastic, that will fold to go into a buoyancy compensator pocket, and varnished for greater protection. The tables sell for $2.00 (Australian) in diveshops. The distributors in Australia are Oceanic Diving Products Pty Ltd, of Box 228, Cheltenham VIC 3192 and Oceans Enterprises, 40-42 Taylor Street, Ashburton VIC 3147. Overseas enquiries should be directed to RJ Knight Pty Ltd, 80 Wellington Parade, East Melbourne VIC 3002.

DR BRUCE BASSETT'S REVISED BOTTOM TIMES "NO DECOMPRESSION" DIVE TABLE

ARRANGED FOR REPETITIVE DIVES BY JOHN KNIGHT & JOHN LIPPMANN

BEFORE USING THIS TABLE READ THE OTHER SIDE.

ACENT RATE 10m A MINUTE

ON ALL DIVES DEEPER THAN 9m (30ft) DO A 3-5 MINUTE SAFETY STOP AT 3-5m.
USE THE TOTAL TIME UNDERWATER (BOTTOM TIME + ASCENT TIME + SAFETY STOP TIME) TO FIND THE REPETITIVE GROUP AT THE END OF THE DIVE.

The times in *italics* in the table are OUTSIDE the Bassett Bottom Time limits but are included for ease of calculating the repetitive group using the TOTAL TIME UNDERWATER.

TABLE 1.

Depth M	Depth feet	Bassett Bottom Time Limits	Time Underwater											
9	30	220	15	30	45	60	75	95	120	145	170	205	*250*	*310*
10	35	180	5	15	25	40	50	60	80	100	120	140	160	*190*
12	40	120	5	15	25	30	40	50	70	80	100	110	*130*	*150*
15	50	70		10	15	25	30	40	50	60	70	*80*	*90*	*100*
18	60	50		10	15	20	25	30	40	50	*55*	*60*		
21	70	40		5	10	15	20	30	35	40	*45*	*50*		
24	80	30		5	10	15	20	25	30	*35*	*40*			
27	90	25		5	10	12	15	20	25	*30*		*40*		
30	100	20		5	7	10	15	20	*22*	*25*	*30*			
33	110	15			5	10	13	15	*20*	*25*				
36	120	12			5	10	12	*15*		*20*	*25*			
39	130	10			5	8	10	*15*		*20*				
42	140	5			5	7	*10*		*15*					
Repetitive group at the end of the dive			A	B	C	D	E	F	G	H	I	J	K	L

ABBREVIATED U.S.N. SURFACE INTERVAL TABLE

Enter the table from the top using the appropriate repetitive group. Move across to the left until the appropriate interval is found then move down the column and out of the table into the REPETITIVE DIVE TABLE

(Table 3)

TABLE 2

	A	B	C	D	E	F	G	H	I	J	K	L
A	0:10											
	12:00											
B	2:11	0:10										
	12:00	2:10										
C	2:50	1:40	0:10									
	12:00	2:49	1:39									
D	5:49	2:39	1:10	0:10								
	12:00	5:48	2:38	1:09								
E	6:33	3:23	1:58	0:55	0:10							
	12:00	6:32	3:22	1:57	0:54							
F	7:06	3:58	2:29	1:30	0:46	0:10						
	12:00	7:05	3:57	2:28	1:29	0:45						
G	7:36	4:26	2:59	2:00	1:16	0:41	0:10					
	12:00	7:35	4:25	2:58	1:59	1:15	0:40					
H	8:00	4:50	3:21	2:24	1:42	1:07	0:37	0:10				
	12:00	7:59	4:49	3:20	2:23	1:41	1:06	0:36				
I	8:22	5:13	3:44	2:45	2:03	1:30	1:00	0:34	0:10			
	12:00	8:21	5:12	3:43	2:44	2:02	1:29	0:59	0:33			
J	8:41	5:41	4:03	3:05	2:21	1:48	1:20	0:55	0:32	0:10		
	12:00	8:40	5:40	4:02	3:04	2:20	1:47	1:19	0:54	0:31		
K	8:59	5:49	4:20	3:22	2:39	2:04	1:36	1:12	0:50	0:29	0:10	
	12:00	8:58	5:48	4:19	3:21	2:38	2:03	1:35	1:11	0:49	0:28	
L	9:13	6:03	4:36	3:37	2:54	2:20	1:50	1:26	1:05	0:46	0:27	0:10
	12:00	9:12	6:02	4:35	3:36	2:53	2:19	1:49	1:25	1:04	0:45	0:26

TABLE 3

MAXIMUM BOTTOM TIME AVAILABLE FOR A REPETITIVE DIVE

Depth M	Depth feet	A	B	C	D	E	F	G	H	I	J	K	L
9	30	213	203	195	183	171	159	147	133	119	104	82	
12	40	113	103	95	83	71	59	47	33	19	4		
15	50	64	57	49	41	32	23	14	4				
18	60	45	39	33	26	20	14	6					
21	70	36	31	25	20	14	9	3					
24	80	26	22	17	12	7	2						
27	90	22	18	14	9	5	1						
30	100	17	13	10	6	2							
33	110	12	9	5	2								
36	120	9	6	3									
39	130	7	4	2									
42	140	3											

Each of these times takes the diver to the equivalent of the Bassett Bottom Time limits for that depth. If these times are accidentally exceeded, add the excess time to the Bottom Time Limit for that depth in Table 1, then use Table 4 to decompress.

READ THIS BEFORE USING THE TABLES

1. Bottom time starts on leaving the surface and stops on starting the ascent.
2. Use the deepest depth of the dive as the depth of the dive for calculation.
3. If the deepest depth of the dive is between two depths in the table use the greater depth for calculations.
4. If the time is between two times in the table use the longer time for calculations.
5. After a dive calculate the repetitive group.
6. After the surface interval calculate the new repetitive group.
7. Using the planned depth of the next dive enter the repetitive dive table to find the no-decompression bottom time available for that repetitive group and depth.

ASCENT RATE 10m A MINUTE.

ON ALL DIVES DEEPER THAN 9m (30ft) DO A 3-5 MINUTE SAFETY STOP AT 3-5 M.

USE THE TOTAL TIME UNDERWATER (BOTTOM TIME + ASCENT TIME + SAFETY STOP TIME) TO FIND THE REPETITIVE GROUP AT THE END OF THE DIVE.

TABLE 4

MODIFIED AIR DECOMPRESSION TABLE*

Depth m	Depth feet	Bottom Time minutes	Decompression Stops minutes at 10 feet	Repetitive group
18	60	70	7	K
		80	12	L
21	70	60	13	K
		70	19	L
24	80	50	15	K
		60	22	L
27	90	40	12	J
		50	23	L
30	100	30	8	I
		40	20	K
33	110	25	8	H
		30	12	J
36	120	20	7	H
		25	11	I
39	130	15	6	F
		20	10	H
42	140	15	7	G
		20	11	I
45	150	5	5	C
		10	6	E

* FOR THOSE WHO ACCIDENTALLY EXCEED THE NO-DECOMPRESSION LIMITS

TO CALCULATE THE REPETITIVE GROUP AFTER A REPETITIVE DIVE.

3rd DIVES BELOW 9m(30 feet) ARE NOT RECOMMENDED.
A REPETITIVE DIVE IS ANY DIVE WITHIN 12 HOURS OF THE LAST DIVE.

1. Subtract the actual bottom time of the repetitive dive from the bottom time available in table 3 to get an answer in minutes.
2. Subtract this time difference from the Bassett Bottom Time limits in table 1. The answer is the equivalent bottom time of the repetitive dive.
3. Add the ascent time and the safety stop time to the answer in 2. This is the equivalent total time underwater of the repetitive dive.
4. Use this time to enter table 1 to find the repetitive group at the end of the dive.

A 2B PENCIL WRITES WELL ON THIS PLASTIC AND IS EASILY RUBBED OUT.

	EXAMPLE	2nd dive	3rd dive*
Repetitive Group before the dive.	B		
Proposed depth of dive	24 m		
Bottom time available	22 min	min	min
- Actual bottom time	20 min	min	min
= Difference	2 min	min	min
Bassett Bottom Time limit	30 min	min	min
- Difference	2 min	min	min
= Equivalent Bottom Time	28 min	min	min
+ Ascent time	3 min	min	min
+ Safety stop time	5 min	+ 5 min	+ 5 min
= Equivalent total time underwater	36 min	min	min
Repetitive group at the end of the dive	I		.

The RESIDUAL NITROGEN TIME can be found by subtracting the MAXIMUM TIME AVAILABLE FOR A REPETITIVE DIVE (Table 3) from the BASSETT BOTTOM TIME LIMITS (column 3 of table 1).

Dr Peter Robinson (doctor in charge of Navy recompression chamber}, Alan Adair (NZUA Medical Advisor) Mike Davis (Medical Officer in charge of recompression chamber, Canterbury Hospital Board}, Peter Chapman-Smith (Whangarei sub group}, and Allan Sutherland and Warren Paykel, for administration and co-ordination.

The Steering Committee met and formulated the proposed actions as listed below:

1. To redesign the SPUMS poster flag for New Zealand conditions.

2. To Unify diving medical standards.

3. To provide an advisory service for difficult medicals and emergency treatment.

4. To compile a list of doctors interested in diving.

The poster flag is the only item which has as yet been completed, and the first batch has been printed with the assistance of CIBA-GEIGY funding. It is a SPUMS flag which has been reduced in size and made into a lasting decal, with information pertaining specifically to diving accidents after the usual CPR has been administered.

At the same November meeting in 1984, it was recommended that moves be made to affiliate the Auckland and North Auckland group of diving doctors with SPUMS as many doctors were already members of both. In April 1985, at the SPUMS AGM in the Maldives, I was officially appointed as Liaison Officer to the New Zealand Chapter of SPUMS. Arrangements were that membership be collected in New Zealand dollars by the Liaison Officer and that Journals would be distributed by same Liaison Officer, the subscription to be $42 NZ for a Full Membership and $28 NZ for an Associate Membership.

We hope to publish full reports of all papers in a later issue.

MINUTES OF THE INAUGURAL MEETING OF THE DIVING MEDICAL ADVISORY COMMITTEE (SPUMS NZ) HELD AT 7.30 pm, 11 DECEMBER 1984, AT 'OUTSPAN', BUSH ROAD, ALBANY

As a result of a recommendation of SPUMS (North Shore) Diving Medical Meeting at Ngunguru, 3rd and 4th November 1984, the following committee was formed, consisting of:

Peter Robinson	)	
Alan Adair	)	- Steering Committee
Allan Sutherland	)	
Mike Davis		- Christchurch Representative
Peter Chapman Smith	)	
David Clinton Baker	)	- Northern Representatives

AIMS

1. To Co-ordinate treatment of Diving Emergencies in New Zealand by Medical personnel and other interested groups.
2. To Inform and Unify the Medical Professions' approach to Diving Medical examinations in New Zealand.

PROPOSED ACTIONS

1. Immediate. With the permission of SPUMS Melbourne to redesign a poster flag in durable materials and circulate to Dive Shops, Clubs, Charter boats and other interested groups. On the poster:

   (a) Emergency Regional Contact phone numbers.

   (b) Emergency Treatments.

   (c) Diving Standards expected.

   This flag to be designed by Peter Robinson. Funding requested from the Water Safety Council by Alan Adair and permission to use idea requested from SPUMS (Melbourne) by Allan Sutherland.

2. A durable plastic coated reminder card for Family Doctors' rooms to assist with Diving Medicals.

   (a) History

   * Absolute contra-indications
   * Relative contra-indications
   (Peter Robinson to compile)
   Special attention given to Asthma with explanations of dangers of Airway Trapping in Free ascent and recent chest infections.

   (b) Investigations eg.

   * Mobile eardrums.
   * Chest X-ray on full expiration (1/2000).
   * Pulmonary Function Tests with Peak Flow the minimum investigation.
   * Cardiac Function with ECG. if over 40 Years.
   (To be compiled by Alan Adair)

   (c) Advice for Medicals or Emergencies is available through the Duty Naval Officer in the Auckland Area.

   (d) Emergency Treatment
   * on site
   * during transport to Recompression facility
   (To be prepared by Peter Robinson)

3. A Medical Advisory Panel to be available to adjudicate on difficult problems as to fitness to dive and Dive Course Education.

4. A List of Doctors interested in diving, to be compiled from:

   Certified Divers
   SPUMS Members
   Labour Department List Health Department Circular

5. Funding

   Enquiry - Water Safety Council (Alan Adair)
   Health Department (Peter Robinson)
   ACC (Peter Robinson)
   Ciba-Geigy (Allan Sutherland)

A further meeting to be arranged.

MINUTES OF THE BUSINESS MEETING OF THE NEW ZEALAND CHAPTER OF SPUMS

Held on Saturday 9 November 1985 at Lost Resort, Kaikoura Island, Great Barrier Island.

Present

Dr Allan Sutherland, in the Chair with the Organising Committee, Drs Peter Robinson, Warren Paykel and 41 other members.

Dr Sutherland reported on the formation of the NZ Chapter of SPUMS by the coalescing of the Australasian SPUMS Group and the Auckland Group of Diving Doctors, which had last met at Ngunguru, 3-4 November 1984. Following this Meeting a Steering Committee of Peter Robinson, Alan Adair, Allan Sutherland, Mike Davis and Peter Chapman-Smith was formed for the purposes of co-ordinating and informing the Medical Profession and the Public about the Diving Accidents and Diving Medicine in New Zealand.

Dr Tony Slark proposed and Dr Peter Chapman-Smith seconded the following motion, "That the Steering Committee be congratulated for its efforts on behalf of New Zealand Diving Medical Practitioners and its work in forming a New Zealand Chapter of SPUMS be endorsed. The Steering Committee is asked to oversee the election of officers, for the New Zealand Chapter, and to continue arrangements for its First Annual General Meeting." This remit was passed unanimously. It was agreed to advertise in the next SPUMS Journal for nominations for the positions of Chairman and Secretary for the NZ Chapter of SPUMS.

A second remit moved by M Fraundorfer and seconded by B Baber. Concern was expressed that the relatively large number of diving accidents reported in New Zealand and it was resolved to support the concept of a list of Medical Practitioners with a knowledge of Diving Medicine to be maintained by the Health Department, for the purposes of education and Sport Diving Medical examinations. This remit was passed 20 for, 11 against.

A third remit was moved by Peter Robinson, seconded by Peter Jansen, that the NZUA be asked to reconsider, in the interests of underwater diving safety, its plan to sink the Rainbow Warrior at a keel depth exceeding 70 feet. This remit was passed 20 to 9.

At the conclusion of the Meeting, John Knight was thanked for his valued contribution to the Conference. He was presented a wetsuit as a memento of his visit by Bruce Savage from CIBA-GEIGY who was also thanked for the generous financial support given to the Conference.

Dr Knight described this first Meeting of SPUMS (NZ) as, "a highly informative, successful Meeting at a lovely venue".

SPUMS ANNUAL SCIENTIFIC MEETING 1986

CALL FOR PAPERS

Closing date 28 February 1986.

Contact: Dr Chris Acott
President SPUMS
Rockhampton Base Hospital
ROCKHAMPTON QLD 4700

NOMINATIONS FOR THE COMMITTEE OF THE NEW ZEALAND CHAPTER OF SPUMS

Nominations are required for the positions of Chairman and Secretary.

Nominations must be in writing, bearing the signatures of the proposer, seconder and nominee. They should be sent by 31 March 1986 to

Dr Warren Paykel,
Acting Returning Officer,
New Zealand Chapter of SPUMS,
120 Vauxhall Road,
MILFORD, AUCKLAND 9

DEBUT OF A NEW JOURNAL

THE JOURNAL OF HYPERBARIC MEDICINE

Published by the Undersea Medicine Society

The rapidly emerging medical/scientific subspeciality, hyperbaric oxygen therapy, claims its own with the debut of the JOURNAL OF HYPERBARIC MEDICINE, scheduled for distribution in January, 1986. Formerly known as the HYPERBARIC OXYGEN REVIEW, the JOURNAL OF HYPERBARIC MEDICINE will feature original clinical articles, scientific communications, book reviews, meeting announcements, case histories, and relevant abstracts as well as review material.

Once used only to treat cases of decompression sickness, the administration of oxygen under conditions of pressure is an accepted treatment for a variety of clinical indications. Highly successful results are obtained in the treatment of soft tissue infection, osteoradionecrosis, carbon monoxide poisoning, gas embolism, gas gangrene, wound healing, compromised skin grafts or flaps, crush injury, cyanide poisoning, burn treatment and blood loss anaemia as well as a number of other clinical conditions.

Timely and requisite, the JOURNAL OF HYPERBARIC MEDICINE will enable medical practitioners, researchers, and other professionals in the field of hyperbaric medicine to keep abreast of current scientific research in this specific area and to review topics of interest.

Papers are being accepted for review and can be sent directly to the Managing Editor, Journal of Hyperbaric Medicine, Undersea Medical Society, 9650 Rockville Pike, Bethesda, Maryland 20814, USA.

Subscriptions are offered to members of the Undersea Medical Society as a benefit of their participation. As members, the choice of the JOURNAL OF HYPERBARIC MEDICINE or UNDERSEA BIOMEDICAL RESEARCH is offered. The other publication can be obtained for $25 per year. Non-members of the Society are invited to subscribe to either quarterly publication at the rate of $50 per year. All inquiries can be directed to the Undersea Medical Society, 9650 Rockville Pike, Bethesda, Maryland 20814, USA. Telephone contact - Leah Blackburn (031) 539 9226.

LETTERS TO THE EDITOR

15th November 1985

Dear Sir

As retiring President of your society I wish to convey my sincere thanks to the outgoing Executive Committee of the South Pacific Underwater Medicine Society. They made my years as President a both fulfilling and enjoyable period.

During the previous years they have worked tirelessly, often thanklessly, on the necessary tasks of ensuring the society's growth and well being. The society has been rewarded by these efforts and I am sure will move successfully into the nineties.

Yours sincerely
Christopher J Lourey.

15 November 1985.

Dear Sir

I would like to request of the SPUMS membership to consider assisting in the provision of surgical supplies to the Maldivian Hospitals, particularly that at Male.

Those members who attended the 1985 Scientific Meeting have appreciated the unique nature of the Maldivian sub-aquatic environment and the need of their Hospital services for equipment. In this regard, those of us who are fortunate enough to live in more affluent countries can assist them.

As the Maldives are being heavily promoted by the Tourist Industry as the "Ideal Diving Holiday" by assisting them you may be even helping yourself, should you need medical assistance when there!

I am not requesting monies, but resources such as sutures, instruments etc, that are not being used by you or the Hospital where you practice.

If you are able to assist, could you contact my office, 25 Hastings Road, Frankston VIC 3199, Phone: 03 783 8140.

Yours sincerely
Christopher J Lourey.

Rockhampton Base Hospital
ROCKHAMPTON QLD 4700

14 October 1985

Dear Sir

The question of Pregnancy and Scuba Diving is interesting. Not much work has been done on it. I would like to begin a survey on the effects on the foetus by scuba diving. If any person has scuba dived during a pregnancy and would be interested in participating in such a survey, could they please contact me.

All replies will be treated confidentially.

Dr Chris Acott
President
South Pacific Underwater Medicine Society

CONFERENCES

SPUMS ANNUAL GENERAL MEETING 1986

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

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

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

Travel arrangements are in the hands of Allways Travel of 168 High Street, Ashburton, Victoria 3147 (telephone (03) 25 8818), who will be mailing a brochure giving further details to all members in the near future.

We have received the following from Dr Chris Lourey, Past President of SPUMS, for publication.

NINTH INTERNATIONAL SYMPOSIUM

ON UNDERWATER AND HYPERBARIC PHYSIOLOGY 16-20 SEPTEMBER 1986, KOBE, JAPAN

Secretariat and Meeting Management
Undersea Medical Society Inc
9650 Rockville Pike
Bethesda, Maryland, 20814, USA
Telephone: 301-530-9225.

4 November 1985

Dear Chris

As you are aware, we are holding the 9th Symposium on Underwater and Hyperbaric Physiology in Kobe, Japan, on 16-20 September 1986.

Our program will contain both Diving Physiology and Medicine and Hyperbaric Oxygen Physiology and Medicine themes. It will be of interest to diving and clinical hyperbaric medicine physicians and basic scientists.

I would like to encourage the members of SPUMS to attend this meeting and submit papers for presentation. Dr Carl Edmonds is a member of the 9th Symposium board, and can be addressed directly for further information.

I look forward to meeting with my many colleagues from Australia in 1986.

Sincerely yours
Alfred A Bove, MD PhD

SPUMS NOTICES

OBJECTS OF THE SOCIETY

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

MEMBERSHIP OF SPUMS

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

The subscription for Full Members is $30.00 and for Associate Members is $20.00.

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

Anyone interested in joining SPUMS should write to:

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

CONSTITUTIONAL AMENDMENT

No objections have been received by the Secretary of SPUMS to the proposal that the outgoing president (Past President) be a member of the Executive Committee in the future. This was proposed on page 3 of the SPUMS Journal, April to June 1985, Vol 15, No 2.

In view of the lack of objections this constitutional amendment is deemed to have been successful in a ballot of the members of SPUMS and will be incorporated in the constitution.

ELECTION OF COMMITTEE MEMBERS

On the morning of 2 December 1985, the 115 votes received by the Secretary were collated and counted. Six were informal. The result of the formal votes was:

Knight	87
McCartney	55
Millar	59
Sutherland	63
Williamson	63

I declare that Drs John Knight, Allan Sutherland and John Williamson elected as Committee Members of SPUMS for 1985-6.

David Davies
Secretary, SPUMS

INSTRUCTIONS TO AUTHORS

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

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

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

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

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

REPRINTING OF ARTICLES

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

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

PROJECT STICKYBEAK

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

Dr D Walker
PO Box 120
Narrabeen NSW 2101

SELECTED ABSTRACTS FROM THE UNDERSEA MEDICAL SOCIETY MEETING 1985

DECOMPRESSION SICKNESS

Air Decompression Schedule Safety From Statistical Models

PK Weathersby, SS Survanshi, LD Homer, JR Hays, BL Hart, ET Flynn and ME Bradley

Hyperbaric Medicine Programme Center, Naval Medical Research Institute, Naval Medical Command National Capital Region, Bethesda, Maryland 20814-5055

All currently used decompression schedules were prepared using deterministic models that predict decompression sickness (DCS) is either certain to occur or certain not to occur. Real data, on the other hand, demonstrate that not every diver will respond in the same way to a given schedule. One means to bridge that gap is the use of statistical models that predict the probability of DCS for a given dive. The models can then be compared (fitted) to actual data by maximum likelihood estimation. Several simple and essentially empirical models of decompression risk were constructed. These contain two to five adjustable parameters, including treatments of gas uptake and elimination and proportionality constants to calculate a "dose" of DCS risk. They were fitted to data from several thousand American, British and Canadian experimental dives. The dives ranged from < 1 min at 600 fsw to 6 hours at 140 fsw. The models achieved a reasonable degree of predictive ability regarding these documented dives, both within each reported study and for the combined set of all dives. A surprisingly large number of dives could be described well by two parameters, including a tissue time constant of about 350 min. When these models were then used to examine the present USN Standard Air Table, great differences in estimated risk were seen. They ranged from less than a 1 per cent chance of DCS in short dives to over a 30 per cent chance in long and moderately deep dives.

DCS Risk And No-Stop Air Diving

RD Vann

FG Hall Laboratory and Anaesthesia Department, Duke Medical Center, Durham, NC 27710

The results of 2,020 air and N_2-0_2 no-stop dives (158 DCS cases) were found in the literature. An empirical decompression "dose" and a DCS risk were calculated for each dive with Hempleman's "root-t" rule (Spencer, J App *Physiol* 40(2): 229, 1976) and a dose-response curve. The best agreement between predicted and observed DCS risk was determined by the maximum likelihood method (Weathersby et al, J App *Physiol* 57(3): 815, 1984).

DCS risks were estimated for USN no-stop dive limits and for Huggins' shorter limits. For any depth (see Table), DCS risk decreased slowly as bottom time was reduced. For a 1 per cent risk, bottom times were about half Huggins' limits. The appropriate question is not "What are the safe no-stop limits?" but "What DCS risk is acceptable?" A small DCS incidence appears unavoidable. For example, in 4 years of Navy diving (22 DCS cases in 242,778 no-stop dives), 17 DCS cases occurred well within the USN limits. An organization such as the Divers Alert Network can play an important role in handling these unexpected events.

	Navy		Huggins	
Depth	Time	Risk	Time	Risk
35'	310	11.9%	165	4.0%
40	200	8.8	135	4.4
50	100	5.6	75	3.4
60	60	4.3	50	3.1
70	50	5.3	40	3.5
80	40	5.7	30	3.4
90	30	5.1	25	3.7
100	25	5.3	20	3.6
110	20	5.0	15	3.0
120	15	4.1	10	1.9
130	10	2.6	5	0.7
140	10	3.4		
150	5	1.2		
160	5	1.5		
170	5	1.9		
180	5	2.3	-	
190	5	2.8	-	-

Prediction Of DCS Incidence From No-Stop Decompression Air Dives.

CE Lehner, M Palta, GG Adler, EN Lightfoot and EH Lanphier

Department of Preventative Medicine and Chemical Engineering, and The Biotron, University of Wisconsin, Madison, Wisconsin 53706

Suitability of a decompression schedule depends on the incidence of decompression sickness (DCS) associated with its use, but a satisfactory method for predicting DCS incidence from practical numbers of test dives has not been available. Exposure of sheep and pygmy goats to compressed air for 1/4, 4 and 24 hours with no-stop profiles to surface followed by "ascent" to 570 torr (ca 8000 ft) provoked DCS. These DCS responses formed the basis for predicting surface and altitude DCS incidence in animals. Data reported by Behnke and by Van der Aue were used to predict human DCS incidence at surface after compressed-air exposures lasting from 5 min to saturation. Regression of the logistic transform of DCS occurrence with log pressure and log duration, solved by maximum likelihood, generated DCS prediction functions for both animals and humans. Animal and human 1 per cent and 4 per cent DCS isopleths of surface dives closely match the no-stop decompression limits of the US and Royal Navy air tables. The similarity of these predictions to accepted tables supports the method and the agreement between human and animal predictions indicates that sheep and pygmy goats offer appropriate animal models of human DCS.

Air Tables Revisited: Development of a Decompression Computer Algorithm

ED Thaimann.

Navy Experimental Diving Unit, Panama City, FL 32407

In 1984 835 man-dives were done to test a real time computer algorithm for computing air and nitrogen-oxygen decompression profiles. Dives were wet with divers working (VO2: 1.4 lb/min) for half the bottom time and resting during decompression. Water temperature (55°-65°F) was set to thoroughly chill divers who wore full wet suits. Divers had a minimum of 36 hours off between dives. Open circuit SCUBA was used for air breathing, a MK-15 closed circuit UBA for breathing 0.7 ATA constant PO_2 in N_2. A total of 81 man dives were done breathing the MK-15 throughout, 95 were done breathing air at depth and the MK-15 during decompression. Of the 659 schedules done breathing only air, 474 were single dives and 185 were repetitive dives. No decompression sickness (DCS) resulted from any of the 107 no-decompression (No-D) single air dives for the following depth (FSW)/time (min) combinations (60/66; 100/30; 120/ 24; 150/15; 190/10). A total of 153 No-D repetitive dives were done at 80, 100, 120 and 150 FSW with 60 to 95 min surface intervals. Results indicate that doubling of No-D times on some repetitive dives, and thereby elimination of up to 35 min of decompression, is possible compared to current US Navy Standard Air procedures. Air decompression dives done over the 50-190 FSW range showed that tripling a total decompression time for long, shallow dives (eg. 60/180; 80/120) and near doubling for medium deep dives (eg. 150/40; 190/30) is necessary for safe decompression. Some air schedules could not be safely dove even when total decompression time was more than tripled (eg. 150/60; 190/40). Doing repetitive 100/60 and 150/40 air decompression dives (60 min surface intervals) showed that DCS-free dives could not be obtained even when decompression time is doubled. When the MK-15 was breathed during decompression stops from air dives, DCS-free dives were obtained with total decompression times close to those found in the current US Navy Standard Air Tables.

Dysbaric Gas Bubble Disease In Dogs. III. A Study Of Hawaiian Diving Practices

Edward L Beckman, Akinori Morita, Birch A Porter and Thomas D Kunkle

University of Hawaii Hyperbaric Treatment Center, 42 Ahui Street, Honolulu, Hawaii 96813

In the years since the introduction of scuba, Hawaii's diving fishermen have empirically developed diving practices remarkably different from those promulgated by the US Navy. A typical daily dive series begins with one or more deep "crushing" dives, followed by several "working" dives, and finishes with one or two "decompressing" dives to a depth of 60 fsw or less. Although the fishermen end the day with many hours of "omitted" decompression, the observed incidence of decompression sickness (DCS) is around 0.3 per cent, much less than that resulting from use of the US Navy Standard Air Decompression Tables. In Paper II in this series it was argued that the success of the Hawaiian diving practices (HDP) is due in part to the protection against bubble formation afforded by the initial crushing dives. Further consideration has led us to believe that the final decompressing dives aid the procedure by effecting the rapid dissolution of any bubble resulting from the working dives. The efficacy of the three-part HDP should, then, depend on completing the full series of crushing, working, and decompressing dives in the proper sequence. In order to test this hypothesis and to investigate further the efficacy of the HDP in preventing DCS, experiments were done with subjects from our dog colony. The dogs were first subjected to the entire three-part series, and their response determined by clinical observation and ultrasonic doppler monitoring. The animals were subsequently exposed to modified dive series in which the crushing or decompressing dives were omitted or in which the sequence of dives was reversed. Comparison of these results with the control outcomes has established the importance of the dive sequencing and the role of the crushing and decompressing dives.

Tiny Bubble Helium Decompression Tables

DC Hoffman and DE Yount

Department of Physics and Astronomy and Department of Physiology, University of Hawaii, Honolulu, Hawaii 96822

In the past, decompression tables for humans have been based upon unsupported assumptions because the underlying processes by which dissolved gas is liberated from blood and tissue were poorly understood. Some of those assumptions are now known to be wrong, and the recent formulation of a detailed mathematical model describing bubble nucleation has made it possible to calculate diving tables from established physical principles. To evaluate this approach, a comprehensive set of air diving tables was developed and compared with those of the US and British Navies. Conventional decompressions, altitude bends, no-stop thresholds, and saturation dives were all successfully described by one setting of four global nucleation parameters, which replaced the US Navy's matrices of M-values. The latest application of the nucleation model extends these tables to include simple helium dives. Comparing the total decompression times required for various bottom times in conventional air and helium tables shows great irregularity, not only from one set to another, but even within sets produced by the same authors. In contrast, this new approach is remarkably self-consistent, permitting accurate interpolation and extrapolation, and it has a wide range of applicability, extending from no-decompression to saturation dives.

Spinal Cord Bends, Scuba Diving And Basic Issues

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Brian Hill's expression, "relevant tissue," has gained special meaning in air-decompression studies in sheep and pygmy goats. The type of exposure greatly influences the incidence of specific types of decompression sickness (DCS) when the decompression is not greatly beyond safe limits. The most urgent implication of this finding concerns the risk of spinal cord DCS in short, relatively deep dives likely to be common with compressed air scuba. The risk to scuba divers is confirmed by the current proportion of "cord bends" among DCS incidents. The cord itself appears to become the dominant (most relevant) tissue under these circumstances. Our findings indicate that other tissues become relevant in other dive profiles. For example, "the chokes" is associated with extraordinary numbers of venous gas bubbles and is rare except following long exposure to compressed air or when shorter exposures involve unusual pressure. The relevant tissues in chokes appear to saturate slowly with nitrogen under ordinary conditions and must have an unusual capacity for that gas. Adipose tissue meets these qualifications. Other relevant tissues can probably be characterized for limb bends (with or without increased intramedullary bone pressure) and dysbaric osteonecrosis. Such analysis should lead to increased understanding of the mechanisms of DCS, better methods of evaluating risks, and improved decompression tables. The significance of gas-elimination studies must depend upon the type of exposure and symptomatology at issue as well as upon the site of measurement.

Treatment Of Severe CNS Decompression Sickness By Deep Excursion From Shallow Saturation

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A 33 year old white female experienced scuba diver presented to the HTC 42 hours after making three uneventful dives. Her decompression sickness had an abrupt onset approximately one-half hour after surfacing, and while still on Maui she initially underwent monoplace treatments three times to 60 feet as emergency treatment of unconsciousness and quadriplegia. This treatment was helpful but not totally adequate and when she arrived at HTC she was conscious but still had almost total lack of nervous function below TIO - both sensory and motor. She also had vestibular, cerebellar and auditory symptoms. Our treatments - to 280 feet - were beneficial but not curative and this led us to attempt a much more intensive/innovative regimen, ie. saturation at 50 feet with deep excursions using air to 210 feet twice a day. In this manner we could utilise our existing equipment, which was not configured for saturation diving. Our results after eight days in the chamber were essentially a complete cure.

Treatment Of DCS In A Monoplace System

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Seventy-four patients, 6 females, 68 males, were received with a diagnosis of decompression illness from 1971 to 1 January 1985 at the Naval Regional Medical Center, Long Beach, California, and Memorial Medical Center, Long Beach, California. The patients arose from diving utilizing open circuit air breathing equipment. Maximum depth of dive 250 feet of sea water (FSW) while minimum depth was 20 FSW. Six patients had improvement during transport to treatment facility. Ten patients had deterioration of symptoms during transport. Three patients were found to be suffering from Munchausen's Syndrome, one patient had a herniated disc and one patient had bilateral perforated tympanic membranes. Twenty-eight patients had DCS I (pain only) - 25 (89 per cent) were asymptomatic with a single treatment of HBO 3 ATA 30 minutes and 2.5 ATA for one hour. Three were asymptomatic with extended treatments. Thirty patients with DCS II (neurological environment) were treated at 3 ATA 30 minutes and 2.5 ATA 60 minutes for the first treatment, then 2.5 ATA 90 minutes Q8H x 24H, then 2 ATA 90 minutes b.i.d. until neurologically stable. Twenty-seven patients were asymptomatic following treatment. One patient's symptoms (paraesthesias) resolved six weeks after cessation of treatment, while two patients had residual. Eleven patients with DCS II received Navy Tables 4, 5A, 6 or 6A with significant residual, five were asymptomatic after extending the tables in the monoplace chamber, while five were improved symptomatically and one had no response.

Review And Analysis Of Dan Accident Cases 1981-84

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The Divers Alert Network (DAN) provides access to the nation's hyperbaric centres through a single 24 hour phone number, (919) 684-8111. DAN provides medical consultation and treatment assistance and has collected information from diving accidents since 1981, some of which is presented in the following table. Diagnosis, delay to treatment, treat effectiveness, symptoms and dive related factors are presented as well as discussion of the problems in compiling dive accident information. As reporting and follow-up become more consistent, these statistics can be expected to improve in accuracy.

	1981-82	1983	1984
Total number of calls	757	1600	2000
Emergency calls	369	414	290
Case reports collected	117	117	196
DCS type I	20	19	32
DCS type II	70	50	57
AGE	39	19	16
AGE and/or DCS	8	5	2
AGE with Pul. Barotrauma	-	4	4
Pul. Barotrauma, no AGE	-	17	16
ENT Barotrauma	-	15	18
DCS symptoms (untreated)	-	19	22
AGE symptoms (untreated)	-	7	10

<u>TREATMENT OUTCOME</u>

Complete relief	-	(40)57%	(42)42%
Residual symptoms	-	(20)28%	(35)34%
Fatalities	-	(10)14%	(6) 6%

The Role Of Field-Administered Oxygen In Dive Accident Management

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Diving medicine and diving instruction authorities agree that administration of 100 per cent oxygen is the primary first aid measure for diving emergencies (decompression sickness or arterial gas embolism). The oxygen services to stabilize the victim while reducing the partial pressure of the offending nitrogen. The diving community has established a standard of care that dictates field delivery of 100 per cent oxygen to diving accident victims pending recompression therapy with hyperbaric oxygen. On-site oxygen is no longer an option for diving instructors, charter boats, or resorts. The Divers Alert Network has worked with a major oxygen equipment manufacturer to develop an oxygen demand delivery system at reasonable cost for lay delivery to diving victims with the F_1O_2 approaching 1.00. Oxygen in this concentration establishes an optimal surface delivered diffusion gradient. A model oxygen therapy training program which exceeds emergency medical technician standards has also been developed by the Divers Alert Network and distributed at no cost to all United States diving education agencies and the British Sub-Aqua Club. The potential benefit of field-administered, high concentration oxygen during a golden period of treatment time that can never be recaptured far outweighs the perceived liability of the local diving instructor, dive boat captain, or resort operator.

MULTI-LEVEL TABLES

Survey Of Multi-Level Diving Techniques Used By Sport Divers

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Multi-Level Diving (MLD) Techniques have become prevalent in the Sport Diving Community due to their ability to extend "No-Decompression" dive time past the US Navy No-Decompression Limits. There have been very few studies and reports on MLD. The various techniques have been developed by sport divers and passed on by word of mouth and in a few publications. This survey attempts to determine the various MLD techniques used by sport divers and their experiences with these techniques. The questionnaire made available to sport divers through various diving publications, is used to determine the MLD technique performed by the diver, where it was learned, frequently performed profiles, and any problems encountered using the technique. Initial returns of the questionnaire (26 as of 14 January 1985) show five different MLD techniques and at least three cases of decompression sickness resulting from MLD. Further analysis will compare the MLD profiles obtained in the survey to various decompression models to determine their "safety" levels.

Doppler Evaluation Of Multi-Level Dive Profiles

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Twelve sport divers were exposed, in a hyperbaric chamber, to nine Multi-Level No-Decompression dives and one Decompression dive profile computed with an algorithm to be used in a diver carried Decompression Computer. To evaluate the safety of these dives the subjects were monitored for venous gas emboli (VGE) formation using a doppler ultrasonic bubble detector and for symptoms of decompression sickness (DS) following the dives. Results show no symptoms of DS in any of the 119 person dives and one case of Grade I VGE following the decompression dive. More studies are encouraged to further explore the limits and possibilities of Multi-Level Diving.

DIVE SEQUELAE

Neuropsychology As A Diagnostic Tool In Diving

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The value of a simple neuropsychological test battery in identifying subtle residual symptoms of decompression sickness is presented. A US Navy diver completed a cold, experimental 80 FSW dive for 50 minutes. Ninety minutes after surfacing the diver experienced rapid onset of severe DCS symptoms which led to collapse. He was immediately recompressed and treated on a modified USN. Treatment Table. Five days later the diver reported fatigue and memory lapses. Neurological examination revealed only minimally slow tracking and alternating movements, whereas neuropsychological testing documented depressed Word Fluency and Trail Making performance. The diver was retreated on a USN Treatment Table 6 (TT-6). Upon surfacing his performance on the neuropsychological tests was normal and remained so 11 months later. Another diver completed a cold, experimental dive to 120 FSW for 80 minutes. Upon surfacing he was tired but reported no other problems. Two days later the diver reported memory lapses and an inability to concentrate. Neurological examination showed decreased pin prick around the right eye and in the right T 9-11. Mental function was poorer than previously documented pre-dive levels on Trail Making, SDMT and Wechsler Memory Scale. The diver was treated on a TT-6. Upon surfacing, neurological examination showed complete resolution of sensory symptoms. Four days following treatment the diver reported poor concentration and muddled thinking. While neurological exam showed slow alternating movements and heel to toe gait, neuropsychological testing revealed severely depressed intellectual functioning. The diver was re-treated on TT-6. Follow up neuropsychological testing revealed normal mental functioning restored. Several neuropsychological tests proven useful in identifying subtle DCS symptoms are described.

After-Effects Of Heliox Dives To 350 MSW

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In two trial dives, six divers were compressed to 350 MSW on heliox (N=12)(1). Five of these divers and four new divers performed an open-sea dive to 300 MSW three months after their trial dive. Neuropsychological examinations were performed before, one week and one year after their latest deep dive. After both trial dives no divers reported specific or general post-dive problems. However, reduced motor tempo, autonomic reactivity, and strength were found for the majority of divers. When examined after the open sea dive, marked changes were found. In addition to tremor increase, reduction in hand grip strength, motor tempo, and memory performance, seven divers reported subjective symptoms such as memory problems, dizziness, short temperedness, headaches and nausea.

One year later, the divers had had 69.6 days in saturation at an average depth of 97.5 MSW since the first post-dive examination. Six divers had performed dives between 170 and 210 MSW. Seven divers reported still having some subjective problems. These were mainly short temperedness and memory problems. However, these symptoms were reported from five of the divers who had performed dives in the 170-210 MSW range since last examination. The same tendency was found in the neuropsychological tests: whilst the divers who performed relatively shallow dives since last examination (70-150 MSW) had returned to pre trial dive levels, some increased tremor and reduced hand grip strength were found among the divers who had dived to 170-210 MSW.

Conclusion

There were subjective symptoms and signs of CNS after-effects when diving to 350 MSW. Whilst a normalization in neuropsychological functions and symptoms was recorded after subsequent shallow diving (<150 MSW) after the deep dive, repeated dives deeper than 170 MSW led to a delay in recovery, and in some cases (the 300 MSW dive) a worsening in symptomatology.

Reference

Vaernes RJ, Tonjum S, Lindrup AG, Myrseth E. Central nervous system reactions during two heliox dives to 36 ATA. *UBR.* 1984; 11 (Suppl): 39.

HYPERBARIC OXYGEN

Hyperbaric Facilities For HBO Therapy: Design Considerations And Their Impact

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In recent years there has been a rapid increase in the clinical use of hyperbaric oxygen therapy as its benefits have become more clearly defined and documented. The general acceptance of HBO as a treatment modality has resulted in many new hyperbaric installations and an ever increasing number of serious enquiries for new acquisitions. Over the years, hyperbaric systems have evolved from simple support apparatus for the working diver to a wide range of special purpose systems to suit a variety of operational and clinical roles. Concurrently, the many regulatory and standards agencies have developed codes of practice for the design, manufacture and operation of such apparatus within their respective areas of interest. The result is a plethora of often conflicting regulations and what may appear to be a confusing array of hardware available at a broad range of costs. This paper outlines the applicable standards for the construction of hyperbaric systems, their performance requirements for changing roles, the functions of the necessary subsystems, desirable features, and the attendant cost impact of making arbitrary decisions related to specifications and the assumed role of the proposed hyperbaric centre. It is essential for the physician or administrator, who is seeking a new or modernized clinical facility, to understand these relationships so that informed and cost effective decisions can be made.

Acquisition Of A Hyperbaric System

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Acquisition of hyperbaric systems by hospitals and private concerns has no uniform guidelines to assist with the procurement process. This paper attempts to guide the prospective buyer(s) by identifying the required steps to obtain certification for use and outlines the necessary critical information needed to document a hyperbaric system. Discussed are the benefits to be gained and pitfalls that can be avoided by documenting system information. Specific information requirements are then outlined to enable the user to select the type and level of information that best fits his specific needs. Example forms are presented which may be used by the user to develop his own documentation system.

This paper, emphasizes the fact that much of the “acquisition” documentation is equally valuable to the user in achieving a safe, efficient, operational and well maintained system long after is has been delivered.

Consideration Of Equipment Used For Patient Care In A Multiplace Hyperbaric Chamber

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Safety guide lines are published by the American Society of Mechanical Engineers, National Fire Protection Association, JCAH and various safe practice government publications. These published guidelines are very vague and not directed toward the different manufactured pieces of equipment including ventilators, infusion pumps, transcutaneous monitors, Swan-Ganz catheters and cardiac output monitors, physiologic monitoring systems and defibrillators. Very few pieces of equipment can be utilized within the pressure environment without close review of their electrical or pneumatic drawings, design function and operational manuals.

The authors have found that most equipment must undergo minor modifications to conform to published guide lines. New standard operational procedures must be generated to compensate for these modifications.

Problems will be identified and solution given for some of the above listed equipment.

The Spectrum Of Monitoring In The Multiplace Hyperbaric Chamber

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Monitoring of the hyperbaric chamber environment; selection and monitoring of personnel, and patients is presented to show the experience at MIEMSS, a busy clinical hyperbaric multiplace unit. Beyond traditional diving medicine technology, comparatively little is established regarding the physiologic changes or the equipment required to monitor critically ill patients in the chamber. Insufficient monitoring should not preclude diving even the most critically ill patients who would clearly benefit from HBO. On the other hand, each parameter monitored introduces a new technologic challenge for the hyperbaric staff, new equipment or modification of existing equipment, with associated potential new risks to safety. Modifications at MIEMMS to monitor cardiovascular function: arterial pressure, Swan-Ganz catheters, pacemakers; respiratory function: ventilators, blood gases, transcutaneous oxygen, x-rays; ultrafiltration: CNS function and psychometric testing, are described. Such modifications require ongoing scrutiny to evaluate reliability of measurements, endurance and safety of equipment in an alien environment. We are embarking on an exciting biomedical engineering frontier where much remains to be done to provide an optimally safe and efficacious therapeutic environment for those who would benefit from HBO.

Treatment Of Severe Head Injury With Hyperbaric Oxygen (HBO)

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The Division of Neurosurgery at HCMC has a randomized prospective clinical trial in progress to evaluate HBO for the treatment of severe head injury. Patients with head trauma who are unable to obey commands or pronounce recognizable words are potential candidates for the study. If a consent is obtained, the patient is randomized into an HBO treatment or control group. All patients receive intensive neurosurgery care, the only variable being HBO which is administered to the treatment group. Parameters monitored during the hospital and post-hospital course to assess the efficacy of HBO are: intracranial pressure; neurological exams; CT scans of the brain; multi-modal evoked responses; neuropsychological tests; and neurological follow-up evaluations. The first 30 patients admitted into the study have been analysed in terms of survival. The mortality rate of those patients with Glasgow Coma Scores (GCS) of 7-9 show no significant difference between the two groups.

Virtually all these patients survive with or without HBO. The patients with GCS of 3 had a 100 per cent mortality rate. Our past experience reveals a 90 to 95 per cent mortality rate in this group, so it is doubtful that any treatment will be effective. Analysis of the small number of patients with GCS of 4-6 suggest an increased survival among the HBO-treated group which has a P value=100. Based on these results and our past clinical experience, we would anticipate an effective treatment to impact the survival of this group of patients. Obviously, the numbers are small and the results very preliminary, but we are encouraged by our initial experience, and hope to demonstrate that the treatment of severely brain-injured patients with HBO will result in decreased mortality rates and ultimately enhance the long-term functional recovery of the survivors. A carefully completed clinical trial will demonstrate whether or not the treatment should be pursued.

Experience With Hyperbaric Therapy In An Acute Head Rehabilitation Centre

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Over the past year, University Heights Hospital has established an acute head rehabilitation centre for those patients suffering from acute head trauma who after immediate medical and/or surgical care have reached a point in their convalescence where they are no longer candidates for continued acute care but they are still in a semi-comatose or comatose state. Utilizing hyperbaric therapy oxygen along with intensive neuropsychological cognitive intervention and physical therapy, a study has been done to objectively measure the improvement possible with this regime. It is our conclusion that this type of program has shown statistically significant findings that this type of patient can be more rapidly rehabilitated and reach a higher functional level than those who are allowed to be sent home or to less aggressive hospitalization. It is felt that that a combination of intense nursing care associated with early cognitive strategies and hyperbaric oxygenation to viable but non functional cerebral tissue is the most productive step in returning these individuals to a point where more advanced rehabilitation efforts can take place.

Pneumatosis Cystoides Intestinalis: An Absolute Indication For HBO?

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Pneumatosis cystoides intestinalis is a benign, relatively rare condition affecting the large and small intestine and characterized pathologically by multiple gas-filled cysts in the subserosal or submucosal tissue. In most instances, it is an unexpected finding on plain abdominal film, during a sigmoidoscopy, or a barium study. Its appearance is occasionally associated with other diseases of the gastrointestinal tract. The exact cause of the gas-filled cysts remains unknown, although there are several theories. Analysis of the gas in the intestinal cysts neither supports any specific theory of cyst formation nor suggests its source. We report a 64-year-old female, suffering for more than one year from frequent rectal bleeding and diarrhoea. Sigmoidoscopy could not be performed because of numerous submucosal gas cysts almost totally obstructing the bowel lumen. The abdominal x-ray examination demonstrated these cysts throughout the whole left colon. We performed a series of ten hyperbaric treatments, BID, at 2.8 ATA, for 90 minutes each. After 5 days of HBO, a colo-sigmoidoscopy could be performed without any problems and showed only some plain residues of the former cysts, polypi or a malignant tumour could be excluded. We discuss the pneumatosis cystoides intestinalis as an absolute indication for HBO in order to enable a causal diagnosis, to exclude neoplasm and possibly to avoid extensive operations like hemicolectomy.

The Hemofiltration Device In The Hyperbaric Chamber

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The hemofilter is a relatively new device to appear in the armamentarium for the care of critically ill patients. Its main application is in the management of volume overload in patients with acute renal failure requiring relatively large volumes of fluid for total parenteral nutrition (TPN), inotropic or other vasoactive support and administration of parenteral antibiotics. It allows administration of these large transport volumes while removing the excess fluid as an ultrafiltrate of plasma. The device is relatively simple with an arterial access feeding into a parallel microtublar filter chamber continuous with a venous return. The ultrafilter chamber has an exhaust port which drains by gravity to an ordinary urometer bag. Theoretically, there should be no difficulty in taking the device into the hyperbaric chamber since it is, when properly assembled, a fluid filled system. At MIEMSS, a 35 year old diabetic patient suffered necrotizing fasciitis of his right leg arising from a foot lesion. His toxic state imposed an overwhelming load on his baseline diabetic nephropathy and he went into complete acute renal failure. To manage his fluid problems, hemofiltration was instituted as was HBO as an adjunct for his necrotizing fasciitis. The device was dived five times without apparent adverse effects to either the patient or the device. The effluent ultrafiltrate volume increased by approximately 20 per cent on each dive. The probable mechanism of this change is the increased cardiac output associated with the period of HBO.

GENERAL INTEREST

Negative Pressures

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Everyday experience reminds us that liquids are capable of sustaining modest tensions. The drinking straw is a familiar example. Ordinary suction pumps are able to lift water up to 10 metres, and even a large-diameter garden hose can siphon gasoline over obstacles several metres high. The useful conversion, 10 msw:1 atm, suggests that tensions in tall trees must be on the order or 10 atm or larger. In this paper we review more than a dozen methods that have been used to subject biological tissues to negative pressures or tensions and compare the limiting values that have been achieved with each. Many of these methods, such as gas super-saturation, acoustic radiation, hydrostatic and hydrodynamic pressure excursions, and the rubbing of solid surfaces are directly relevant to Man and especially to diving physiology.

Respiratory Function In The Upright Working Diver At 6.8 ATA (190 FSW)

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An earlier study from this laboratory investigated the effects of static lung loads (SLL; +20 to -20 cm H_2O) on respiration in immersed exercising subjects in the prone position at pressures up to 6.8 ATA (190 FSW). Because the upright position imposes different hydrostatic pressure profiles on the chest, the present study was performed. Dyspnoea was an infrequent occurrence in the upright posture during exercise up to 175 w. In 270 man-dives in 7 subjects only 12 dives (4.4 per cent) generated dyspnoea of mild to moderate intensity scores. In contrast, 22.9 per cent of the dives in the prone position caused dyspnoea which was generally more severe. In both studies, dyspnoea was more prevalent with negative SLLs. The occurrence of dyspnoea did not correlate with changes in end-tidal CO_2 pressure. There were no significant changes induced by SLL or posture in CO_2 elimination, O_2 uptake, ventilatory volume, heart rate or end-tidal CO_2 pressure. A possible explanation for the reduced tendency for dyspnoea in the upright position may be that the extrathoracic airways are exposed to less external pressure than in the prone position. Positive static lung loads may prevent dyspnoea by such mechanisms as preclusion of inspiratory muscle fatigue, and, consequent to a larger expiratory reserve volume, reduction in dynamic airway closure during expiration. It is concluded that breathing gear for divers should provide a static lung load of approximately 0 to 10 cm H_2O relative to the pressure centroid of the chest regardless of the diver's orientation in the water. The diver should assume an upright posture when engaged in strenuous work under water.

Face Mask VS Mouthpiece Breathing - Respiratory Function At 6.8 ATA (190 FSW)

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The physiological effects of mouthpiece vs face mask breathing were compared in 4 subjects exposed to varying static lung loads (SLL; +10 to -20 cm H_2O) while immersed at 6.8 ATA chamber pressure (190 FSW) and exercising at work loads up to 175 watts. Breathing with a mouthpiece at 190 FSW resulted in substantial reductions (by 21 per cent) in ventilatory volume ($\dot{V}_E$). In some, but not all, subjects elevations in end-tidal carbon dioxide tension (P_{etCO_2}) were also observed. Reductions in $\dot{V}_E$ were the result of a lower breathing frequency while using a mouthpiece, whereas tidal volume was maintained. Oxygen consumption, carbon dioxide elimination, and, presumably, carbon dioxide production remained unchanged by mouthpiece or face mask breathing. Since carbon dioxide production and elimination were not affected by the use of a mouthpiece, yet $\dot{V}_E$ was substantially reduced, the absence of elevations in P_{etCO_2} in some subjects requires consideration. It is noteworthy that dyspnoea was most common while using the mouthpiece. Dyspnoea also occurred predominantly at negative static loads. These results are significant in that the occurrence of both hypercapnoea and dyspnoea threaten the safety of the diver. There is a possibility that hypercapnoea while breathing from a mouthpiece may be more severe than is indicated by the P_{etCO_2} data. The tendency for mouthpiece breathing to cause hypoventilation may possibly call for re-engineering of breathing gear to employ a full face mask design rather than a mouthpiece in certain applications.

Medical Disorders In Sport Diving: Public Health Aspects Of Diving Medicine

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Although sport diving has continued to grow as a recreational activity, the sport continues to have a problem with the general health of these divers. Because medical criteria for sport diving are less critical than professional standards, and because of the large population of sport divers, dissemination of information for diving medicine to the sport diving community is essential. We have participated in a nationally distributed sport diving communication to provide medical information to the diving public. Correspondence from 103 divers over 3 years included a broad variety of questions. The table below lists the topic areas and percentage incidence (rounded to the nearest whole number).

Topic area	%	Topic area	%
General medical	22	Contact lenses	5
Ear related	18	Marine toxicology	4
General surgical	17	Air consumption	4
Drugs and diving	8	Long-term effects	2
Women in diving	5	Hypothermia	1
Dizziness	5	Blast injury	1
Physician training	5	Carbon monoxide	1

The broad list of disorders requires the diving-trained physician to maintain a knowledge of diving physiology and medicine as well as general medicine and surgery. Unlike commercial and military diving, where divers are screened to exclude individuals with medical disorders, medical support for sport diving requires a broader application of general medical and surgical principles.

CAVE AND SINKHOLE DIVING IN SOUTH AUSTRALIA

Peter Horne

The Adelaide and Melbourne newspapers once again had a 'field day' in April 1984. Two scuba divers, one with considerable cave diving experience, had dived to a depth in excess of 60 metres in the world-famous Piccaninnie Ponds freshwater cave near Mount Gambler, and had failed to surface.

It seems that there are three particular types of headline-grabbing accident which elicit sometimes hysterical public reactions, falls from great heights (eg. buildings, skydiving, aircraft), shark attacks and entrapment in confined areas (specifically caves, especially those which are under water).

Such response is generally understandable, people can readily identify with the feelings of terror and hopelessness of the victims of such tragedies. However, it is all too easy to lose perspective of the situation as a whole. In the case of cave diving (at least in Australia), around ten thousand safe dives are undertaken each year by hundreds of qualified cave divers. As in the case with all other activities and hobbies of a "physical" nature, cave diving is a safe and enjoyable "sport" once the participants have gained the necessary knowledge and experience.

Since the mid 1960's, cave and sinkhole diving has grown into a relatively popular specialised form of recreational advanced diving. Probably over 90 per cent of all Australian cave diving takes place in the lower South East of South Australia, with the remainder being done by relatively small groups in the Nullarbor Plain, Tasmania and other isolated areas,

The countryside around Mount Gambier is dotted with literally hundreds of caves, several dozen of which are large open "sinkholes" which sometimes intersect the regional water-table. About 15 of these are voluminous waterfilled caverns which contain crystal-clear fresh water - a very rare sight indeed in South Australia! In fact, it is only this calm, clear water which initially attracts the attention of budding cave divers.

Swimming into a pitch-black, waterfilled passage in a cave is naturally very different to undertaking a run-of-the-mill ocean dive. Cave divers need to be fully conversant with the skills required to undertake safely, the related disciplines of deep diving, night diving, wreck diving, underwater orientation and even "dry" caving. Experience in silt-avoidance and line-handling techniques, and the ability to work safely through emergency situations (such as equipment failure) underwater, are also essential if the inherent hazards of cave diving are to be minimised.

In view of the very specialised nature of this activity, it is obvious that cave divers are very isolated from any form of surface assistance, relying totally on their individual training, experience and equipment to keep, or get, them out of trouble. Where you have people, however, you have the potential for "human error". Waterfilled caves, even more than their dry counterparts or the sea, are extremely unforgiving of those who err ... as 13 unfortunate divers have learnt in the caves of Mount Gambler to date. In every case, the victims of these tragedies made seemingly simple mistakes through error of judgement or inexperience and ignorance of the special hazards of cave diving, simple, that is, if those mistakes had been made in an open body of water, where the easiest solution would have been to merely inflate their buoyancy vests.

Nitrogen narcosis played a significant (if not the MAIN) role in 9 cases, where the divers at considerable depths either lost track of their airtimes or became entangled in their safety lines. Inflation of vests would merely have lifted them to the roof of the cave or worsened their entanglement, waterfilled passages have no air surface conveniently overhead. The other 4 divers drowned after entering low, shallow passages, accidentally stirring up the deep layers of fine silt which covers the floors of most caves. Without a guideline to lead the way back to the entrance, the victims had little hope of survival after all visibility disappeared in severe "silt-outs". (In one instance which resulted in a triple-fatality, a fourth diver stumbled across the entrance glow just as his air began to run out, a VERY close call.)

Over the last 12 years, cave diving in the Mt Gambier area has had a good safety record, with only a single accident (the double-fatality of 1984, see the previous issue of the SPUMS *J)* occurring since 1974. This is interesting when one considers that 7 scuba divers, 2 snorkellers and a hookah diver have perished in South Australians seas during the same period. The uncompromising, careful assessment and education of prospective cave divers by the Cave Divers Association of Australia Incorporated (CDAA), which was formed in 1973 after two major accidents involving 7 divers had occurred only months apart, has undoubtedly played the major role in saving cave divers' lives.

The means by which the CDAA assesses divers' abilities and the level of skill required to safely dive in various caves is known as the "Category System". All of the popularly-dived sinkholes and caves of the Mt Gambier area were categorised according to their known hazards and potential hazards, and tests were designed to cater for each of these three levels, beginning with the "safest", Category 1 standard.

Category 1 sinkholes are basically large, open waterfilled caverns with few overhangs and low silting potential. Divers need only to have mastered the skill of good buoyancy control (as well as general scuba competence, of course) to be able to enter the shallow regions of Category 1 holes. However, because relatively deep water can be found in several sinkholes, divers are required to have a good understanding of the various decompression tables and their inherent risks. More advanced cave diving requires different equipment and higher in-water skill including the safe handling of guidelines, and divers need to demonstrate the ability to handle diving emergencies. Prospective cave divers must have logged at least 20 dives during the past 12 months, including 5 to 18 metres and 2 night dives, before they can apply for CDAA testing to Category 1 standard.

After gaining 5 hours of Category 1 sinkhole experience, and after passing the requisite Category 2 test, divers can explore Category 2 sinkholes. These are similar to Category 1 features but in several instances, have long underwater passages or deep sections which require more detailed planning and expertise to enter safely. Divers are discouraged from undertaking excessively deep dives (those in excess of 36m) and deep-diving hazards are thoroughly discussed. The Category 2 qualification opens up the major popular sinkholes to recreational divers, including such places as Piccaninnie Ponds, Ten-Eighty and One Tree.

Category 3 caves require special training and assessment before cave divers can safely explore them. Although they are generally very picturesque near the surface, containing some of the clearest water in the South East, they may contain numerous hidden traps such as unstable rockpiles in confined areas and in particular, thick layers of silt which are VERY easily disturbed. The cave divers' guideline is often the only means of finding the way back to the surface in low or zero-visibility water, clear water made pitch black by the mere movement of a diver's body through the silt.

The CDAA's Category 3 test is thus the most difficult and detailed of them all. Only cave divers who have undertaken many sinkhole dives in fresh water and have practiced the various emergency drills (such as being able to recognise an underwater emergency in zero-visibility conditions and share air supplies without face-masks whilst following a guide-line by feel alone) can expect to have any chance of passing. Unlike most examinations, divers rarely attempt to cheat, as the tests are well-organised by a group of experienced examiners and, at any rate, candidates realise that the only people they are going to cheat are themselves, as it is THEIR lives at risk!

The CDAA has certified over 1,300 cave divers to date and has a membership of around 700 financial members at present. Overall safety in the activity of cave diving has been good as well, there have only been a couple of reported decompression sickness cases in the last decade (perhaps amazing when one considers the fact that most cave diving is undertaken in water depths in excess of 30 metres). Before cave diving in Australia was in any way regulated, 11 divers died in the space of 5 years, between 1969 and 1974. Today, despite a continuing increase in the number of sinkhole dives and the thousands of dives undertaken each year, serious incidents are few and far between. Modern cave and sinkhole diving is probably as safe as any specialised sporting activity.

Why DO people jump into deep, dark, waterfilled holes in the ground anyway, you may ask? Why do people enjoy the activities of skydiving, abseiling, or even normal sea-diving? It is, like these activities, a world all of its own. You have to give it a go to really understand why YOU enjoy it! It is truly a unique and often educational pastime.

For further information about the CDAA or about cave diving in general, please write to:

The Cave Divers Association of Australia (Inc.)
at either
PO Box 290
NORTH ADELAIDE SA 5006
or
GPO Box 2161T
MELBOURNE VIC 3001

DECOMPRESSION TABLES FOR SPORTS DIVERS

Wal Williams

In an effort to find a safer decompression table for sports divers, over the past two years the AUF has contacted authorities on underwater medicine throughout the world. Actually, this has confirmed what we already know, but it had to be done in case new tables were on the way somewhere - there is no “safe” table for sports divers. All tables should be used making allowances.

Neither is there much research being conducted anywhere on air tables; navies, universities and oil companies are pouring research money into saturation diving. Shallow water diving using compressed air is a very poor cousin.

However, the Royal Australian Navy is working on a project using air tables at the School of Underwater Medicine (SUM) at HMAS Penguin. This project is scheduled to proceed for the next five years. The AUF found that if we could gain the support of the Department of Defence and provide money to cover our share of the costs, the project could easily be extended to produce a set of tables specifically designed around the needs of the sports diver.

Accordingly, earlier this year, all instructor bodies and diving agencies (AUF, FAUI, PADI, NAUI, BS-AC, SDFA, PDAA, CDAA, etc.) were invited to attend a meeting at the School of Underwater Medicine to discuss the peculiarities of sports diving as compared with military diving. If you think there is not much difference, think again, it takes a minimum team of five to get one navy diver in the water the diver and his attendant, a standby diver and his attendant, plus the dive supervisor.

A meeting was held later in March this year between the AUF, Department of Defence (Navy), Department of Sport, Recreation and Tourism, and the Australian Sports Commission. The proposal was that the Department of Defence may be able to assist with the development of recreational diving tables, but that separate finance and the possible assistance of sports divers would be needed. It was agreed that the next step was for the AUF to approach the Minister for Defence and formally ask for the assistance of the Navy in the development of these tables. The project is expected to take five years, but first priority will be given to a better definition of ‘fudge factors’.

If we get the green light, it will be a unique opportunity to design the first set of safe diving tables for sports use. The School of Underwater Medicine has indicated that there may be a need for assistance to test the new tables after they are initially designed. What a great opportunity to get some diving in with the Royal Australian Navy - the queue starts behind me!

Just a final word of caution, my last five years in the Army was spent as a Project Officer, and I know the difficulties of getting any defence project through the various committees, advisory panels, consultative groups, etc., even before the project gets funding. Even if approved and running, a project can still be stopped through lack of funds. So, “five years” should be taken as a conservative estimate - it could be eight years.

More on the project as it proceeds. Estimated cost is $200,000.

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ALTERNOBARIC PALSY OF THE FACIAL NERVE

MV Khan and KM Jameel

Abstract

A case of transient peripheral right sided facial palsy in a diver after a no-decompression stop dive is reported. Ischaemic neuropraxia resulting from the compression of the vasa nervorum of the facial nerve, due to over pressure in the middle ear where it is dehiscent, may be the cause of facial palsy.

In his book “Methods in Madness,” the author colourfully describes the way investigators are busy minting new terminologies to fit their scientific discoveries. In 1965 Lundgren, seeming to fulfil this pattern coined the term “alternobaric vertigo” when he de-

TABLE I

DIVING-RELATED ALTERNOBARIC FACIAL PALSY LITERATURE

Authors	**Diver**	**Pressure**	**Depth**	**Side**	**Onset**	**Recovery**
McCleave 1978	SCUBA male	<760 mm Hg	<10 m	left	sudden	active
McIver 1979	Male	988 mm Hg	13 m	left	a few minutes	slow
Molvaer 1982	SCUBA	912 mm Hg	12 m	right	10 mins	slow
Present case	pro diver	684 mm Hg	9 m	right	a few minutes	slow

(Aviation cases have been omitted from this review)

scribed the case of a diver who developed nausea and staggering following a dive. The term was enthusiastically accepted and included with other medical mnemonics. Man is subjected to many new stresses when he enters the new environment of hyperbaric conditions known to be capable of having many unusual pathological effects. Facial palsy is known to result from a number of different mechanisms. When the condition occurs in an alternobaric environment its pathogenesis may be discussed in the light of the fluctuations occurring in that invisible enemy, PRESSURE, to which the diver subjects himself. On the basis of the case history, observations and investigations the condition has been diagnosed in this Indian diver.

Case Report

On 10 January 1980 Mr M, a thirty year old professional diver, performed a compressed air dive of 40 minutes at 9 metres to clean the hull of a ship. In all he made three dives at depths ranging from 3 to 9 metres and after surfacing from the 9 metre dive reported a feeling of nausea and experienced a dizzy feeling which caused him to walk unsteadily along the deck. He noticed a change “as if something was being stolen from the right side of his face,” this soon changing to a sensation of “lifelessness” in the area. He soon noticed that he could neither blink nor close his right eye and was unable to whistle. His face was distorted due to a right sided facial palsy. His blood pressure was 100/90 mm Hg, blood sugar 88 mg % and both urine and x-ray were within normal limits. Except for the right sided facial palsy his clinical and neurological examinations were within normal limits.

While he was under observation he reported a return of awareness of the wind blowing on the right side of his face and of a feeling of some ill-defined activity going on there. Activity was seen to return to the face after 20 minutes and after 40 minutes he was completely returned to normal.

Discussion

On the dive profile chosen by Mr M, there was no risk of incurring decompression sickness. Estimates of the frequency of dehiscence of the facial nerve range from 5 to 57 per cent and it is suggested that in this case, the facial nerve, during its course within the middle ear was without a bony covering. If the right ear had failed to adequately equalise pressure during the dive disequilibrium would have been produced with right middle ear overpressure on ascent. This increased pressure could have produced alternobaric vertigo and would have been sufficient to compress the vasa nervorum of the 7th cranial nerve (facial) resulting in neuropraxis and transient facial palsy. The condition resolved without treatment as the pressure equalised. It is thought that a pressure of 684 mm Hg produced the condition described, though the actual middle ear pressures were not recorded. Facial palsy among pilots, flight crew, and air line passengers has been recorded as occurring at pressures less than reported in the present case.

In a case like this, recommendations concerning continuation of diving are difficult to discover in the literature, but it can be said with certainty that such persons should avoid diving during the acute infectious phase of an upper respiratory tract infection or when they find it difficult to “clear” their ears.

Table 1 reviews the relevant literature.

Summary

A case of transient right sided facial palsy in an Indian diver.

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RETURN TO ACTIVE DIVING AFTER DECOMPRESSION SICKNESS

During May 1980, the Association of Diving Contractors expressed concern for the wide diversity of opinion among physicians regarding the restriction from diving activity following the treatment of decompression sickness. This concern has been further heightened by the most recent revision of the United States Navy Diving Manual, which recommended a minimum of one week's restriction following the treatment of Type I DCS. Applied to the diving industry this restriction was considered to be overly conservative, and likely to result in a number of undesirable side effects. Some of these might include the medico-legal implications as physicians recommend something other than that which is published in the diving "bible", and the possibility that some divers may fail to report their condition whenever possible if they perceive such delays as financially detrimental.

A workshop was arranged, under the auspices of the Undersea Medical Society, and held in New Orleans during that same year. Chaired by Dr Jeff Davis (a recent contributor to Triage), the workshop provided a forum for clinicians, researchers and operational personnel with the aim of producing appropriate industry standards.

Throughout the one day meeting it became clear that many unanswered questions would remain. Knowledge of the pathophysiology of Type I DCS is noticeably incomplete, and without this vitally important ingredient absolutes are impossible. So much so that at the end of the day, the seven day Navy restriction didn't appear quite so conservative!

Consensus Recommendations

Guidelines to be considered for return to work by divers who have suffered decompression accidents:

1. When can a diver return to diving after a treatment table for limb bends results in total resolution of symptoms?

   Recommendation: About twenty-four hours as a minimum.

2. When can a diver return to diving after a treatment table for limb bends with resolution except for residual soreness in the affected area(s)?

   Recommendation: This diver should be sent to a physician for evaluation. Return to diving should be only after all soreness is gone.

3. When can a diver return to work after:

   a. Pain under pressure and complete remission after treatment?

      Recommendation: The consensus was to use the same recommendation as in 1 above. There was some difference of opinion with some members recommending evaluation by a physician before returning to diving.

   b. Neurological decompression sickness with complete remission on single treatment?

      Recommendation: This diver should be given a detailed neurological examination to include studies indicated in the specific case, eg. EEG and ENG. Circumstances of the dive must be considered to determine whether or not the diver appears to be uniquely susceptible to decompression sickness. If all examination and studies are normal, diving may resume after a minimum of one week after the treatment.

   c. Neurological decompression sickness with complete remission only after serial or saturation treatment?

      Recommendation: This diver is considered to be more susceptible to future decompression sickness which may be more severe if it OCCURS.

   d. Neurological decompression sickness with incomplete remission after serial or saturation treatment and which residual remaining is functionally acceptable for return to diving?

      Recommendation: The consensus was that this diver should not return to diving at any time. One participant would allow return after the deficit had been fully stable for six months.

   e. Successful treatment for chokes (pulmonary decompression sickness)?

      Recommendation: This diver can be returned to diving after full recovery and evaluation by a physician reveals a normal examination.

   f. Cerebral air embolism and complete remission after single, serial or saturation treatment?

      Recommendation: If the pulmonary overpressure accident appears "justified" by the history (that is, the history does not suggest local air trapping which would be unpredictable in future diving) and if complete neurological and pulmonary evaluations are normal, he may be returned to diving.

   g. When can a diver be returned to work not involving diving after a decompression accident?

      Recommendation: The diver can be assigned to non-diving duties as soon as functionally possible and safe within the constraints of the work site.

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'IRUKANDJI' SYNDROME OR DECOMPRESSION SICKNESS OR CEREBRAL ARTERIAL GAS EMBOLISM? A DIFFERENTIAL DIAGNOSTIC TRAP FOR PRACTITIONERS OF DIVING MEDICINE IN NORTH QUEENSLAND.

John Williamson

Introduction

Although the number of species and genera that comprise the jellyfish family "Carybdeidae" is at present not clear,[1] at least one genus of this family is Carukia.[2] The most celebrated and to date one of the adequately identified species[2] of this family is Carukia barnesi, named after its discoverer, Dr Jack Barnes of Cairns. The unpleasant systemic syndrome produced by a sting from this animal was first described, albeit in part and non-specifically, by Southcott and Powys in 1943 and 1944 (unpublished data). Flecker[3] and Barnes[4] completed the clinical description. Subsequently, Carukia barnesi was identified by Barnes[5] as at least one of the offending animals in the production of this syndrome, and this hitherto undescribed jellyfish was dissected, classified and named by Southcott.[2]

The Classical "Irukandji Syndrome"

The name for this syndrome "Irukandji syndrome" was coined by Flecker,[3] (after the tribal name for aborigines who inhabited a North Queensland coastline) and consists classically of immediate burning pain at the site of skin contact with the thread like tentacles, followed by an area of diffuse erythema without wheal formation, and fairly rapid subsiding of pain. At a variable time after that (30-50 minutes) severe muscle pains develop at the site of the envenomation, and these quickly extend proximally, to produce generalised severe muscular type pains, painful breathing, and culminating in severe headache, nausea, vomiting and prostration, even in previously fit athletic people. The skin area of the original sting may show a "goose pimple" effect, with minimal persisting erythema, and the patient is usually greatly alarmed and distressed by the pain, headache and nausea. Regional lymphadenopathy does not appear consistently, in the experience of the writer.

There is no antivenom, the nature of the toxin is totally unknown, and treatment is non specific, but of necessity vigorous, viz. intravenous narcotics via an IV line under full medical care facilities.

The syndrome usually persists for 6-12 hours and subsides by 24 hours, leaving the patient weak, with muscular soreness and very occasionally, in prematurely released patients, a recrudescence of some of the generalised symptoms. No fatalities are known.

In the words of Jack Barnes, "I should sooner have small Box-jellyfish (Chironex fleckeri) sting, than an Irukandji sting"!

Carukia Barnesi

Carukia barnesi is thus commonly referred to colloquially as "Irukandji", and is a small jellyfish (1-2cm across the bell or body), with a translucent bell and only four (4) thread like retractable and extendable tentacles, which vary in length from 2.5 to 4.5cm at rest and are capable of about a 3 times extension in length.[2]

Nematocysts (stinging cells) are located along each tentacle on circumferential rings, and also on warty mamillations on the outside of the bell.

However, the animal is never seen by the victim in the water, because of its minute size and its colour, and the tentacles do not adhere to the skin. Only a tiny patch of bare skin is necessary for sting, so warm water wet suit rigs do not offer protection.

"Irukandji" has so far only been located in the northern parts of Australia, in tropical waters, and it appears to frequent both inshore and open waters (unlike Chironex fleckeri).

The Problem

To my knowledge, there have now been two cases of Scuba divers receiving an Irukandji sting during a dive, and on their return to the boat, they and companions, not surprisingly diagnosed the ensuing Irukandji syndrome as either developing decompression sickness or cerebral arterial gas embolism (CAGE)! A third possible case (which was treated as CAGE) is at present being diagnostically re-examined in retrospect!

Thus, for the diving medical practitioner who is unacquainted with the "Irukandji syndrome", and who is urgently consulted in such cases, a serious differential diagnostic trap exists for the difference in the management of these two diagnoses (one of which may also involve in addition an aeromedical evacuation to the recompression chamber) is striking to say the least!

It is now becoming clear that there is more than one species of the family Carybdeidae, and perhaps also of the genus Carukia that are capable of producing the "Irukandji syndrome"[1] (Barnes JH, unpublished observations) and this difficult differential diagnostic problem is not going to become less common in Northern Australia.

To date, all observed Irukandji syndromes have demonstrated only subjective systemic symptoms, and none have shown objective signs of neurological sensory or motor dysfunction. However this may reflect the relative paucity of neurologically closely observed and carefully documented cases to date. One can only wonder what effect this toxin might have on the central, or peripheral nervous system with pre-existing pathology.

ACKNOWLEDGMENT

My thanks to Dr Carl Edmonds for the "unwitting", and to Dr John Knight for the "witting" stimulus which led to this report!

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Since submitting this paper Dr Williamson has written to say that Dr Jack Barnes, whose pioneering work is referred to in the above paper, died in Cairns on 11th August 1985.

FROM THE MEDICS LOG...

PULMONARY OVERPRESSURE SYNDROME

Dick Clark

On 1 October 1984, RP, a 30 year old, fit young male who was in the final phases of a 10 month commercial diving course, was using a Superlite 17 helmet and dry suit while diving from a barge in a lake about 75 miles north of Toronto, Canada. On the barge is a recompression chamber (RCC) capable of simulated depths to at least 165 feet. Mr P surfaced from a 90 foot dive for 30 minutes after doing 7 minutes of decompression at the 10 foot stop. It is noteworthy that just prior to the incident dive, the patient aspirated a small piece of ham/cheese/lettuce sandwich that he coughed up before entering the water. During ascent he coughed on several occasions due to some residual "throat irritation". Further, he was not as attentive to ascent rate as usual since he was pre-occupied with thoughts of approaching exams and impending break-up with his current girlfriend. (Divorce from his wife was to be final 20 October 1984). His tenders were not aware he had reached the 10 foot stop since they told him to continue ascending, ie. ascent may have been faster than 60 fpm. At the 10 foot stop he felt vaguely unwell and lightheaded. He did not ascend beyond the 10 foot stop until after 7 minutes of decompression.

The dive, including ascent was otherwise unremarkable. Within 3-4 minutes after surfacing he felt very weak, dizzy, then very nauseated and started to lose consciousness. He was caught by his tenders and placed in the decompression chamber which was taken to 165 feet: the time was about 1400 hours. By the time treatment depth (165 fsw) was reached, all symptoms were relieved and he felt well and was completely orientated.

After 30 minutes at 165 fsw, ascent was attempted, but the patient experienced retrosternal chest pain and the chamber was returned to 165 fsw until the Diving Medical Officer arrived at the wharf where the barge had come to shore after the accident (1600 hours). Total time at 165 feet was 135 minutes. It is significant that the steel RCC was exposed to the weather on the barge deck and air temperature was about 40°F.

The inside diving medic was directed to auscultate both lung apices using a Cardiosonic R acoustic amplifier to verify that breath sounds were present - they were. Pulse was 72 and systolic BP 110. Respirations were about 14/min. The chamber was then travelled at 25 fpm to 80 fsw (which would be the first stop on an air dive to 170 feet for 2 hours using USN extreme exposure tables). A brief stop was necessitated at 150 fsw by recurrent chest pain, but due to pulse rate of 74 and breath sounds bilaterally, tension pneumothorax was ruled out and ascent continued. Pain decreased during ascent from 150 feet and was absent at 60 feet. USN table 170/120 (air) was followed to 60 fsw at which time a USAF modified USN Table 6 Treatment was started. One extension of 20/5 was given at 60 fsw and two extensions of 20/5 at 30 fsw to ensure that the total length of the treatment was at least as long as decompression on air from 170 ft/120 min. Tenders alternated O_2 periods at 60 and 30 feet (patient did all) and both tenders and patient breathed O_2 from 30 fsw to the surface. It is theorized that the retrosternal chest pain was due to mediastinal emphysema which dissipated on ascent.

During the third O_2 period at 60 fsw the DMO locked in to re-start the IV and give 50 mg Solu-Cortef (1750 hours) and 40 mg Decadron (1805 hours) by slow IV push. Ringers Lactate (R/L) was continued at 50 cc/hr to KVO since patient had voided 1500cc after receiving 500 cc R/L earlier in the dive. Examination in very cramped quarters was unremarkable as to vital signs, subcutaneous emphysema, strength, orientation, breath sounds, heart sounds and level of consciousness.

At the surface he was symptom free except for mild headache and he was sent to the local hospital for overnight observation. Both tenders were also symptom free and remain so.

A chamber crew stayed on call in the area overnight in case of relapse. Patient was discharged after an uneventful night at 0800 hours, 2 October.

Follow up exam, including complete CNS evaluation at 1130 hours, 2 October was completely unremarkable. Inspiration expiration chest x-rays 2 October were reported as showing no abnormality.

It was recommended that patient was unfit for diving for three weeks, but since this Pulmonary Overpressure Syndrome is "explained" by coughing during a fairly rapid ascent, and since there were no focal neurological signs or symptoms, resumption of diving is permissible with the proviso that the diver is aware he at "increased risk" of a recurrence of Pulmonary Overpressure Syndrome and must be very attentive during ascents in future.

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