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Diving First Aid Supplement
(Initial Management of Diving Injuries and Illnesses)

EDITORIAL

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To convene members of the Society annually at a scientific conference.

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THE EDITOR'S OFFERING

This First Aid Supplement contains papers which were presented at the 1997 Annual Scientific Meeting held at Waitangi in New Zealand as part of the process of producing the SPUMS Policy on the Initial Management of Diving Injuries and Illnesses, which was published in the Journal for December 1997. This document is reprinted here on pages 30-35, as a conclusion to the papers, as it was produced from the meeting's responses to the papers and discussions.

The contributions from dive training organisations, published in the June 1998 issue, about first aid training have not been reprinted as they mainly dealt with educational theory and the reasons for not teaching diver rescue in the basic recreational diving course.

Our aim has been to produce a volume which will stimulate readers to think for themselves. To this end we have included a number of the flowcharts (pages 36-39) which preceded Dr Mike Davis' latest one printed on page 3. As research has changed our knowledge these charts have had to be modified. The original charts recommended a 45° head down position, which was very uncomfortable but considered to be important to prevent bubbles reaching the brain. Only later was it demonstrated that steep head down positions resulted in cerebral congestion.

All the charts included the need for reports of such incidents to be sent to some central body. There is still need for such reports, which are unfortunately seldom provided. It is only by learning how accidents occur and how the scenarios develop that evidenced based improvements in diver training and safety can be instituted. Such a step has been left off the SPUMS headed charts, which are designed to be applicable world wide in the early management of divers, as every country has a different body interested in collecting data about accidents.

Dr Michael Davis emphasises the fact that in water accidents require a general first aid approach, the well known ABC, which includes rest and protection from the elements. When drowning, near drowning and decompression illness are involved oxygen is an essential requirement to reverse hypoxia. The first aider can cope this far without a diagnosis, which except for tension pneumothorax where rapid relief of intrathoracic pressure is essential, which can be arrived at when the victim reaches a hospital or hyperbaric facility.

But before one can provide First Aid one has to find the casualty. Dr David Davies reviews the various aids to recognition that divers can carry so that they can be easily seen from afar. His recommendation is to carry a Safety Sausage and a mirror to use as a heliograph to flash at potential rescuers.

Dr Veale provides a clear description of how to recognise that rare occurrence the diving induced tension pneumothorax, which can kill as the intrathoracic pressure rises to prevent venous return to the heart, and how to perform the essential piercing of the chest wall to let the air out of the chest.

Dr Peter Chapman-Smith discusses the GP's role in the treatment of diving accidents, Dr Mike Bennett discusses the problems of diver evacuation and how to organise it while Dr John Knight reports on a demonstration of helicopter rescue during the 1997 Annual Scientific Meeting.

Dr Chris Acott shows that oxygen is often provided at less than optimum concentrations and yet oxygen administration at these concentrations appears to provide better final results than no oxygen at all. These findings are encouragement to keep on prodding divers to take oxygen, and plenty of it, on every diving expedition. No one can use oxygen if it is not available.

Dr David Komesaroff provides information about the results of low flow, circle, oxygen resuscitation systems. It is clear that training is needed to use the equipment satisfactorily, but the principles are simple, for a conscious person. The rescuer uses an 8 litre a minute flow to fill the system before putting the mask on the victim, who holds the mask on his or her face to achieve an air-tight seal, then after three minutes reduces the oxygen flow to 3 litres. Provided there are no leaks this will deliver an oxygen percentage in the high 90s and vastly increase the duration of each cylinder.

Dr James Francis provides an excellent practical guide to immersion hypothermia and its early treatment. Of course the best treatment is prevention by wearing appropriate protective insulation.

Page 40 reprints two cartoons which appeared on the front cover of the Journal in the 1980s. Both have messages which still apply, watch for your surfacing divers and know where to get advice about what to do. The telephone number in this cartoon is the current Australian DES emergency line.

The volume closes with three papers reprinted from diving magazines. Two deal with diver rescue, one recommending ditching the victim's kit to make the tow easier, the other advocating retaining the buoyancy device so that the victim is not drowned during the tow. The reader should consider what he or she would do and how the buddy should manage if the reader is the victim. The final paper is on Surviving common dive hazards.

FIRST AID FOR DIVING EMERGENCIES DOES THE DIAGNOSIS MATTER?

Michael Davis

Key Words

Accidents, flowchart, first aid.

In accordance with Murphy's Law diving emergencies develop out of the blue when least expected and usually at the worst possible moment. They are invariably the result of a chain reaction of circumstances that breaks through the loose-knit but nevertheless effective safeguards built into scuba diving and are rarely caused by any one factor alone.

This is a harrowing moment for a group of divers faced with sudden chaos and a motley of non-specific symptoms and signs in the victim (Table 1).

The circumstances may provide sufficient clues to what is happening (e.g. oxygen toxicity is hardly likely in someone in difficulties on the surface before an air dive, but near drowning is a strong bet).

I believe that precise disease diagnosis is largely irrelevant to the institution of appropriate First Aid.

The approach to First Aid teaching must either be based on an in-depth study of each medical condition, or be a pragmatic one that presents a sequence of simple decisions and actions, a treatment algorithm, that provides immediate care for all potentially life-threatening conditions, while medical aid is sought.

This approach is clearly illustrated in the modern teaching of Basic Life Support. It must also be emphasised that the actions of those at the accident scene largely determine the outcome for the injured diver.

This is not to say that the triad of Resuscitation, Disease Diagnosis and Treatment do not go hand-in-hand in dealing with medical emergencies. I simply consider that it is unproductive to teach this process to most recreational divers. Indeed, evidence from case referrals to the Christchurch Hyperbaric Unit suggests that the wet suited mini-doctor sometimes does his fellow diving victim a disservice.

The old adage that *a little learning is a dangerous thing* should not be forgotten!

TABLE 1

THE POSSIBLE PRESENCE OR ABSENCE OF 15 SYMPTOMS AND SIGNS IN 8 POTENTIALLY SERIOUS DIVING-RELATED CONDITIONS

Note that there is not a single condition or presentation combination that is diagnostic

Common signs and symptoms	DCI	Pneumothorax	Ear barotrauma	Marine sting	Near drowning	Hypothermia	Myocardial infarction	Trauma
Pain								
Limb	+	-	-	+	-	+	+	+
Chest	+	+	-	+	+	-	+	+
Headache	+	+	+	+	+	+	+	+
Fatigue	+	+	+	+	+	+	+	+
Shivering	+	+	+	+	+	+/-	+	+
Nausea and vomiting	+	+	+	+	+	+	+	+
Shortness of breath	+	+	-	+	+	+	+	+
Cyanosis	+	+	-	+	+	+	+	+
Tinnitus	+	-	+	-	-	-	-	+
Motor loss	+	-	-	+	-	-	+	+
Sensory loss	+	-	-	+	-	-	+	+
Convulsion	+	+	-	+	+	-	+	+
Loss of consciousness	+	+	+	+	+	+	+	+
Signs of shock	+	+	-	+	+	+	+	+
Cardiorespiratory arrest	+	+	-	+	+	+	+	+

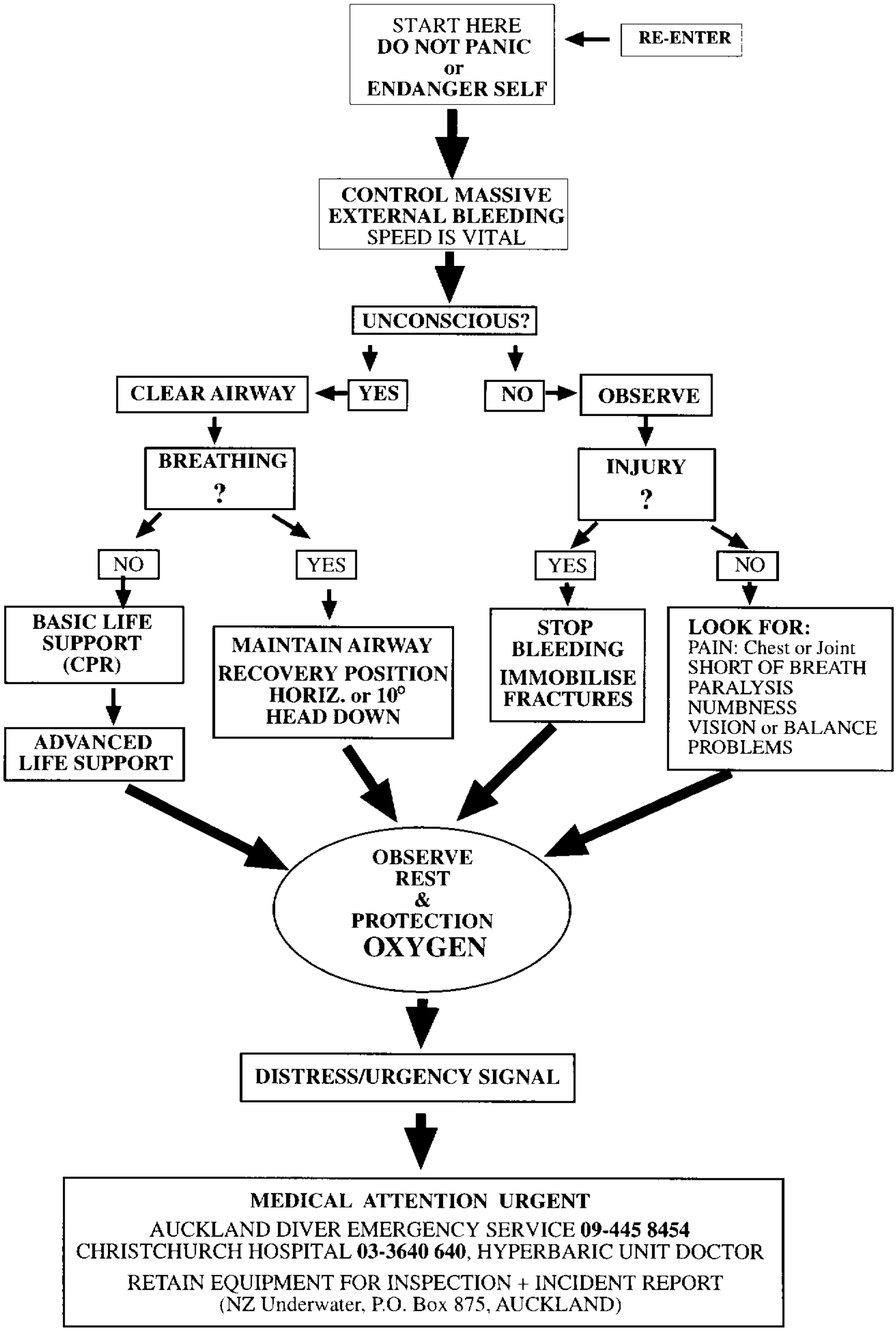

Figure 1. First Aid Algorithm: This decision flow chart is the 1997 revision of a chart originally developed by the author in 1978 for teaching diving first aid management. This was first published in the SPUMS Journal (Supplement) 1981: 63-67 and subsequently promulgated in Australia in a revised form by SPUMS (See pages 36 to 39). A very similar flow chart appears on the back cover of the DES Emergency Handbook, revised 4th Edition, John Lippmann & Stan Bugg.

TABLE 2

TEN COMMANDMANTS OF FIRST AID FOR DIVERS

1	Do NOT place yourself in DANGER and KEEP CALM.
2	BASIC LIFE SUPPORT - Airway, Breathing, Circulation.
3	POSTURE - recovery position, control bleeding, immobilisation.
4	OXYGEN - in every case.
5	REST and PROTECT - from the elements, further injury, spread of toxins etc.
6	OBSERVE and RECORD - the diver's condition repeatedly and without bias.
7	CONSULT - Emergency Services, medical advice (e.g. DES/DAN).
8	SPECIFIC CARE - Fluids, marine stings and bites, Advanced Life Support.
9	EVACUATE - Hospital/Hyperbaric Centre etc.
10	SECURE EQUIPMENT and DOCUMENT the accident fully.

What replaces disease-orientated diagnosis in the immediate First Aid management of diving accidents is condition recognition. That is, the establishment of priorities in immediate care. For instance, there is little point treating shock only with intravenous fluids if the real cause of the shock is severe hypoxia from upper airway obstruction due to head trauma from an outboard propeller blade and not the haemorrhage from the scalp wound!

Therefore, the question is largely rhetorical. Of course diagnosis is important, but primarily to identify and decide priorities for immediate life-threatening problems such as airway obstruction, rather than to determine a disease label.

Principals 1-6 in Table 2 do not require disease recognition and it is only for 8, often combined with 7, that this becomes necessary.

Figure 1 is a flowchart (algorithm) used by the author for many years for teaching diving accident management.

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DIVER LOCATION DEVICES

David Davies

Abstract

Much has been written about the first aid and medical management of the injured diver, but the initial step in this management is to remove the diver from the source of injury, and this requires that first the diver must be found. There is little on this subject in the diving literature so most of the information needs to be gleaned from other sources.

All too frequently divers become separated on the surface from either their companions or the dive boat. Many survivors later report that, although they could see the boat, they were unable to attract its attention. Numerous devices have been used in the past to rectify this situation including a torch, camera strobe, flares, coloured dye, the Safety Sausage, a whistle and a sonic beacon. All have proved of limited value.

This paper classifies and compares some of these devices and makes suggestions for two cheap alternatives which should become part of a diver's routine equipment and enable rescuers to locate a lost diver more rapidly.

Key Words
Equipment, safety.

Introduction

A short time before the last SPUMS meeting in Palau (1993), a group of Japanese divers and their dive guide was swept off Peleliu Corner by unexpected currents.[1] Despite intensive air and sea searches, the divers were not found for five days, by which time they had succumbed to exposure. A diary of the event, kept by one of the divers until she died, recorded that rescue craft had passed within two hundred metres of them but had failed to see them in the choppy conditions. It also recorded that they had tried to attract attention with torches and whistles, all to no avail.

A similar group was swept away in the same area while SPUMS was at Palau and they were rescued some hours later, at dusk, when the flashes from the camera strobe became visible. Again, whistles and torches were of no value in attracting attention. One SPUMS group at this time also had a near miss but their very experienced boatman had the foresight to follow their bubbles during decompression and be close at hand when they surfaced well offshore.

Divers can become separated from the dive boat for a number of reasons which may include the dive boat dragging its anchor, inattention by the boat crew or no person being left on watch in the boat, failure to record divers into and out of the water by the dive master, unexpected currents or current strength and deteriorating surface conditions during the course of the dive.

Auditory devices

WHISTLE

The transmission of sound across water is unreliable and depends very much on atmospheric conditions. The blast of a whistle can be more penetrating than a shout and may be heard at 100-150 m down wind but only 50 m upwind. This will be less audible with interference from the boat's engine noise and will, of course, be totally inaudible in an aircraft. A whistle is cheap, reliable and easy to use and is often standard issue with a buoyancy compensator. The whistle requires little energy and can be very useful when the voice is failing. It may be more useful for maintaining contact between divers on the surface than for attracting the attention of a boat with a noisy outboard motor.

SONIC BEACON

A sonic beacon, driven by the compressed air feed to the buoyancy compensator, emits a louder noise with a slightly greater range but becomes ineffective when the gas supply fails. This device is more expensive than a simple whistle and its increased sound intensity serves to deafen its user.

Visual devices

DYE

Any device which increases a divers visibility on the surface will be of value. A coloured dye tipped into the water will diffuse rapidly over quite a large but discrete area and be readily visible, especially from the air. It has been found that in choppy conditions such dyes dissipate rapidly and lose their effectiveness over three to six hours. Accordingly they should only be used when the searching vessels and aircraft are actually in the vicinity. They are useful only during the day.

SAFETY SAUSAGE

Especially among SPUMS members, the Safety Sausage has become almost standard issue. This two metre long red plastic cylinder, which is cheap to buy and occupies almost no space in the BC pocket, can be inflated by mouth or by compressed air and, when turgid, will stand vertically above the water surface. At night it can be illuminated from the inside by a torch, whereupon it becomes a glowing beacon readily visible at several hundred metres. Its length is such that it will show above wave height except in the most unpleasant conditions. Partly inflated it will lie on the water surface and still be visible from the air.

A variation of this is a smaller version attached to a fine cord that can be inflated during the in water decompression stop and allowed to ascend to the surface. This indicates to other surface vessels that divers are below and to the dive boat that the divers are about to surface.

CYALUME STICK

Cyalume sticks generate a chemiluminescent glow of varying colours that is visible only at fairly close range. The emitted light will last, with gradually waning intensity, for about 12 hours. These single use sticks are readily available, cheap, come in a variety of colours for the fashion conscious and can be clipped onto the BC.

REFLECTORS

Life jackets found on aircraft, life rafts and commercial shipping all have reflective patches sewn on, back and front, at shoulder level. These are flexible and highly effective, making the wearer readily visible in the beam of a torch or search light from a rescue vessel. The author feels strongly that these patches should be fixed on all buoyancy compensators. Such an addition would not detract from the design or appearance of the BC nor should it increase the cost of manufacture or cost to the customer.

TORCH

Many divers already carry a torch for looking under ledges and in caves. Torches vary in size, weight and battery capacity and can be very useful at night for attracting attention from passing boats. Most have a limited battery capacity and need to be used sparingly, especially if they have been used extensively during the dive. During daylight hours even the most powerful have very limited effectiveness.

STROBE

Some divers carry a small battery powered strobe which, when activated, emits short flashes of intense light. Held above the head it can help to make a diver readily visible as such flashes usually indicate a variation from the norm and require investigation. Strobes have the disadvantage that they are yet another piece of equipment to carry, drop, lose, supply with batteries and to fail when most needed. In an emergency, the flash strobe from an underwater camera can and has been used for this purpose. Again, it is more useful during periods of reduced ambient light.

FLARES

In the UK especially, many divers carry flares. These are single use only, bulky, very unreliable once they have been immersed, especially at pressure, cannot be carried in aircraft and have a limited lifespan. Once their lifespan has been exceeded they are then difficult to dispose of safely and legally. They have been known to burn the hand that ignites them. Light and parachute flares have limited visibility during the day whereas coloured smoke can be used only during the day. Parachute flares which rise to a height of about 300 m and burn for several minutes are readily visible for many kilometres.

HELIOGRAPH

Last year, a yacht in distress in the North Atlantic successfully used a heliograph mirror to signal to a commercial aircraft flying at over 30,000 ft. More recently, in the Kimberley region of WA, the pilot of a crashed aeroplane used one to guide rescuers to his location. It has been reported that the flash from a heliograph has been visible at a distance of 30 km.

The heliograph mirror is a cheap, compact, neutrally buoyant device which has been used for signalling over long distances for many years. It was used extensively on the Northwest Frontier from before the Crimean War and until the introduction of the telephone. Anecdotal reports suggest it may have been used in ancient Egypt. The heliograph is standard equipment in aircraft emergency kits and in all lifeboats and life rafts.

The heliograph requires sunlight, or powerful moonlight, but can be used to effect even in lightly overcast conditions. It is simple and reliable to use, maintenance free and needs no batteries. At night it can be used to reflect a searchlight beam. All divers should be encouraged to acquire this device, carry it and learn its use.

Electronic

EMERGENCY POSITION INDICATOR RESCUE BEACON (EPIRB)

This device, when activated, transmits an electronic distress signal detectable by an orbiting satellite and then relayed to a ground control centre which, in turn, initiates an air-sea search and rescue. It was this device which initiated the rescues of yachtsmen Tony Bullimore and Thierry Dubois in the Southern Ocean in early 1997.

These devices are expensive to buy, are too bulky for divers to carry as personal equipment and are not designed to be taken to depth. They should, however, form part of the routine equipment, like flares, life jackets and a marine radio, on all boats that venture more than a few kilometres offshore.

Discussion

Divers often complain that they need to carry too much heavy equipment, and the size of the dive bags that they put on board dive boats indicates that what they do carry is too bulky. To ensure that the maximum enjoyment can be obtained from a dive then a minimum effort should be required to transport the equipment to the dive site.

Any extra equipment should be light, compact, easy to use, clean and maintain and, preferably, cheap to buy or replace. The heliograph mirror and the reflective patches sewn onto the BC both fall into this category.

As the 1998 Annual Scientific Meeting of the Society is scheduled to be held in Palau again, all potential delegates should be aware of the vicissitudes of tidal currents that abound in that region and especially around Peleliu Corner. For their own preservation, it is recommended that delegates should carry and become familiar with the use of the equipment available to facilitate their own rescue should they have the misfortune to become mislaid at this popular dive site.

Acknowledgments

The author is grateful to Mr Hugh Morrison of Perth Diving Academy for his help in preparing this article.

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TENSION PNEUMOTHORAX IN DIVERS

Andy Veale

Key Words

Accident, first aid, pulmonary barotrauma, resuscitation, treatment.

Introduction

TENSION PNEUMOTHORAX
IS THE
ONLY
DIVING-SPECIFIC DISORDER
WHICH CAN KILL AT A DIVE SITE
AND YET IS

TOTALLY TREATABLE IF RECOGNISED.

The diver in the boat can
MAKE THE DIFFERENCE

BETWEEN LIFE AND DEATH.

Basic assumptions

Divers will (in general) not have pre-existing lung disease.

Divers will rarely have a coagulopathy or other important co-morbidity.

Symptoms

Divers developing a pneumothorax underwater will almost always develop symptoms of shortness of breath and or chest pain during the dive, though these may not be recognised at the time. Shortness of breath will **ALWAYS** get worse during ascent. Chest pain often **IMPROVES** during ascent as the pneumothorax enlarges and the lung no longer touches the chest wall.

Such symptoms developing **AFTER** a dive are of no greater concern than any other pneumothorax.

ONLY

A PNEUMOTHORAX DEVELOPING

DURING A DIVE OR DURING ASCENT

is likely to become a tension pneumothorax as air outside the lung expands with ascent. Spontaneous pneumothorax ashore very rarely results in a tension pneumothorax.

Signs of pneumothorax

1 Tachypnoea (rapid breathing, usually shallow).

2 Asymmetry of the chest wall, which is best seen from above. The side with the pneumothorax is larger as the lung is no longer in contact with the chest wall and preventing it from expanding. The normal position of the chest wall is due to a balance between the natural expansion of the chest wall and the inward traction of the lung resisting the outward pull. The increased size does not imply tension.

3 Tracheal deviation to left or right. This can be seen and felt in the suprasternal notch. The trachea moves away from the pneumothorax due to the traction of the normal lung on the mediastinum and loss of contact with the chest wall on the affected side. Tracheal deviation does not imply tension.

Signs of TENSION pneumothorax

Raised jugular venous pressure (JVP), with the jugular veins standing up high in the neck and hypotension with tachycardia (rapid heart rate) means that life-threatening tension pneumothorax is present. The raised JVP is evidence of obstruction of venous inflow into the heart. This follows the rise in intrathoracic pressure, due to the tension pneumothorax, above the normal central venous pressure which reduces the venous flow into the thorax as the intrathoracic pressure rises. Hypotension and tachycardia (a rapid, difficult-to-feel pulse) are evidence of inadequate cardiac output consequent on the reduced venous inflow. Reducing the high intrathoracic pressure is needed so that venous inflow and cardiac output can improve. Otherwise when the intrathoracic pressure rises above the venous pressure, venous return stops, which stops cardiac output and the person **DIES** there and then.

It is not an oversight that there is no mention of a stethoscope. A stethoscope is useless at sea due to the surrounding noise levels in a dive boat especially with the motor running.

Emergency treatment

The aim is to equalise pressure across chest wall i.e. eliminate tension. It is not necessary to try to get rid of the pneumothorax as such. But venting the high pressure within the chest is ESSENTIAL.

Anatomy (Figure 1)

Go through the chest wall in the 2nd or 3rd intercostal space in the mid-clavicular line on either side. The needle, or knife, needs to be held perpendicular to the

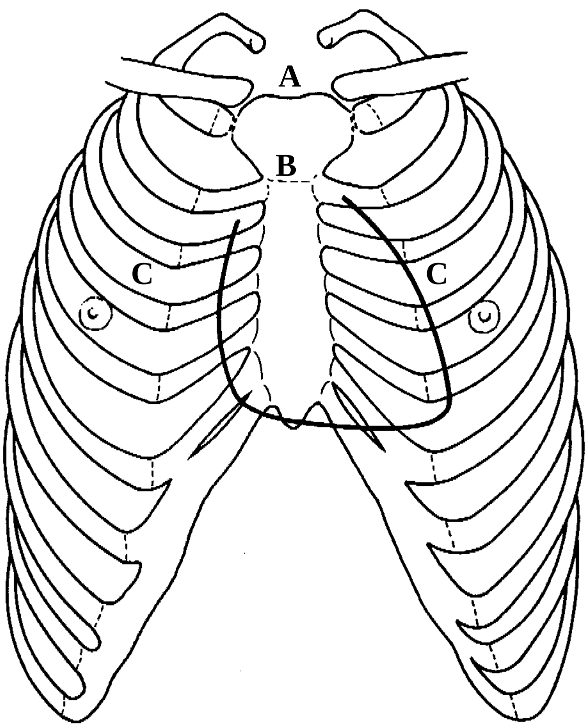

Figure 1. The supra sternal notch lies between the ends of the clavicles (A). The dotted line across the sternum is the angle of Louis (B). The black line overlying the ribs is the approximate position of the heart. The third intercostal space lies between the 3rd and 4th ribs (C). In thin males the nipples lie roughly in the mid-clavicular line.

skin. Using the 3rd space (between the 3rd and 4th ribs) makes it easier to control the knife. This approach will miss the heart, the great vessels and internal mammary arteries (which may be needed for later coronary artery surgery). The 2nd intercostal space in the mid-clavicular line risks the subclavian artery and vein if the needle is angled upwards.

To find the second rib put a finger in the suprasternal notch (between the inner ends of the clavicles) and run it down the manubrium to the angle of Louis (the junction with the sternum), about two fingers breadths down from the suprasternal notch, move outwards and the finger is on the second rib. Slide the finger towards the feet, off the rib and it is on the 2nd intercostal space, between the 2nd and 3rd ribs. Over the third rib the finger is on the 3rd intercostal space.

A lateral approach risks the long thoracic nerve and entering the oblique fissure of the lung which may prevent adequate drainage and so relief of pressure.

Always go down onto a rib as all the variation in depth is outside the rib. From the outer table of the rib there is a further 6 mm in women and 10 mm in men to the pleural space. The intercostal vein, artery and nerve lie under the lower border of each rib. Keeping the needle close to the top of the rib below keeps it well away from the nerve and vessels.

Technique

To find the intercostal space put a finger on the rib below the space. Push the needle vertically through the skin to hit the rib. Lift the needle slightly so that it no longer is in contact with the rib. Tilt the hub down (towards the patient's feet) slightly and advance it. If it hits the rib repeat the process until it slides over the top of the rib and through the pleura into the pneumothorax. There will be a whistling as the high pressure air in the chest escapes.

Use local anaesthetic if you have it, if you do not, get an assistant (strong and heavy) but do it anyway!

Use a hollow needle or cannula, a chest drain or any sharp clean blade to piece the chest wall and establish continuing escape of air. A chest drain with Heimlich valve is Rolls-Royce treatment.

The follow-up chest X-Ray will always show a pneumothorax so you will always have been correct in your diagnosis and treatment.

Medical kit

A kit for dealing with a tension pneumothorax should have local anaesthetic, a 20 ml syringe, a 23 gauge needle and 14 gauge intravenous needle/cannula plus a 28 French gauge chest drain and tape.

The above paper has been prepared from a poster presentation at the 1997 SPUMS Annual Scientific Meeting in Waitangi, New Zealand.

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THE GP'S ROLE IN DIVE ACCIDENT MANAGEMENT

Peter Chapman-Smith

Key Words

Accidents, case report, decompression illness, rescue, sequelae, transport.

Introduction

Many people dive around the North Island of New Zealand which has a magnificent coastline. Our varied geography, with deep diving available at a string of excellent offshore island venues as far as the Three Kings in the far North, can present acute diving emergencies at any time and in isolated areas surrounded by hills and mountains.

The GP's role

Before the accident the GP can screen diving candidates to reduce their chances of becoming an accident. Local knowledge of diving sites can be useful when advising novices and when an accident occurs. Prescribing for divers needs care to avoid harmful side effects. Being aware of diving illnesses and knowing their treatment prepares the GP to handle diving accidents better. Knowing the Royal New Zealand Navy (RNZN) Hospital telephone diving emergency number (09-445-8454) makes contacting expert advice easy.

At the time of the accident the GP can be involved in First Aid and in diagnosing the problem. The informed GP is the person to contact expert advice about further treatment and decide how to act on the advice. This will involve organising transport, stabilising the patient's condition for transfer, arranging for recompression therapy, giving oxygen and fluids and keeping clinical records of the patient's condition, drugs given and fluid balance.

After the accident the patient needs to be followed up. A minimum is at one week, at one month and one year. This latter interview should include an interview with the spouse, who is the most sensitive detector of mental changes in the diver since the accident. Adequate support and medical assistance to a damaged diver may require much more frequent follow up. The other important post-accident service to the patient is keeping him or her from diving, or flying, for at least a month.

Table 1 summarises the ways that GPs can help their patients after a diving accident.

GP ROLES IN DIVE ACCIDENTS

Before the accident

l Screen dive trainees
2 Geographic knowledge
3 Awareness of diving illness.
4 Prescribe carefully for divers
5 Know RNZN Hospital telephone number (09-445-8454)

At the time of an accident.

1 First Aid
2 Diagnose the problem
3 Communication with expert advice
4 Reach an informed decision about treatment.
5 Organise transport
5 Stabilise for transfer/treatment at RCC
6 Give oxygen and fluids as appropriate
7 Keep records of clinical state and drugs/fluids given.

After the accident

1 Follow up at 1 week, 1 month, 1 year (with spouse)
2 Support and medical assistance
3 No diving nor flying for 1 month minimum

Discussion

Divers get into trouble at sea or in lakes and local GPs are often involved in the first aid treatment. This is helpful in assessing fluid administration and in accurate observation at a distance from the centre where definitive recompression may be offered. If these doctors are aware of hyperbaric principles this contact is valuable, but those who know little or nothing about diving medicine (which can include A&E house surgeons) may misdiagnose and cause delays in transport.

Land evacuation has to weighed against air evacuation before evacuation is arranged, In the meantime the highest possible oxygen concentration should be administered and hydration kept up. Networking local knowledge with the Naval Unit Medical Team's desire for stabilisation and rapid transport, where indicated, is the aim.

Recreational divers often present late. They may not mention that they were diving several days before and the diagnosis can be elusive. A high index of suspicion is needed to avoid missing diving related problems. Inner ear pathology may well be not reported by patients unless the symptoms are specifically asked about.

For severe disease rapid transport to a hyperbaric facility, after stabilisation, is indicated. This is even more important when symptoms of DCI appear early. New Zealand's geography means dive locations are often remote and separated from Auckland by mountains. Helicopters, being able to keep below 300 m, and some fixed wing aircraft, which can be pressurised to ground level, may have advantages over !and transport by car or ambulance.

In the early 1980s in the Northland area we instituted a local service based on St John's Ambulance notification. Now the Westpac helicopter service, which is co-ordinated from Auckland, has replaced the original scheme. The main disadvantage is the lack, in Auckland, of local knowledge of the geography. Paramedics now attend emergencies and diving doctors are no longer used. In some cases helicopters are, in fact, a slow option because of delays in reaching the patient when the helicopter is already in use elsewhere,

Helicopters enable access to remote areas, Northland is now being serviced from Auckland by the Westpac Squirrel or from Whangarei by the Northland Emergency Services Trust (supported by Northpower) using a Kawasaki BK117 helicopter. These are expensive, limited for space, but well equipped with resuscitation gear. If the patient is acutely unwell and unstable, helicopters can be a less safe option than an ambulance which has room for on-going resuscitation and treatment by a doctor.

The following case illustrates some of the problems in Northland.

Case report

In March 1984 a 20 year old man, an experienced diver, entered the water at 0930 off the Cavalli Islands, about 225 km, as the crow flies, north of Auckland. The previous day he had dived to 24 m for 25 minutes. He dived to 27 m, swimming hard in a current, for crayfish, for 17 minutes. On the surface at the end of the dive, he was conscious and inflated his buoyancy compensator. He developed pins and needles and numbness, then lost consciousness for 2 minutes. He did not vomit or cough up blood.

In the previous 2 years he had noted paraesthesias and elbow pain on at least 3 occasions after diving, and had done at least one bounce dive to 69 m. He had had a normal chest X-ray 5 days before the accident. As a result his GP advised that he was safe to dive, although he had had a cough and recurrent chest infections for 6 months before his accident.

He was rapidly taken by boat to Te Ngaere Bay, a distance of some 10 km. Assistance was sought by CB radio en route, advising the then Winfield helicopter service at 1000. An ambulance met the boat and oxygen by mask was started 30 minutes after surfacing. He was conscious in an ambulance to Kaeo Hospital, a journey of about 15-20 km. His breathing had become laboured 1 hour post dive. The helicopter arrived at 1330, 3 and a half hours after being notified. By this time he was unconscious again and needed stabilisation to travel. The helicopter was low on fuel so they flew about 50 km north west to Kaitaia to refuel. They flew to Auckland down the West Coast, stopping about every 15 minutes to allow the paramedic to reassess his condition. The helicopter covered about 250 km to reach the Royal New Zealand Navy Hospital at 1600, six and a quarter hours after he surfaced.

He was recompressed, then had to be decompressed early because of increasing respiratory difficulty and transferred to the Critical Care Unit at Auckland Public Hospital. He survived as a T6 paraplegic. His marriage failed after his accident. Sadly his accident was before the ICU-under-pressure facilities were installed at the Slark Hyperbaric Unit.

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EVACUATION METHODS IN DIVING INJURIES

Mike Bennett

Key Words

Accident, transport.

Introduction

The evacuation and retrieval of diving injuries is an unavoidable issue for those involved in the treatment of decompression illness (DCI) in the recreational diver and is likely to remain so for the foreseeable future. This is because civilian hyperbaric facilities in Australasia are relatively widely scattered and the best dive sites are often remote from a treatment chamber. This means that acutely unwell divers will require transfer over considerable distances in order to reach definitive care. This paper outlines the principles involved in selecting the appropriate transport and illustrates some of these with reference to recent cases at the Prince of Wales Hospital.

Retrieval options

There are four methods by which a patient with DCI may reach a hyperbaric facility. These are by private car or public transport (usually without seeing a doctor first) or by ambulance (road, helicopter or fixed wing). While the proportions alter according to local resources and geography, for many facilities all will be utilised to some extent. In New South Wales (NSW) approximately half our patients arrive by car or public transport without prior medical attention, while for the remainder ground, rotary wing and fixed wing ambulances are roughly equally utilised.[1] At times the particular form of ambulance used may be dictated by circumstance or economic necessity, but often a decision will have to be made. Such decisions should be informed by a knowledge of the available resources (including vehicles, crew and clinical equipement), optimal communications and experience of the practical capabilities of each crew/ambulance combination available. A local appraisal of topography, weather and access by a person at the scene is often invaluable.

The traditional approach to optimal transfer has relied on a number of principles which can often be in conflict. Chiefly, these principles are:

1 That the time interval from exiting the water (sometimes time from onset of symptoms is preferred) to compression is prognostically important.

2 That the altitude attained during retrieval may affect disease progression and ultimately prognosis.

3 The initial severity of the injury is also prognostically important.

It is not yet clearly demonstrated which, if any, of these principles is more important in determining outcome and should therefore take precedence in the case of conflict. Some attempt has been made to relate delay to treatment and outcome, but without any firm conclusions being drawn.[1] The 1996 edition of the Divers Alert Network (DAN) report strongly suggests such a relationship, but relates delay to treatment with residual symptoms after the first treatment only, rather than on completion of treatment course.[2] Theoretical considerations and many anecdotal reports suggest that altitude stress is important and there has been at least one local case of litigation on this basis. A number of severity scoring systems have been proposed and appear to have some prognostic value.[3,4]

Table 1 lists a number of factors which may be important in the transport of patients following diving accidents and the performance of three transport platforms with regard to each. These are discussed below.

Response time is rapid with dedicated retrieval vehicles, both rotary wing and road ambulances, as there is little preparation to be made before call out. This reflects the primary purpose of such vehicles to respond to emergency situations. The response time for a helicopter will be dramatically altered if retrieval is only a secondary function. Fixed wing craft inevitably have a longer response time, particularly if operating out of a busy airport. The figures in Table 1 are those achieved by the New South Wales retrieval system.

Once a retrieval is underway speed has a powerful influence on the interval from dive to compression. Analysis of our experience in NSW suggests that the combination of response time and speed results in a "doughnut" concept of those retrievals for which a helicopter is appropriate. Within the Sydney metropolitan

TABLE 1

SOME FACTORS FOR CONSIDERATION WHEN CHOOSING THE MOST APPROPRIATE TRANSPORT PLATFORM

	Road	**Fixed Wing**	**Helicopter**
Response time	Minutes	1 hour	10 minutes
Speed	60 km/hr	550 km/hr	200 km/hr
Altitude	Topography dictates	Sea level equivalent	Day 50 m Night 800 m
Access	Road system	Airfield	Versatile
Weather	Independent	VFR/IFR*	VFR (IFR)*
Availability	Excellent	Variable	Variable
Crew	Graded response	Variable	Variable. Often have specific training
Vibration	0-5 Hz, low magnitude	Bi-phasic,1-12 Hz and 100-600 Hz, high magnitude	6-34 Hz, moderate magnitude

*VFR: visual flight regulations, IFR: instrument flight regulations.

area, ground ambulances are almost instantly despatched and helicopters rarely deliver the patient significantly more rapidly. Further than 350 to 400 km, fixed wing transfer is usually the preferred option as the aircraft's greater speed through the air overcomes the longer response time. This leaves an area of operations from about 40 km to 400 km in which helicopters are the superior option if time to definitive treatment is considered in isolation.

Altitude stress is a problem particularly identified with unpressurised aircraft or commercial aircraft with partial pressurisation (a typical long-haul flight cruises at a cabin pressure equivalent to 1,500-2,500 m). Many dedicated fixed wing ambulances are capable of being fully pressurised (to sea level) which eliminates the problems of crossing mountains. Road transport is highly dependent on topography and any planned retrieval where altitude is critical should be examined closely. It is often a helicopter flying at low altitude over the ocean which results in least altitude exposure. However, at night the minimum safe operating altitudes for helicopters are considerably higher than in daylight, commonly around 600 m.

Access to an injured diver may sometimes be a problem. While the road system in many parts of the world is extensive, there are usually some remote spots where a walk or boat ride is the only way in. Under these circumstances, a helicopter or ground party will clearly be required to bring help to the scene. Indeed, helicopters with a personnel winch and rappel-capable emergency medical staff are irreplaceable under these circumstances.

Weather can disrupt the best laid plans for a retrieval and any effort to retrieve a diver by air should only be undertaken after consulting the appropriate meteorological authorities. Poor weather or freezing conditions may ground, or force higher, many aircraft. This is particularly true of helicopters.

The training and abilities of retrieval medical personnel may influence the choice of transport platform beyond the physical capabilities of the platform itself. Highly trained and experienced medical and paramedical crew are a valuable resource and may need to be relocated with their sophisticated equipment by a means which would otherwise be rejected. In NSW, we are fortunate to have a retrieval network which includes several specialist-based medical teams which may be despatched rapidly by any transport platform. Part of the complex task of retrieval co-ordination is to match the skills required for a particular retrieval with the resources available.

It has been suggested that the vibration characteristics of different platforms may adversely effect the patient with DCI. In particular, high frequency, energetic vibration may adversely effect bubble generation, evolution or distribution. There is, as yet, no clinical data to support or reject this hypothesis. Bosshard and Yeo[5] studied the vibration characteristics of the three types of ambulance in a study concerned with the transport of spinal injured patients. They concluded that the helicopter studied (a twin engined Squirrel) produced vibration of moderate magnitude in a predictable range of frequencies. Vibration in the fixed wing aircraft (Beechcraft King Air) was more energetic and of higher frequency during flight and of very low frequency but equal magnitude on take-off and landing. The road vehicle was least challenging in terms of vibration energy. The significance of these findings in relation to bubble behaviour is unknown.

Recent experience in NSW

The last 133 cases treated at the Prince of Wales Hospital Hyperbaric Unit have been analysed retrospectively with regard to transport platform, time to recompression, altitude stress and resolution of symptoms at discharge. The results are summarised in Table 2. A more detailed analysis of a similar group has been published previously.[1] The numbers are too small for definite conclusions about the relative importance of the factors discussed and we are collecting prospective data for a more formal analysis.

Table 2 suggests that those who self-refer take significantly longer to seek compression than those who arrive by fixed wing or road ambulances. The helicopter group have been omitted because the high incidence of cerebral arterial gas embolism (CAGE)-type disease and markedly shorter intervals to compression. The difference, on average, of 28 hours is statistically significant ($P<0.001$, 95% CI 14.4 hours to 41.6 hours), however the longer interval from symptoms to compression does not lead to a significantly increased rate of incomplete resolution (38% in the self-referred group versus 28% in the fixed wing/road group, χ^2 0.42, $P=0.52$).

There is no evidence of a benefit in terms of recovery grade at discharge between retrieval at low cabin altitude in the fixed wing aircraft and transfer by road ambulance (average cabin altitude 52 m by fixed wing and 200 m by road, χ^2 0.64, $P=0.44$). Better prospective data on a larger group may enable us to tease out the relative importance of time delays, altitude exposure and severity.

Case 1

A 22 year old diver of moderate experience had been diving, for one week, with a group on an island three and a half hours flight off the coast of NSW. She had not made more than two dives in a single day for a total of 12 dives over the week and each individual dive was unremarkable. She had not breached the sports tables she was using.

Approximately four hours after the last of these dives she became unwell, complaining of lethargy, malaise and

TABLE 2

TRANSPORT MODE, ALTITUDE AND RESOLUTION FOR 133 DIVERS WITH DCI

Retrieval Method	Patient numbers	Mean maximum altitude	Average interval to compression	Full resolution		Incomplete resolution	
Self-referral	69	200 m	52.0 h	50	(72.5%)	19	(27.5%)
Fixed wing	23	52 m	27.7 h	19	(82.6%)	4	(17.4%)
Rotary wing	23	150 m	5.0 h	17	(73.9%)	6	(26.1%)
Road	18	200 m	21.0 h	13	(72.2%)	5	(27.8%)

paraesthesia in both hands. There were no objective signs. She sought help at the local hospital and one and a half hours after the onset of symptoms was on high flow oxygen through a non-rebreathing mask with reservoir. The attending medical officer contacted our unit and by this time her symptoms had resolved about 75%.

The regular commercial return flight from the island was due to leave in 2 hours and it was quickly determined that space was available for her and an attendant should we wish to use this flight for repatriation. Alternatively, the NSW Air Ambulance (4 Beechcraft King Air pressurised aeroplanes) was fully employed elsewhere and would not be able to reach the patient with nurse/paramedic team for approximately six hours. To this would need to be added turnaround time on the island, return flight and the short ground trip in Sydney. Total retrieval times would therefore be about 6 hours for the commercial option and 12 hours for the dedicated retrieval vehicle.

THE RETRIEVAL DILEMMA

Which of the two principles, minimising the interval to definitive treatment or minimising altitude stress, was the more important? The commercial flight was discussed but the dispatching medical team on the island were uncomfortable with this and elected to wait for the Air Ambulance.

OUTCOME

Total delay from symptom onset to compression was 16 hours. She required an initial RN Table 62 and two further oxygen soaks (2.4 bar for 90 minutes each), before being discharged well. She had some minor recurrence of paraesthesia which settled over the next couple of weeks and was completely recovered at review six weeks after discharge.

Case 2

A 32 year old experienced male diver had been diving on the south coast of NSW over the weekend. He had done 5 separate dives over Saturday and Sunday, during the last of which he had attained a maximum depth of 46 m and a profile which exceeded the DCIEM Tables. This dive was the second for the day but the deeper of the two and he had completed the dive in the late afternoon.

About 30 minutes after surfacing he began to complain of pain in the right shoulder, right elbow and both ankles. There was some associated paraesthesia in the right hand, he felt unsteady on his feet and gradually developed an occipital headache which worsened over the next 30 minutes while en route to the local hospital.

On arrival he walked into the Emergency Department and after giving a brief history and accurate diagnosis to the nursing staff, our unit was contacted. Concurrent medical examination was unremarkable except for a very poor Romberg's (a few seconds only), which was performed before lying him flat and administering high-flow oxygen and intravenous fluids. There was little or no improvement in his symptoms after this first aid was instituted.

The hospital is located 160 km (about 2.5 hours by road) from Sydney and has both a helicopter pad in the grounds and a military airfield nearby open to emergency vehicles if required. The road trip requires a maximum altitude of about 500 m with many short ascents and descents.

THE RETRIEVAL DILEMMA

Retrieval options all presented some problems. Road transfer is discouraged because it involves altitude stress and the loss of an ambulance and crew from the region for an extended period. No medical attendant would be possible. Total time from hospital arrival to compression would be about three hours.

Helicopter transfer with doctor/paramedic crew is the preferred option during the day as low-level (<100 m) flight is possible and specialist personnel will reach the patient in minimal time, little more than the 30 minute helicopter flight. At night however, the minimum safe altitude is over 600 m and may be higher in bad weather. Total time from hospital arrival to compression would be about two hours.

Fixed wing ambulance transfer is not usually contemplated for such a short flight but given the constraints above was considered. Such a vehicle enables sea level cabin pressure on the return leg and a paramedic/nurse crew which may be supplemented by a retrieval medical officer if required. There is a 15 minute road ambulance trip from the hospital to the local airfield. Total time from hospital arrival to compression would be about 3.5 hours.

OUTCOME

Because of the expected return in the hours of darkness, the unwillingness to consign the patient to a lengthy road trip without specialist attendants and little evidence that his symptoms were settling with first aid measures, it was decided to transfer the patient by fixed wing aircraft. This expensive option was, in fact, subject to unavoidable operational delay and the actual interval from symptom onset to compression was 7.5 hours. He was treated initially with an RN Table 62 with rapid resolution of symptoms and required one further short table before being discharged well. He reported no return of symptoms and continued well and resumed his diving six weeks after the incident.

Conclusions

The retrieval of diving injuries can be complicated by a number of factors which impinge on the decision as to which transport method is most appropriate and the level of medical attendance required. Rational choice depends on the retrieval decisions being taken by those with experience both in the primary pathology and the practicalities of the retrieval system.

It is not yet possible for decisions to be made on the basis of good evidence as to which strategies provide optimal outcomes. Further investigation as to the important, modifiable determinants of such outcomes (if any) is needed.

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NORTHLAND RESCUE HELICOPTER HI-LINE TRANSFERS

John Knight

Key Words

Accidents, equipment, rescue.

During the 1997 SPUMS Annual Scientific meeting the Northland Emergency Services Trust (NEST) helicopter lowered, and recovered, a crewman onto one of the diving vessels, during the mid-day surface interval, as a demonstration of how helicopter rescue of divers is performed. This paper includes information taken from the NEST poster display and pamphlet available at the meeting.

Being under a hovering helicopter is very windy and noisy and conversation is difficult without a loud-hailer. Being rescued from a boat is much more comfortable than being rescued from the sea or a life raft. In my experience a small life raft is blown along by the helicopter down draft making it difficult for the rafter to reach the strop. After five attempts to bring the stop within reach had failed I went into the water, the Solent in February, and swam to the strop. Being lifted out of the water was wonderful, but being winched up, dangling unable to help oneself, was still a scary experience. How much easier would it have been using if the Royal Navy had been using modern techniques, lowering a crewman to assist the casualty, back in 1954.

Using the Hi-Line technique described below the arrival of the helicopter crewman was a swift and simple operation. The weighted line was dropped (Figure 1), when the helicopter was well clear of the ship's various overhead obstructions, onto the dive boat bow, where the boat crew hauled in the line until it was tight. Then the helicopter moved to one side of the boat and the winchman prepared to descend. As the winch cable was paid out the boat crew maintained tension on the Hi-line so pulling the crewman towards the boat, over the guard rail and onto the deck. Here he disconnected himself from the cable. After a short

Figure 1. The NEST helicopter approaching the dive boat with the winchman standing on the skid holding the weighted Hi-line.

Figure 2. The NEST helicopter approaching the dive boat with the weighted Hi-line hanging free.

presentation in the cabin the winchman did the reverse journey. The weighted Hi-line was recovered to the helicopter and it wheeled away to Whangarei while the dive boat moved off for the afternoon dive.

The text below and the diagrams are taken from the NEST handout on Hi-line transfer.

Figure 3. The NEST helicopter with a crew member holding the winch cable while the winchman was hauled inboard.

The Northland Emergency Services Trust helicopter is a Kawasaki BK 117 based at Whangarei and equipped for Emergency Medical Service and Rescue operations. It is winch equipped and capable for positioning paramedic staff into inaccessible areas or vessels at sea, recovering patients back into the helicopter and delivering them to suitable medical care. This service may be initiated through the emergency 111 system by requesting Ambulance as the desired service or initiating the same request through Coast Radio Stations. This service is provided on a no cost basis in the case of illness or injury.

Winching to high-masted vessels or vessels with obstructions such as cranes and gantries creates a degree of difficulty for the standard vertical lift, particularly in heavy seas. In most such cases the Hi-line technique is used, both by military and civilian Search and Rescue (SAR) units.

Initially the helicopter will contact you on Channel 16 and may request you to change to a working channel.

Normally you will be required to lower your sails and keep steerage way with the wind approximately 30° on the Port bow, but wind speed and direction, sea state, position of the transfer area and manoeuvrability of the vessel may necessitate variations to the above. In any case, the helicopter should hover into the relative wind and care should be taken that variations in the vessel's course do not prejudice this during transfers.

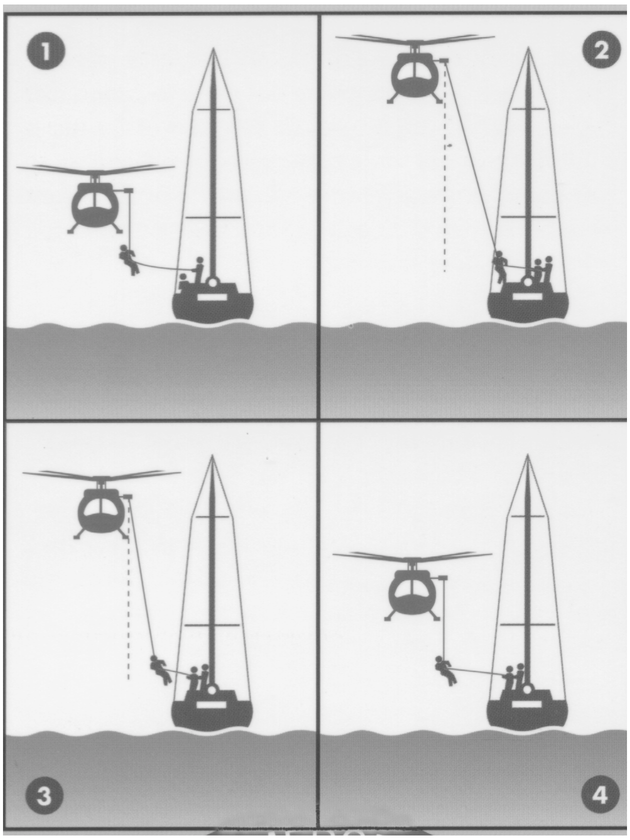
The transfer area should be selected to give as clear an area as possible with unobstructed access to the deck edge. Normally the vessel's Port quarter is used although circumstances may dictate otherwise. The helicopter crew will advise you where the transfer is to take place.

The "Hi-line " itself, is a 120' length of 1/4" braided nylon line. A screw gate karabiner is attached to both ends. The top end has a weak link and is attached to the helicopter winch hook. The bottom end is weighted.

The weighted end of the line is lowered to the deck of the vessel. If available, two deck crew should receive this and take in the slack, coiling loose line onto the deck or better still, into a bucket clear of obstructions.

THE HI-LINE MUST NEVER BE ATTACHED TO ANY PART OF THE VESSEL !!!

Tension on the line should be maintained to keep the line taut. Do not heave-in the line at this time. Deck crews are advised to wear gloves whilst handling the Hi-line (Diagram 1)



Once the line has been taken by the deck crew, the helicopter will move away from the vessel to prepare the winchman for lowering to the deck. At this time the deck crew must pay out the Hi-line. After winching out the winchman, the helicopter will climb to a safe height over the masts and obstructions whilst lowering the winchman to keep him level with the transfer area. The deck crew should take up the slack in the Hi-line so that the winchman does not swing.

The helicopter will then move towards the transfer area. Now the deck crew must continue to take up the slack and on the signal from the winchman, haul him on board (Diagram 2). When the winchman is on the deck, he will disconnect himself from the winch hook and the helicopter will move away from the vessel. The deck crew should now pay out the Hi-line. The winchman will brief the deck crew on any requirements.

For recovery, the winch hook is pulled in board to allow the casualty and the winchman to be attached. They will then be lifted off the deck. The deck crew should retain tension on the Hi-line to prevent excessive swinging (Diagrams 3 and 4).

Once the winchman and casualty are inside the helicopter, the Hi-line will be recovered by taking up the Hi-line until only the weighted end is left on the vessel. The deck crew should clear the weighted end from all obstructions and the Hi-line will be fully recovered by the helicopter crew.

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IS 100% OXYGEN NECESSARY IN THE EMERGENCY MANAGEMENT OF DECOMPRESSION ILLNESS?

Chris Acott

Key Words

Accident, decompression illness, first aid, oxygen, retrieval, treatment.

Abstract

Surface oxygen is now considered an essential component of the emergency management of decompression illness (DCI). Data suggest an improvement in pre-treatment symptoms, however outcome data are inconclusive. Frequently the FiO_2 in the emergency management is unknown and perhaps any concentration of

oxygen greater than 0.21 (21%) would benefit the patient and simplify oxygen administration. These issues are discussed in this paper.

Fructus, in 1979, advocated that aspirin, parenteral steroids, fluids and 100% oxygen be used in the emergency management of DCI patients. There are some data to suggest that aspirin is detrimental to pre-treatment outcome but this effect can be negated by the use of steroids and fluids. There is, however, a debate in Australasia about how fluids should be administered and the controversy of oral administration compared with parenteral fluids is discussed in this paper.

Introduction

Bert advocated the benefits of normobaric oxygen in the management of decompression illness (DCI) in 1878.[1] Behnke calculated an eleven fold increase in nitrogen washout using 100% ($FiO_2 = 1$) normobaric oxygen in 1937.[2] The reasons for using 100% oxygen for the emergency care of DCI patients are shown in Table 1. Fructus in 1979 advocated the combination of oxygen, aspirin, parenteral steroids and fluids in the emergency care of DCI from data obtained in the 1960s and 70s.[3]

TABLE 1

THEORETICAL REASONS FOR THE USE OF 100% OXYGEN IN THE EMERGENCY CARE OF DCI

No additional inert gas
Maximum gradient for inert gas washout
Relieves hypoxia

Normobaric oxygen

100% surface oxygen was recommended in the emergency management of DCI in the late 1960's[3] but there are few data to suggest that it has improved the outcome following treatment.

Recent DAN data reported that 58% of divers who received emergency oxygen were symptom free following treatment compared with 55% of divers who did not receive emergency oxygen. However, 12% of divers who received emergency oxygen were symptom free at presentation for treatment whereas only 2% of divers who did not receive oxygen were symptomless. What was not reported was the length of time emergency oxygen was used and at what concentration.[4] Earlier data published by Fructus showed that there was an improvement in pre-treatment symptoms when either oxygen or the complete emergency care protocol (Tables 2, 3 and 4, on page 18) were used in emergency care, unfortunately there was no correlation between outcome following treatment and the use of oxygen.[3] The FiO_2 was not established in these data. However, Marroni's 1996 European DAN data indicated a better outcome following treatment if emergency oxygen was used.[5] These data are shown in Table 5.

TABLE 2

EMERGENCY CARE PROTOCOL (FRUCTUS 1979)

100% Oxygen
Fluids
Aspirin
Steroids

TABLE 5

MARRONI'S EUROPEAN DAN DATA 1989-1993

	Oxygen		No Oxygen	
	Divers	%	Divers	%
Total divers	119	59	83	41
Symptoms before treatment				
Resolved	14	12	1	1
Improved	66	55	0	0
Unchanged	39	33	82	99
Symptoms after treatment				
Full resolution	114	96	58	70
Sequelae	5	4	25	30

Fluid administration

No definite conclusions can be drawn from Fructus's data because of the small number (57) of divers involved, however, there is an indication that the addition of aspirin has a negative effect on the pre-treatment outcome which can, in turn, be negated by the addition of parenteral fluids (500 ml Dextran 40) and steroids (either hydrocortisone 1,000 mg or dexamethasone 30 mg or medrocortisone 160 mg).[3]

Diving has a dehydrating effect (up to a 10-12% reduction in the circulating blood volume)[6] and DCI induces plasma loss,[2,6,7] therefore, fluid replacement should be an essential component in the management of DCI.[7] Maintenance of the cardiac output and normal blood viscosity are important in the maintenance of epidural and

TABLE 3

CHANGES IN SYMPTOMS BY THE TIME OF TREATMENT (DENOTES NO CHANGE) (FRUCTUS 1979)

Symptoms	Complete protocol		Oxygen and aspirin		Oxygen		None	
Cerebral	12	(3)	1	(0)	2	(0)	8	(8)
Spinal	27	(7)	4	(2)	1	(0)	6	(6)
Mixed	6	(3)	0		0		0	
TOTAL	**45**	**(13)**	**5**	**(2)**	**3**	**(0)**	**14**	**(14)**
Unchanged symptoms	30%		40%		0%		100%	
Improved	**70%**		**60%**		**100%**		**0%**	

TABLE 4

DIVERS WHO WERE (ASYMPTOMATIC) AT THE TIME OF TREATMENT (FRUCTUS 1979).

Symptoms	Complete protocol		Oxygen and aspirin		Oxygen		None	
Cerebral	12	(6)	1	(0)	2	(1)	8	(0)
Spinal	27	(5)	4	(0)	1	(0)	6	(0)
Mixed	6	(0)	0		0		0	
TOTAL	**45**	**(11)**	**5**	**(0)**	**3**	**(1)**	**14**	**(0)**
Asymptomatic	**25%**		**0%**		**33%**		**0%**	

cerebral blood flow to prevent sludging and vascular stasis which hinder tissue and bubble inert gas washout. Parenteral fluid replacement (normal saline) has been clearly shown to be beneficial in an equivalent animal model of DCI, allowing a significantly better survival compared with none.[6] Data about fluid replacement is of parenteral administration and not oral.[3,6,7] The advantages and disadvantages of oral compared with intravenous fluid are listed in Tables 6 and 7.

Oral fluid replacement has a minimal place in emergency care and should only be used when IV fluid administration can not be achieved and an appropriate fasting time achieved before recompression treatment commences. Oral fluid must never be given to an unconscious or obtunded patient. The composition of the fluid used should be similar to that of the fluid lost and should not contain glucose/dextrose.[8] Its use should not interfere with oxygen administration, change the patient's first aid posture nor worsen the patient's clinical state (i.e. convert a nauseated patient to a vomiting one which will worsen the patient's dehydration).

TABLE 6

ADVANTAGES AND DISADVANTAGES OF INTRAVENOUS FLUIDS IN THE EMERGENCY MANAGEMENT OF DCI

Advantages

Direct into circulation
Fluid balance easier to calculate
Either crystalloid or colloid fluids can be used
Glucose containing fluids easily avoided
Can be used in nauseated, vomiting and obtunded patients
Do not present an aspiration risk in an epileptogenic environment of 2.8 bar oxygen
Can be used for rapid administration of medications if required
Patient's flat posture can be maintained
Does not interrupt oxygen administration

Disadvantages

Requires training, skill and revision of skills
Potential for fluid overload
Expensive

TABLE 7

ADVANTAGES AND DISADVANTAGES OF ORAL FLUIDS IN THE EMERGENCY MANAGEMENT OF DCI

Advantages
Inexpensive
Easy to administer

Disadvantages
Rely on gut absorption for access to the circulation
Fluid balance estimates inaccurate
Can not be given to obtunded or vomiting patients
Large amounts may cause vomiting in nauseated patients
Aspiration risk in an epileptogenic environment of 2.8 bar oxygen
Have to remove oxygen mask to give
If only given in air breaks large amounts are difficult to give
May need the patient to change posture to drink
Oral salt solutions are unpalatable or contain glucose and are not similar in composition to the fluid loss that occurs in DCI

Is 100% oxygen essential?

In the published data[3-5] the F_IO_2 was unknown (a substantial number would have been less than 1.0 or 100%) but many patients' symptoms had resolved by the time of treatment.

The Diving Incident Monitoring Study (DIMS) data, listed in Table 8, indicate some of the difficulties of administering 100% oxygen in the field.

Table 8 about here

TABLE 8

DIVING INCIDENT MONITORING STUDY [DIMS] FIRST AID DATA

38 reports analysed
In the majority the FiO_2 was unknown
Oxygen equipment was not checked; oxygen cylinders were found to be empty
A lack of knowledge on how to use the oxygen equipment
Inappropriate air breaks used
Resolution of symptoms in 50% of cases where was oxygen used
Oxygen was not administered in 20% of cases due to lack of equipment or other reasons

Administration of a lower F_IO_2 (less than 100%) would simplify oxygen administration by eliminating the need for air breaks, reduce the incidence of pulmonary oxygen toxicity, simplify and reduce the cost of the equipment needed. As the kinetics of gas elimination in a patient with DCI are unknown, any increase in the gradient for inert gas washout is likely to benefit the patient. Using a lower oxygen percentage will reduce the risk of the oxygen supply running out and so increase the time that increased oxygen is available.

Does lignocaine have a role?

Should a lignocaine infusion be commenced during transport to the nearest recompression facility? The answer will be evident once the role of lignocaine in the treatment of DCI has been established or refuted.[9] If lignocaine's role is established then an infusion could be commenced provided the necessary monitoring and resuscitation equipment are available.

Conclusions

Training for emergency care should always be aimed at the management of the worst case scenario thus enabling the first aid provider to manipulate his or her management to suit each situation. Intravenous fluid replacement should be encouraged and training courses established to achieve this. However at present such courses are not available for recreational divers in Australasia. Oral fluid administration guidelines need to be agreed upon and issued.

The theoretical advantages of the administration of 100% oxygen in the emergency care of any diving injury are well known, however, there are limited data that suggests it improves post-treatment outcome.

An F_IO_2 of 1.0 (100%) is difficult to achieve and the equipment required is expensive. Oxygen administration would be simplified if an F_IO_2 of less than 1.0 was used and cost of the equipment would be less.

The role of parenteral steroids and lignocaine in the emergency care of DCI is not yet established.

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OXYGEN ADMINISTRATION IN DIVING ACCIDENTS

David Komesaroff

Key Words

Accidents, equipment, first aid, oxygen, rescue.

Introduction

Oxygen administration in diving accidents has been well documented.[1] However the importance of duration of oxygen supply, humidification and temperature of inspired oxygen and pain relief has often been overlooked.

Basal (resting) physiological oxygen requirements of an adult are approximately 250 ml/min (3 ml/kg). Activity, body temperature and the presence of pain increase this. 2 l/min is about the maximum possible oxygen utilisation (measured in athletes following a 100 m sprint).

In demand valve resuscitators, high flow rates of oxygen are used to flush the exhaled carbon dioxide to the atmosphere. This has several disadvantages.

Approximately 10 l/min of oxygen are required.

The inhaled oxygen is dry and cold.

Sterilisation of equipment after use is inconvenient or impossible.

In closed circuit resuscitation systems less oxygen is used as expired carbon dioxide is removed by an absorbent, for example soda lime or baralyme.

Oxygen supply

A demand valve system requires a fresh gas flow in excess of 10 l/min. A demand valve system with manual triggering for the non-breathing patient (Manually Triggered Ventilator or MTV) will require more. C Size portable oxygen cylinders (2.84 l water volume) contain about 400 litres of oxygen, so a cylinder change is necessary about every 30 minutes. It is therefore essential to have available either multiple C size cylinders or a larger non-portable D (9.5 l water volume), containing about 1,600 l, or E (23.8 l water volume), containing about 2,200 l, size cylinder.

A closed circuit system (such as the OXI-dive1™) theoretically requires a fresh gas flow of about 0.25 l/min but in practice about 3 l/min is needed to achieve 100% inspired oxygen in a diving accident victim. A portable cylinder will last about 120-130 minutes. In experienced hands the closed circuit system requires only 1-2 l/min equating to approximately four hours supply of oxygen.

Humidification and warming of inspired gases

Diving accident victims require warming. With open circuit, high flow systems the administration of cold dry gases over long periods causes a loss of expired water vapour and a reduction of ciliary activity in the respiratory tract mucosa. In a closed circuit breathing system recirculation of the breathing gas retains humidity and heat.

Cross Infection

The National Health and Medical Research Council (NHMRC) in Australia have published infection control guidelines for breathing circuit apparatus.[1] Equipment used for the administration of oxygen must be renewed or sterilised before re-use on another patient.

Demand valve oxygen systems are difficult to sterilise. As the separate components must be dismantled for cleaning, extreme care must be taken to ensure correct reassembly. In the OXI-dive™1, the breathing circuit components, including the KAB™ carbon dioxide absorber, can be autoclaved to ensure sterility. Alternatively it may be more convenient to use disposable components.

Inspired oxygen concentrations in the Oxi-dive™1

An investigation of respiratory rates, inspiratory and expiratory pressures, inspired oxygen concentrations and end tidal $PC0_2$ when using the Oxi-dive™1 was carried out. The Oxi-dive™1 is a closed circuit system which incorporates the KAB™ carbon dioxide absorber (available in autoclavable or disposable versions), a circle breathing system, oxygen cylinder, KDK™ Autovalve and self-sealing valve connections for attaching to an external oxygen supply. The tough plastic case housing the components is waterproof. The oxygen cylinder supplied with the Oxi-dive™1 is smaller than a C size cylinder (water volume 2.12 litres, contents about 320 litres). A C size cylinder is available on request fitted in a larger case.

Method

Two adult volunteers, Case 1(32 year old, 71kg male) and Case 2 (43 year old 90kg male) were the subjects. An OXI-dive™1 closed circuit resuscitator incorporating a KAB™ circular carbon dioxide absorber and a "Flexhose" twin hose breathing circuit (Figure 1) was used. The monitor port at the Y-piece was connected to a Datex Capnomac monitor after calibration against room air. A second line was connected to a pressure gauge (graduated -10 cm to +70 cm H_2O) to measure inspiratory and expiratory resistance in Case 1.

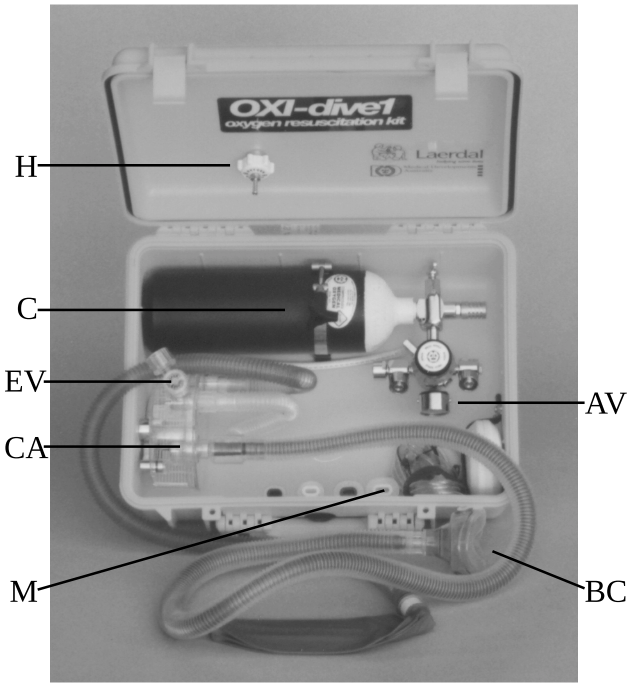

Figure 1. The OXI-dive™1 closed circuit oxygen resuscitator in its Pelican waterproof case. Individual items are the 8 l/min handwheel (H), oxygen cylinder (C), KDK™ AutoValve with 2 or 3 self seal outlets with a flow outlet at 11 o'clock (AV), KAB™ carbon dioxide absorber, shown empty of absorbent, (CA), the breathing circuit (hose in hose tubing) with a cushioned face mask and a breathing bag (BC), the adjustable pressure limiting exhause valve (EV) and storage for airways, a Hudson mask and a Laerdal pocket mask (M).

A size 5 disposable, cushion facemask (King Systems) was fitted to the patient port of the breathing circuit. The oxygen bypass (Flush) button was used to fill the breathing bag rapidly at the start of each set of tests. When the volunteers were connected to the circuit the adjustable pressure limiting (APL) valve was rotated (anti-clockwise) to the open position. The time, respiratory rate, end tidal PCO_2 and the inspired oxygen concentration (FiO_2) were recorded regularly. The inspiratory and expiratory pressures were recorded at random intervals. Four different flow rates were tested. These are described below

Results

High oxygen concentrations were obtained using all the settings tested. In all experiments inspiratory and expiratory pressures were acceptable. End tidal CO_2 levels were in the normal physiological range, showing that the absorbers were functioning correctly.

TABLE 1

OXYGEN FLOW RATE 2 l/min FOR 2 MINUTES THEN 0.5 l/min

Time Minutes	Respiratory rate Case 1	Respiratory rate Case 2	Inspiratory pressure cm water Case 1	Expiratory pressure cm water Case 1	End tidal PCO_2 Case 1	End tidal PCO_2 Case 2	Inspired oxygen % Case 1	Inspired oxygen % Case 2
Flow rate 2 l/min								
0	14	13	-1.5	+2	40	40	21	21
0.5	12	12			41	38	78	56
1	11	11			38	39	80	65
2	11	10	-1.5	+2	37	37	80	76
Flow rate reduced to 0.5 l/min								
3	10	12			36	41	58	77
4	10	11			37	37	67	77
5	11	10			39	34	68	79
6	12	11	-2	+2.5	36	38	63	79
10	12	11			37	37	67	80

TABLE 2

OXYGEN FLOW RATE 2 l/min UNTIL F_IO_2 100% THEN 0.5 l/min

Time Minutes	Respiratory rate Case 1	Respiratory rate Case 2	Inspiratory pressure cm water Case 1	Expiratory pressure cm water Case 1	End tidal PCO2 Case 1	End tidal PCO2 Case 2	Inspired oxygen % Case 1	Inspired oxygen % Case 2
Fresh gas flow 2 l/min								
0	11	12	-1.5	+2	40	40	21	21
0.5	10	12	-1	+2	39	37	71	69
1	9	12			41	38	85	79
2	12	12			39	40	91	86
2.25	10	11			36	40	91	90
3	11	12			41	37	94	90
4	11	10			38	39	92	94
5	11	10			37	36	93	97
6	10	11	-2	+2.5	39	35	94	98
7	10	11			38	37	96	99
7.25	10	11			36	37	98	100
8	11	11	-1.5	+2	36	38	98	100
Fresh gas flow rate reduced to 0.5 l/min								
9	11	11			39	38	95	96
10	13	12			36	38	93	94
11	12	11			36	39	90	92
12	10	10			38	40	88	89
13	14	11			34	36	88	86
14	11	11			37	39	86	87
15	12	11			36	38	87	85

In the first experiment, the flowrate on the KDK Autovalve™ was set at 2 l/min for two minutes and then reduced to 0.5 l/min. After 10 minutes the inspired oxygen was only 67% in Case 1 and 80% in Case 2 (Table 1).

In the 2nd experiment the flowrate was set at 2 l/min until an inspired oxygen of 100% was achieved, which took 7 minutes and 25 seconds for Case 2. Case 1 had reached 98% after 8 minutes. Then the flowrate was reduced to 0.5

TABLE 3

OXYGEN FLOW RATE 8 l/min FOR 5 MINUTES THEN 2 l/min

Time Minutes	Respiratory rate Case 1	Respiratory rate Case 2	Inspiratory pressure cm water Case 1	Expiratory pressure cm water Case 1	End tidal PCO_2 Case 1	End tidal PCO_2 Case 2	Inspired oxygen % Case 1	Inspired oxygen % Case 2
Fresh gas flow 8 l/min								
0	11	12	-1.5	+2	41	40	21	21
0.5	13	11	-1	+2	37	38	90	100
1	12	10			40	38	100	100
2	10	13			39	39	100	100
2.25	13	10			36	37	100	100
3	11	13			37	39	100	100
4	13	11	-2	+2.5	37	38	100	100
5	12	11			37	37	100	100
Fresh gas flow rate reduced to 2 l/min								
10	11	11			40	38	97	98
11	12	11	-2	+2	37	39	97	96
12	12	10			38	40	94	94
13	10	10			38	38	95	96
14	11	10	-1.5	+2.5	38	39	94	96
15	11	10			38	38	95	94

l/min. The oxygen percentage dropped to 93% in Case 1 and 94% in Case 2 at 10 minutes and by 15 minutes it had dropped to 87% in Case 1 and 85% in Case 2 (Table 2).

In the 3rd experiment the flowrate was set at 8 l/min for five minutes and then reduced to 2 l/min. An inspired oxygen of 100% was achieved in 1 minute in both volunteers. However 5 minutes after reducing the flow rate to 2 l/min there was a steady drop in inspired oxygen and at 15 minutes it was 95% in Case 1 and 94% in Case 2 (Table 3).

In the 4th experiment the flowrate was set at 8 l/min for five minutes and then reduced to 3 l/min. The inspired oxygen for both subjects was 100% at 1 and at 5 minutes. At 10 minutes inspired oxygen was 99% in Case 1 and 98% in Case 2. At 15 minutes both subjects were breathing 99% oxygen. (Table 4 page 24)

Discussion

The basal oxygen requirement at rest is about 250 ml/min. However 0.5 l/min is the minimum recommended fresh gas flow of oxygen for closed circuit resuscitation systems. With low fresh gas flows the inspired oxygen only increases slowly with time because of mixing with expired gas, which has lower concentrations of oxygen (Table 1). This is accentuated in the presence of nitrogen loading which is common in diving accidents.

To maintain 100% inspired oxygen concentration, an initial fresh gas flow rate of 8 l/min of oxygen for five minutes and then reducing the flow to 3 l/min is recommended (Table 4).

To maintain inspired oxygen concentration over 90% an initial fresh gas flow rate of 8 l/min of oxygen for five minutes and then reducing to 2 l/min is required (Table 3).

How to use OXI-dive™1

1 Set the KDK Autovalve™ to an oxygen flow rate of 8 l/min.
2 Pre-fill the rebreathing bag with oxygen by occluding the patient port of the breathing circuit and depressing the oxygen bypass (Flush) button.
3 Attach the facemask to the breathing circuit and apply to the victim’s face. The facemask is preferably held by the victim but can be assisted by the operator.
4 Open the exhaust (APL) valve.
5 After 5 minutes reduce the oxygen flow rate to 3 l/min.
6 Observe that the breathing bag regularly inflates and deflates. If the breathing bag tends to deflate, correct the application of the face mask to reduce leaks and/or increase the flow rate until the bag remains adequately inflated.
7 The oxygen bypass can be depressed at any setting to instantly refill the breathing bag.

TABLE 4

OXYGEN FLOW RATE 8 L/MIN FOR 5 MINUTES THEN 3 L/MIN

Time Minutes	Respiratory rate Case 1	Respiratory rate Case 2	Inspiratory pressure cm water Case 1	Expiratory pressure cm water Case 1	End Tidal PCO_2 Case 1	End Tidal PCO_2 Case 2	Inspired oxygen % Case 1	Inspired oxygen % Case 2
Flow rate 8 l/min								
0	14	14	-1.5	+2	41	40	21	21
0.5	13	13	-1	+2	39	38	90	100
1	13	13			40	38	100	100
2	12	11			39	37	100	100
2.25	11	12			37	39	100	100
3	11	13			39	38	100	100
4	10	11			37	39	100	100
5	11	10			38	36	100	100
Flow rate reduced to 3 l/min								
9	13	13			39	40	100	99
10	11	14			39	38	99	98
11	13	12			40	37	99	99
12	12	13			36	37	98	100
13	10	11			38	37	99	99
14	10	11			37	39	99	99
15	11	10			38	37	99	99

Important points when using Oxi-dive™1

If the patient is breathing, the exhaust (APL) valve must be remain in the open position (turned anti-clockwise). Excess gas in the breathing circuit is automatically vented.

If the patient stops breathing, close the APL valve (turn clockwise). The operator maintains the facemask in position and compresses the breathing bag intermittently approximately 14 times a minute. Excess gas in the breathing circuit is vented by briefly opening the ALP valve as required.

The oxygen bypass (Flush) rapidly inflates the re-breathing bag at the commencement of operation. It is also used for intermittent rapid filling if the breathing bag deflates.

To increase the rate of nitrogen or toxic gases (e.g. carbon monoxide) removal from the breathing circuit:

1 Remove the face mask from the patient's face every 5-10 minutes.
2 Empty the breathing bag.
3 Rapidly refill the breathing bag by depressing the oxygen bypass.
4 Re-apply the facemask and proceed as described above.

Other oxygen administration systems

Medical Developments Australia also produce three other oxygen resuscitation systems. All include accessories such as airways, pocket masks, etc. Venturi suction is available as an option.

OXI-dive™ 1A

Combined closed circuit and non-rebreathing demand valve system. It is the same as OXI-dive™1 with an manually triggered ventilator fitted with a self-store, coiled hose in the same case.

OXI-dive™2

Non re-breathing demand valve system. Consists of a manually triggered ventilator, oxygen cylinder, KDK™ regulator and self-sealing valve connections for attaching to an external oxygen supply. The tough plastic case housing the components is waterproof.

OXI-dive™3

As for OXI-dive™2 in a small compact case without the oxygen cylinder. Includes the PIBN adapter for connecting the KDK™ regulator to an external oxygen cylinder with a threaded fitting.

Conclusions

It is surprising that high flow non-rebreathing systems continue to be used in diving accidents. Conservation of oxygen, provision of warm, humidified gases and a clean breathing circuit for each patient are obvious advantages of closed circuit rebreathing systems.

The OXI-dive1™ closed circuit resuscitator achieves high inspired oxygen concentrations. An initial oxygen flow rate of 8 l/min for five minutes followed by 3 l/min provides 100% oxygen almost immediately and 99% indefinitely. A C size oxygen cylinder used at these rates with the OXI-dive1™ lasts for about 1.5-2 hours.

With an initial oxygen flow rate of 8 l/min for five minutes followed by 2 l/min the Inspired oxygen is 90+% after five minutes of 100%. A C size oxygen cylinder will last about 2.5-3 hours.

The duration of oxygen supply will be reduced if there is a poor seal with the facemask or if the facemask is removed for short periods.

Pain relief

In Australia methoxyflurane is now the most widely used agent for pre-hospital pain relief in ambulance services, defence, mining and ski areas. The efficiency of pain relief is at least equivalent to, and probably better than, the use of 50% nitrous oxide/oxygen (Entonox) in a demand valve system.[3,4] Entonox is, of course, contra-indicated in diving accidents as nitrous oxide is a more soluble gas than nitrogen so using Entonox after a dive will increase the diver's inert gas load and worsen any decompression illness present.

Methoxyflurane is administered using the hand held Penthrox™ Inhaler. 3-6 ml is carefully poured onto the base of the inhaler. The methoxyflurane then passes through circumferential openings into the polypropylene wick within the body. The mouthpiece can be fitted with a standard facemask or inserted directly into the patient's mouth. Inhalation provides pain relief for 25-55 minutes depending on whether 3 or 6 ml (the maximum recommended dose) is used. If higher concentrations of methoxyflurane vapour are required, the opening near the mouthpiece of the Penthrox™ Inhaler may be occluded with the index finger.

Oxygen can be connected to the nipple in the base. 3 l/min provides 35-40% and 8 l/min 50-60% inspired oxygen with the inhaled methoxyflurane vapour.

In 1987 Toomath published an article in the New Zealand Medical Journal[5] describing two patients who died following several weeks of intermittent administration of methoxyflurane for pain relief. The doses administered were approximately four times those approved by the Food and Drug Administration in the USA and ten times the dose recommended in Australia. As a result methoxyflurane was withdrawn from use in New Zealand. However an application is being made to re-register methoxyflurane for use in New Zealand.

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IMMERSION HYPOTHERMIA

James Francis

Key Words

Accidents, first aid, thermal problems, treatment.

Introduction

I have a feeling that I was asked to do this because I hail from the "frozen north" although, looking around at some of the divers this week, hypothermia is not necessarily an exclusive problem for those north of the equator!

As we all know, the temperature of the body is determined by the balance between heat gained and heat lost. I am not going to address the thermal input side of the equation today, but will focus on the problems associated with heat loss.

Routes for heat loss

There are four routes for heat loss. Most important for divers is conduction. Water conducts heat away from the skin much more effectively than air, which is one of the reasons a dry suit affords better insulation that a wet suit. Heat loss from the head, largely via conduction, is particularly important because the blood vessels of the scalp do not vasoconstrict in response to cold in the same way as they do in other parts of the body.

Convection is also an important route for heat loss when diving. Convective heat loss is minimised by the use of wetsuits, which substantially reduce the convective currents which cause the replacement of the warm boundary layer with cold water in unprotected, stationary divers, and more or less eliminated by dry suits.

Evaporation is not an important route for heat loss while in the water, except possibly via the respiratory tract when breathing very dry, cold air or mixed gas, particularly on deep dives, in which case conduction also plays a part. But it does become an important route for heat loss once the diver is out of the water, even before getting out of the wetsuit. The fabric cover of most wet suits retains a lot of water which will evaporate and cool both the suit and the diver inside it. Once the wet suit is removed, evaporation will proceed until the skin is dry or an impermeable layer is donned. This can result in a very substantial loss of heat and this has to be considered during the management of an injured diver.

Finally, radiation is a negligible component of heat loss in the diving and most other settings.

Thermoneutral water

Thermoneutrality of sea water is between 33 and 35°C. It varies a bit between individuals. In water that is much below 30°C, the diver will be more or less fully vasoconstricted.

Thermal conductivity

Table 1 shows the thermal conductivity of various things which interest us. Water conducts heat well, as does muscle. Skin is, alarmingly, a good conductor of heat. Then we get down to the more comfortable zone of fat, which is a much poorer conductor of heat, sufficiently so to be classed as an insulator. Wool is a pretty good insulator and neoprene foam is even better. Air is an excellent insulator, which is one of the reasons why dry suits are so effective.

TABLE 1

THERMAL CONDUCTIVITY (kcal.cm/m^2.h)

Water	52
Muscle	35
Skin	28
Fat	16
Wool	8
Neoprene foam	5
Air	2

There are two sorts of hypothermia which can result if the diver is without insulation or the insulation is inadequate, or one has the misfortune of being in a cooling situation. These are local and whole body hypothermia.

Local hypothermia

Local hypothermia is more commonly known as freezing injury or frostbite, in which ice crystals form in tissues. More commonly in the diving situation tissues do not freeze and the hypothermia is in the form of a non-freezing injury (NFCI). Non-freezing cold injury is most unusual in exposures to 5°C water for less than about 60 minutes.

There is a protective mechanism against cold injury, cold-induced vasodilatation. This is a response that, after a period of maximal vasoconstriction, such as follows putting a hand in ice-cold water for about 10 minutes, causes a gradual relaxation of the arteriolar vasculature, allowing a brief restoration of circulation to the cooled part. Then the vasoconstriction reasserts itself. This "hunting reaction of Lewis", named after the man who first described it, provides a minimal level of blood flow, even in circumstances of maximal vasoconstriction. This reaction can be overridden under some circumstances. It is reduced in whole body hypothermia and it can also be reduced in situations where there is a high vasomotor tone. A scared and cold person is at greater risk of NFCI than one who is more relaxed.

It is unusual for divers to get NFCI, although there are some exceptions. In the Royal Navy and the US Navy, some clandestine operations, and the training for them, requires extremely long dives in very cold water, such as up to 9 or 10 hours in water which is only 1 or 2°C. These people do have a problem with NFCI and in order to undertake these operations they need active thermal protection for their hands and feet.

Whole body hypothermia

Hypothermia is defined as a rectal temperature below 35°C. It has been, to some extent arbitrarily, divided into mild, moderate and severe. Mild being between about 35° and 32°C, moderate 32° down to 28°C and severe hypothermia below 28°C.

Rescue from the water

As we saw in the boat the other day, recovery from the water ought to be done, if possible, with the casualty horizontal. There are a number of steps in the reasoning for this.

1 Both immersion and exposure to cold results in a movement of blood from the periphery, into the core

2 Both stimuli also result in a diuresis, which reduces blood volume. This does not matter while the individual is immersed in water and the circulation is supported by hydrostatic pressure, but it matters once the victim is removed from the water.

3 Once local tissue temperatures get below about 12°C (peripheral, not core temperature) there is a loss of autonomic control of the peripheral vasculature and a loss of vasomotor tone.

4 With even modest hypothermia, the central baroreceptors and hypothalamus work less effectively than under conditions of normothermia.

5 As a hypothermic diver, who will have a reduced blood volume from diuresis due to immersion, is removed from the water vertically the central blood pool is rapidly distributed to the dependent periphery, which has been freed from the water pressure which had kept the veins compressed, resulting in a massive reduction in venous return and central venous pressure (CVP). This results in a fall in cardiac output and, because there is little or no venous return due to depression of both central and peripheral vascular control mechanisms, a fall in systemic arterial blood pressure occurs.

It is thought that this sequence of events may underlie the sudden death of people who have survived a prolonged immersion in cold water but who die shortly after being rescued. The objective of removing the victims of immersion hypothermia from the water horizontally is to preserve the CVP and cardiac output.

Mild hypothermia

In mild hypothermia, both the victim, who is conscious, and any observer will notice that the diver is shivering. Shivering usually starts at a core temperature of about 36°C. It becomes maximal at 35°C to 34°C, and then gradually begin to decrease. At a core temperature of 35°C, the skin will feel very cold to the touch.

Even if the diver has not been trying to rehydrate himself inappropriately, there may be slurred speech and poor co-ordination. This sort of person will sit down in the corner and ignore everyone else, becoming a bit morose and introverted. This development is a danger sign, particularly in a normally gregarious person.

At 34°C, nobody should miss that something is wrong. The diver is going to be shaking like a leaf with teeth chattering for most of the time. Along with that, there may be a measure of amnesia, which is probably a good thing, as no one is going to enjoy life at this stage.

By a core temperature of 33°C, the shivering becomes less intense and less frequent. At this stage cardiac arrhythmias can develop. The myocardium is particularly sensitive to cooling and arrhythmias are one feature of this as is bradycardia.

At a core temperature of 32°C shivering is further reduced and may even cease. Shivering is very variable between individuals and varies with the rate of cooling. Rapid cooling causing more shivering that a gradual loss of core temperature. In most cases shivering will cease once the core temperature reaches 31°C, although one cannot be dogmatic about it. At the border between mild and moderate hypothermia the victim will look blue, will have a respiratory alkalosis, the metabolic rate will be well down and there may be some muscular rigidity and pupillary dilatation. It may be difficult to measure the blood pressure using a cuff.

Moderate hypothermia

Once shivering ceases, the victim has entered the realm of moderate hypothermia in which the battle to maintain the core temperature by increasing thermogenesis has effectively been abandoned and the condition is generally progressive without external intervention. The other feature of this stage is that, generally, the victim can still be roused. Hypoventilation sets in and these people may have virtually undetectable breathing patterns. Rather than a respiratory alkalosis the biochemical pattern changes to a lactic (metabolic) acidosis. A 'J'-wave may be observed on an ECG.

With further cooling the victim may appear to be dead. There is a decrease in renal function which may exacerbate the dehydration which has already been caused by both cold and immersion.

At about 29°C there may be a loss of deep tendon reflexes and once a core temperature of 28°C is reached the victim is in serious trouble. The heart muscle is irritable, ventricular ectopics are not at all uncommon and spontaneous ventricular fibrillation (VF) is possible. There may be evidence of bronchorrhea and signs of pulmonary oedema. But they are still rousable.

Severe hypothermia

Once hypothermia victims become unrousable it is evidence of severe hypothermia. They have stopped shivering. They have a clinically dead appearance with fixed, dilated pupils. Muscles which have been increasingly rigid will start to relax. Further cooling produces hypotension and spontaneous VF. All thermo-regulation is lost.

Apnoea occurs at around about 24°C and cardiac arrest around about 21°C. The lowest ever recorded core temperature from accidental cooling, where the patient survived, was 18°C. Controlled experimental lowering of core temperature has been survived at 9°C.

A very important point.

Severely, and even some mildly, hypothermic people appear to all intents and purposes to be DEAD when they may NOT be. Nobody should be declared dead until they are warm and dead. In other words, one should take active measures to rewarm apparent fatalities from hypothermia before declaring them dead.

Treatment

Most important, and the first line of treatment in the field, is to prevent any further heat loss. The most effective measure is to protect the diver from the wind since evaporative cooling is the major cause of heat loss. Even a moist wet wetsuit provides thermal protection once the wind is prevented from evaporating water from its surface. Removal of the wetsuit and its replacement by dry clothing (insulation) and then providing protection from the wind is even more effective. However, removing a wetsuit requires a lot of movement, even if it is cut away from the casualty, and this is risky in a moderately or severely hypothermic person. Furthermore, not all dive boats have storage space for dry clothes. So, wrapping cold divers in plastic of some sort is probably the best and safest measure. Mylar space blankets, which reflect little heat back into the casualty, are effective at preventing loss of heat by evaporation. Plastic bin liners are even better, as they are well sealed and allow the generation of a microclimate within them. And above all, cover the head. Something like 60 to 70% of all heat loss will occur from an unprotected head because of lack of scalp vasoconstriction.

Cardiopulmonary resuscitation

This is a very awkward and controversial area. One thing I think everybody has agreed on is that the hypothermic person needs to be treated gently. They have an irritable myocardium and it is very easy to trip them into arrhythmias, especially ventricular tachycardia (VT) or VF. If one is going to provide CPR in the field, it is a good idea to have monitoring available. That is, of course, a joke, as in most circumstances it will not be available. Of more practical application, if CPR is going to be initiated there should be sufficient people to keep it going until the victim gets to a medical facility. The decision to start CPR on a severely hypothermic person is not one to be taken lightly. My view is that if the rescuers consider that they are able to maintain effective CPR until reaching a hospital, then it is probably worth doing. Otherwise leave the person alone.

Evacuation should be arranged as soon as possible. Assessment of the level of hypothermia is important to allow the receiving facility to make adequate preparations. As few people carry a low reading clinical thermometer, it is necessary to be able to assess the mild, moderate and severe hypothermias from the physical signs.

Rewarming

What can one do in the field beyond drying the victim, insulating with dry clothing, protecting from the wind and allowing the victim's sluggish metabolism to rewarm him or her? There are a number of options.

Hot water bottles are cheap, readily available and simple to use. But one must get the water temperature right. If the water in these bottles above about 40°C, the patient's skin will be burnt. The heat will warm the skin, unfortunately these people have very little skin blood flow, so the extra heat is not carried away and the skin in contact with the bottle rapidly reaches the same temperature as the bottle. It is best to start with cooler water and refill the bottles frequently as the peripheral circulation improves. The boat's engine cooling water is a ready source of hot water.

The same applies to chemical heat packs. They are easy to use, but their temperature control is not good and they have caused burns. They are also rather expensive.

Shared body heat has been widely promoted but, unfortunately, it is largely ineffective. Even if the heat donor is immediately adjacent to the victim in a double sleeping bag, little heat is actually exchanged.

One of the most dangerous things one can do to a really cold person is the hot shower. Do not, no matter what the grade of hypothermia, usher this individual into the shower, whack on the water as warm as you can tolerate, and say "Just stand there and you'll be warm in no time" and then leave them alone while you read the paper. Because, next thing you know, they will have fainted and collapsed, with a good chance of injury on the taps on the way down.. Because showers have a small base the victim is going to slump head up against the side of the shower recess, with the brain still deprived of oxygen. If one is to use a shower to get a person warm, and it will make them feel warm, always sit them down. Unfortunately, in the normal run of things, a shower is unlikely to be available on the dive boat.

Another technique, which is unlikely to be available on the dive boat, but has been used, is to breathe warm, humid oxygen. A closed circuit oxygen rebreather is the usual source. It actually delivers very little heat. However, the heat is delivered directly into the chest, and may warm the myocardium, which is the organ that one is most concerned about. It almost certainly will not do any harm and it may actually do some good. Also it is a simple and safe thing to do. Even if it does the diver little good it will make you feel a lot better.

What about a bath? A bath is unlikely to be available on the dive boat. Once ashore a bath is good treatment for mild hypothermia of rapid onset. With moderate or severe hypothermia, the rewarming should be undertaken in a medical facility. They are not candidates for a warm bath at home.

Warm baths have their problems. What is a comfortable temperature to a warm hand is excruciatingly hot to a cold hand. One must start with cool water, acceptable to the casualty, and gradually add more warm water after the patient is in the bath. The casualty will be the best judge of how rapidly the bath should be warmed. There has been much controversy over the years about whether the limbs should be in the water. It turns out that it does not make any difference. The theory of having the limbs out of the water was that what one did not want to warm up the periphery so that a large amount of cold peripheral blood was returned to the fragile myocardium. It appears this does not happen.

Rehydration

All hypothermic divers are volume-depleted. Vasodilators, which will have the effect of dropping the blood pressure are therefore inappropriate and that includes alcohol. But warm, sweet drinks are probably a good idea if the person can protect their own airway. There is no point forcing oral fluids into someone who is not able to protect their airway.

Heated IV saline or dextrose saline can be used. It not going to transmit much heat this way but if the victim is in need of intravenous rehydration, which they probably will be if they are anything other than mildly hypothermic, it is a good idea to warm the fluids before administering them. It is actually more comfortable for the patient and the drip will flow better when the fluid is warm. Do not heat the fluid more than about 40°C because it could then start to coagulate proteins. It is probably not a good idea to use Ringer's Lactate (Hartmann's Solution), which is a commonly used fluid in North America, as in moderate and severe hypothermia, liver function is reduced and will not metabolise the lactate.

Any more adventurous therapy should be undertaken in a medical facility, which is beyond this dissertation. Furthermore, there are enough anaesthetists here to address this, so I stop here.

Discussion

Unknown speaker

Do you mean all those nice St Bernard dogs are out of a job?

James Francis

Afraid so.

Bill Day, Wellington

Are you not concerned about the speed of rewarming?

James Francis

I am talking about acute mild to moderate hypothermia who can safely rewarmed rapidly. People with long onset hypothermia, particularly the elderly and drunks who have been out in cold weather for a long time should be rewarmed in a medical facility. Do not dunk them in warm water. They will be very volume depleted and resuscitating them requires a lot of attention to central venous pressure CVP and blood volume.

Bill Day, Wellington

In the first aid setting, what is your view on giving oxygen if it is not warmed and humidified. Just oxygen as most of us have, or some of us have, at dive sites.

James Francis

I do not think it will do any harm. I cannot see it is of any practical benefit, but it will not do any harm. If you can warm it, so much the better.

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THE SPUMS POLICY ON THE INITIAL MANAGEMENT OF DIVING INJURIES AND ILLNESSES

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THE SPUMS POLICY ON THE INITIAL MANAGEMENT OF DIVING INJURIES AND ILLNESSES

Des Gorman, Drew Richardson, Mike Davis, Richard Moon, and James Francis

Key Words

Accidents, decompression illness, first aid, injuries, policies, rescue, transport, treatment

An introduction to SPUMS policies

The Society considers education and dissemination of information to be among its primary roles. This is the rationale for a Society Journal. The Society is also often asked for opinions on subjects in diving practice and health. This is the rationale for Society policies. On occasions, these policies have been the product of individuals or small working groups. More recently, workshops have been used to produce substantial policies (e.g. emergency ascent training,[1,2] computer-assisted diving,[3] asthma,[4] certification of diving fitness[5] and recreational technical diving[6]). In future, the newly formed Ex-Presidents Committee will be asked to develop some Society policies.

A SPUMS policy is intended to be a statement of best practice. While such policies are based on the concept of practicability, they are not intended to be drafts for subsequent codes or regulations. The concept of practicability deserves some explanation. In the context of Society policy, this refers to something being achievable. Practicability is not synonymous with convenient. For example, in an ideal world, all injured and ill divers would be rescued from the sea in an horizontal position and all would undergo intravenous fluid resuscitation. Are these responses practicable ? An horizontal rescue is achievable already in the majority of diving situations, given some forethought and practice, and achievable for most others given minor modification. Consequently, an horizontal rescue is considered to be practicable and is cited in the Society policy. Conversely, it is almost impossible to maintain intravenous infusion skills for existing para-medics, let alone recreational dive instructors, dive masters and charter boat operators. Consequently, with the exception of diver medical technicians, a requirement for anyone supporting diving to be able to undertake intravenous fluid resuscitation is considered impracticable and is not cited in the Society policy.

SPUMS policy on the initial management of diving injuries and illnesses

Introduction

There is a plethora of diving first aid protocols and procedures available to the diving and medical communities. Some of these are in conflict and the Society has been asked to clarify its position in this context. In addition, there are data that now support an increasing role for some drugs in the treatment of decompression illness (DCI). The potential for the latter to be widely recommended as first aid measures needs to be determined and included in any policy on the initial management of injured and ill divers.

Because of the differing interpretations of the term “first aid”, this policy is deliberately titled, *The initial management of diving injuries and illnesses.* This policy describes a generic approach to the initial management of an unwell diver, regardless of the nature of the injury or illness. This is in recognition of the difficulties that most medical practitioners and essentially all divers have with specific diagnoses. The policy aims to describe initial management that does not require an accurate diagnosis and is divided into the following sections:

1 training requirements;
2 resuscitation equipment and supplies;
3 rescue and resuscitation;
4 posture;
5 oxygen administration;
6 fluid resuscitation;
7 drug therapy and pain relief;
8 communications systems and retrieval;
9 management of specific conditions.

The term occupational diver here is used in the modern context of any diver who dives for pay or reward. The term commercial diver is used to distinguish all other occupational divers from recreational dive instructors.

Training requirements

All occupational divers should be trained in basic life-support techniques. There is a need for occupational divers to be able to demonstrate an ongoing (annual) competence in airway management, expired air resuscitation (EAR), external cardiac compression and administration of oxygen at as close as is possible to 100% oxygen to both conscious and unconscious people.

Recreational divers should be encouraged to acquire and maintain these skills by undertaking advanced diver training modules and/or by attending first aid courses run by organisations such as St John Ambulance. These recommendations are consistent with the policy goals of the Australian and New Zealand Resuscitation Councils.

While the ability to administer intravenous fluids is highly desirable, access to training in this is limited. Only diver medical technicians should be expected to demonstrate an ongoing competence in intravenous line insertion and fluid administration.

Resuscitation equipment and supplies

All dive platforms should have a proven and exercised system to rescue an unconscious diver from the water horizontally. Similarly, shore based operations should have a proven and exercised procedure for removing a diver from the water horizontally.

All commercial dive and dive-training platforms should comply with local regulations and codes with respect to the provision of an on-site diver medical technician and should also have equipment and supplies immediately available to enable:

10 oxygen administration (see Note 1);
11 intravenous fluid administration;
12 compliance with the local diving codes and or regulations.

All platforms and shore based operations used to train recreational divers, and all vessels that are chartered to recreational divers should also have a first aid kit (an example of a suitable inventory is that developed by PADI and published in their Rescue Diver Manual[7]) and equipment and supplies available to enable oxygen administration (see Note 1). It is also recommended that, where possible, this level of equipment and supplies be available at all dive sites.

NOTE 1.

With respect to oxygen administration, the following comments apply:

13 oxygen should be administered at as close as is possible to 100% oxygen to both conscious and unconscious people;
14 the volume of oxygen needed for any diving operation should be enough to supply the ventilatory needs of two divers simultaneously throughout a retrieval to the nearest facility with oxygen supplies;
15 more oxygen will be needed for a demand flow system than for a rebreather circuit and even more oxygen is needed for a continuous flow apparatus.

Rescue and resuscitation

Recovery of a free-swimming diver from underwater should follow the techniques currently taught by the recreational dive instructor agencies and the licensed occupational diver training schools. The recovery to and resuscitation of a diver on or in a stage, open or closed bell will be determined by the specific diving system in use.

Expired air resuscitation in the water should never delay the recovery of a diver to a diving platform or ashore. There are sufficient doubts about the safety and efficacy of EAR in the water to currently prevent the general recommendation of this technique.

Resuscitation of a diver should be conducted in accordance with the current guidelines of the Australian Resuscitation Council or equivalent national organisation.

The re-warming of a cold diver should be based on the following.

16 The avoidance of any further cooling by removing wet clothing (with the possible exception of wet suits) and insulating the diver with warm, wind-proof material(s). The head should be covered.
17 If intravenous fluids are administered, these should be warmed, but to no more than 45°C. Oral fluids should also be warmed, but should only be given to fully conscious persons.
18 A cold diver who has stopped shivering or who is unconscious represents a medical emergency and requires urgent evacuation to the nearest appropriate treatment facility (see below).

Posture

The best posture for most injured divers (the exception being those with isolated vertigo and nausea, with or without hearing loss) is horizontal. This may be impossible in diving bells because of the limited available space. The recovery position (as defined and taught by organisations such as St John Ambulance[8]) should be used for patients who are unconscious or drowsy or where there is some other concern for their airway (e.g. fractured jaw).

Divers with vertigo should be encouraged to keep still and not to do anything which could cause additional stress to the inner ear, such as a Valsalva manoeuvre or straining.

Sitting or standing up a diver to perform tests of balance and gait, or to undertake investigations such as a chest X-ray, should only be undertaken by a physician and then only after specific contraindications are excluded (such as a significant risk of cerebral arterial gas embolism, postural hypotension and severe vertigo). Preferably, this should be delayed until the patient arrives at a definitive treatment facility, one which has a recompression chamber (RCC).

Administration of oxygen

Oxygen should be stored and used in accordance with local standards, codes or regulations.

Oxygen should be administered to all injured and ill divers at as close as is possible to 100% oxygen. With the specific exception of instructions from a physician at a facility which has agreed to accept an injured or ill diver for hyperbaric treatment, this administration of oxygen should not be interrupted.

There are sufficient doubts about the safety and efficacy of oxygen therapy in the water to currently prevent the general recommendation of this technique.

Fluid resuscitation

Intravenous administration is the preferred method of fluid resuscitation for any severely injured or ill diver. This should either be conducted according to a fixed protocol (such as an initial regimen based on one litre of normal saline given as fast as is possible, followed by alternating a litre of Hartmann's solution and normal saline over 4 hours) or adjusted according to clinical parameters (such as urinary output and/or haematocrit on a physician's instructions). Glucose containing intravenous fluids should not be given to an injured or ill diver, although an appropriate amount of glucose in an oral fluid (80 to 120 Mm, such as 20 g per litre) will enhance the rate of water absorption without causing an appreciable increase in plasma glucose.[9]

Suitable oral fluids[9] can be given to injured or ill divers, but only under the following circumstances:

19 the diver is fully conscious, is not nauseated and there is no concern for the airway;
20 the diver has been walking around or sitting up before first aid was started;
21 the administration of oxygen will not be interrupted for more than a few minutes each time.

An accurate record of fluid administered and urinary output should be kept for any injured or ill diver. Bladder catheterisation by or on the order of a physician may be necessary.

Drug therapy and pain relief

There are at present (April 1997) no drugs that can be recommended for the initial management of diving injuries and illnesses. Inhalation of nitrous oxide (such as Entonox) for pain relief should **never** be used for analgesia in anyone suspected of decompression illness (DCI). Parenteral administration of analgesics should only ever be undertaken on the instructions of a physician.

Communications systems and retrievals

All dive operations should have systems in place to provide immediate contact with the local diving emergency services and the local emergency services to obtain advice about initial management, regional retrieval systems and treatment facilities. An accurate record of events should be kept.

An acutely injured or ill diver should be retrieved to the nearest suitable treatment facility by the most appropriate method possible, providing that the following conditions are recognised or apply:

22 any retrieval should be timely as it is likely that the longer the delay for a diver with DCI to recompression, the worse the outcome;
23 any necessary resuscitation, oxygen administration and fluid therapy should not be compromised by the retrieval;
24 if DCI is possible, then the retrieval should occur as close to sea level as is possible.

An altitude of 300 m is considered the maximum that should be allowed during the retrieval of a diver suspected of suffering from DCI. However, situations do arise where a commercial aircraft with a cabin pressure equivalent to an altitude of 2,400 m is the only option available. Clearly, this option is not ideal and should be enhanced by continuous oxygen administration.

A transportable RCC can be used to transport divers with DCI, but given the cost, logistical problems and dangers involved, such a RCC should only be employed under appropriate conditions and with sufficient support.[10]

Management of specific conditions

The management of marine animal envenomations should follow standard guidelines.[11]

Flow charts for managing DCI and omitted decompression are show on pages 41 and 42 respectively.

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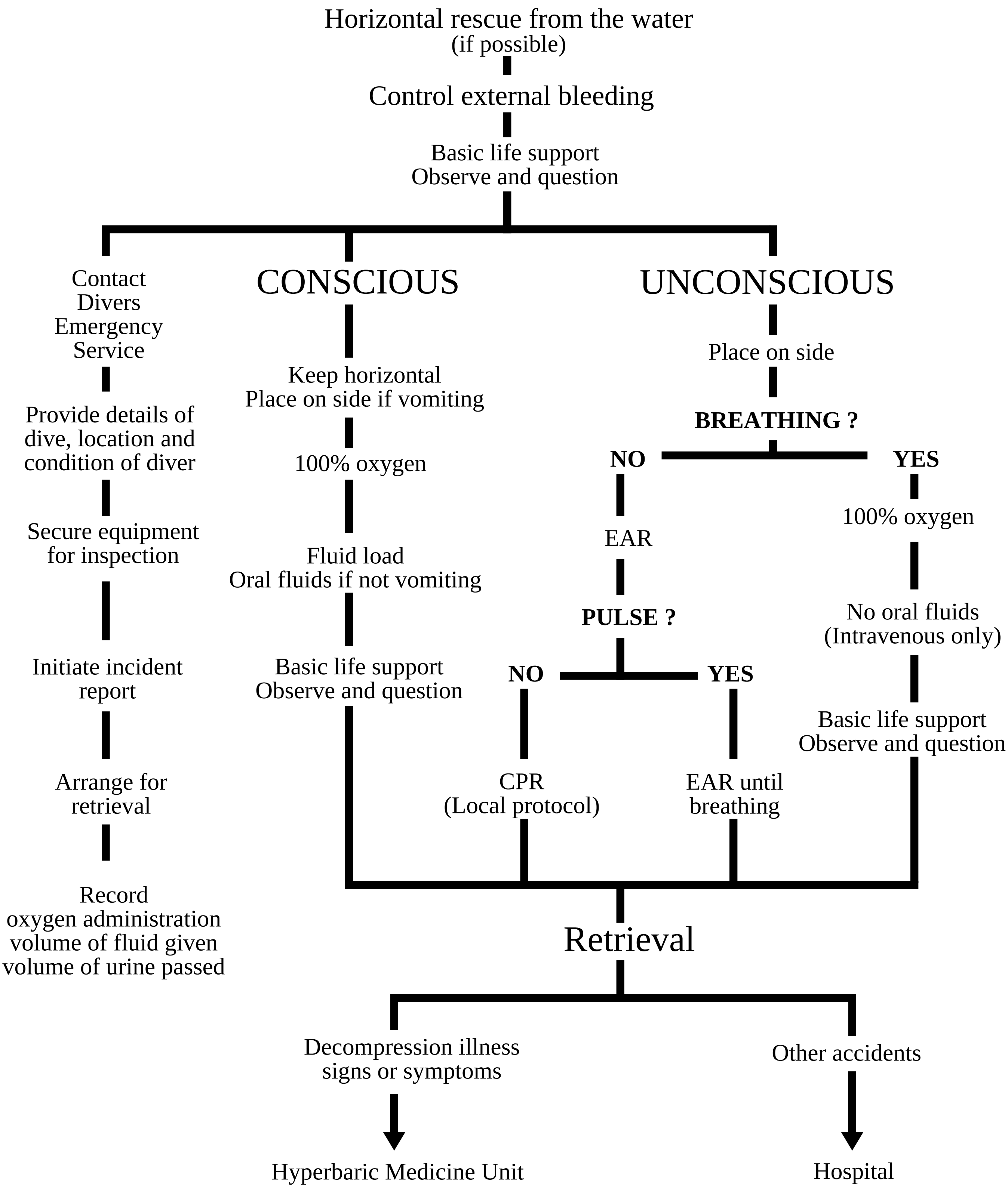
DIVING ACCIDENT PROCEDURES



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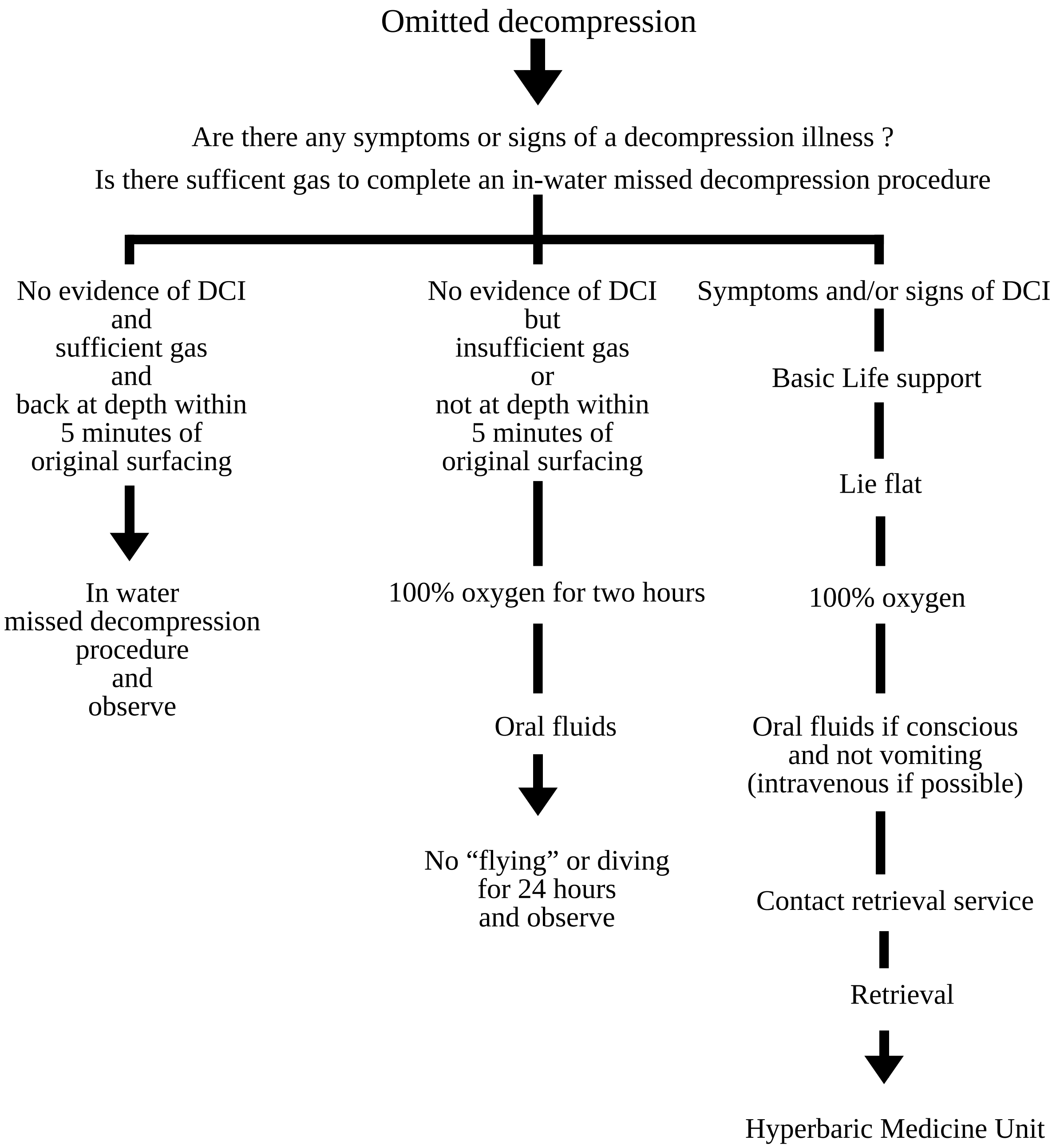
OMITTED DECOMPRESSION PROCEDURES



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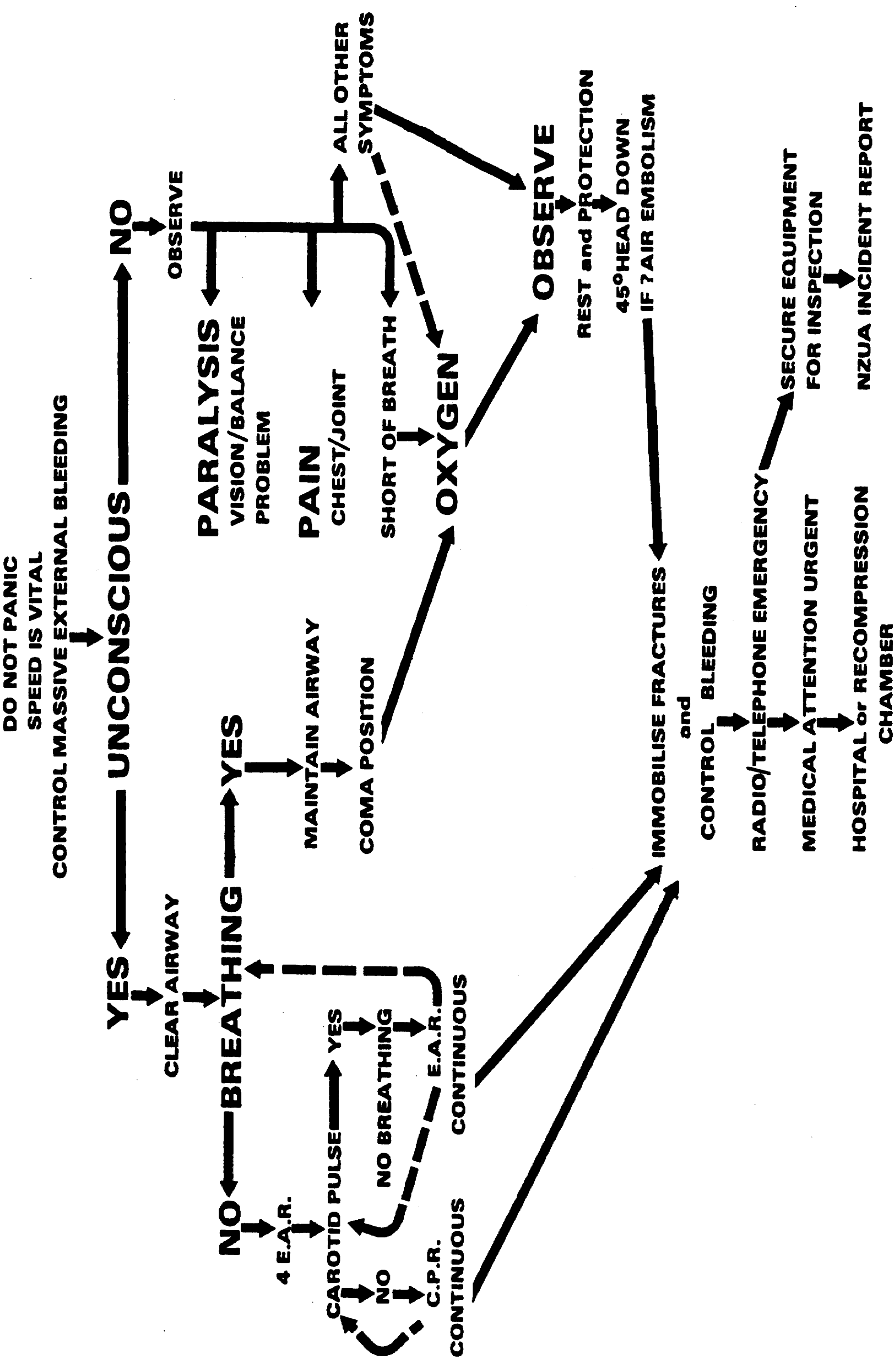

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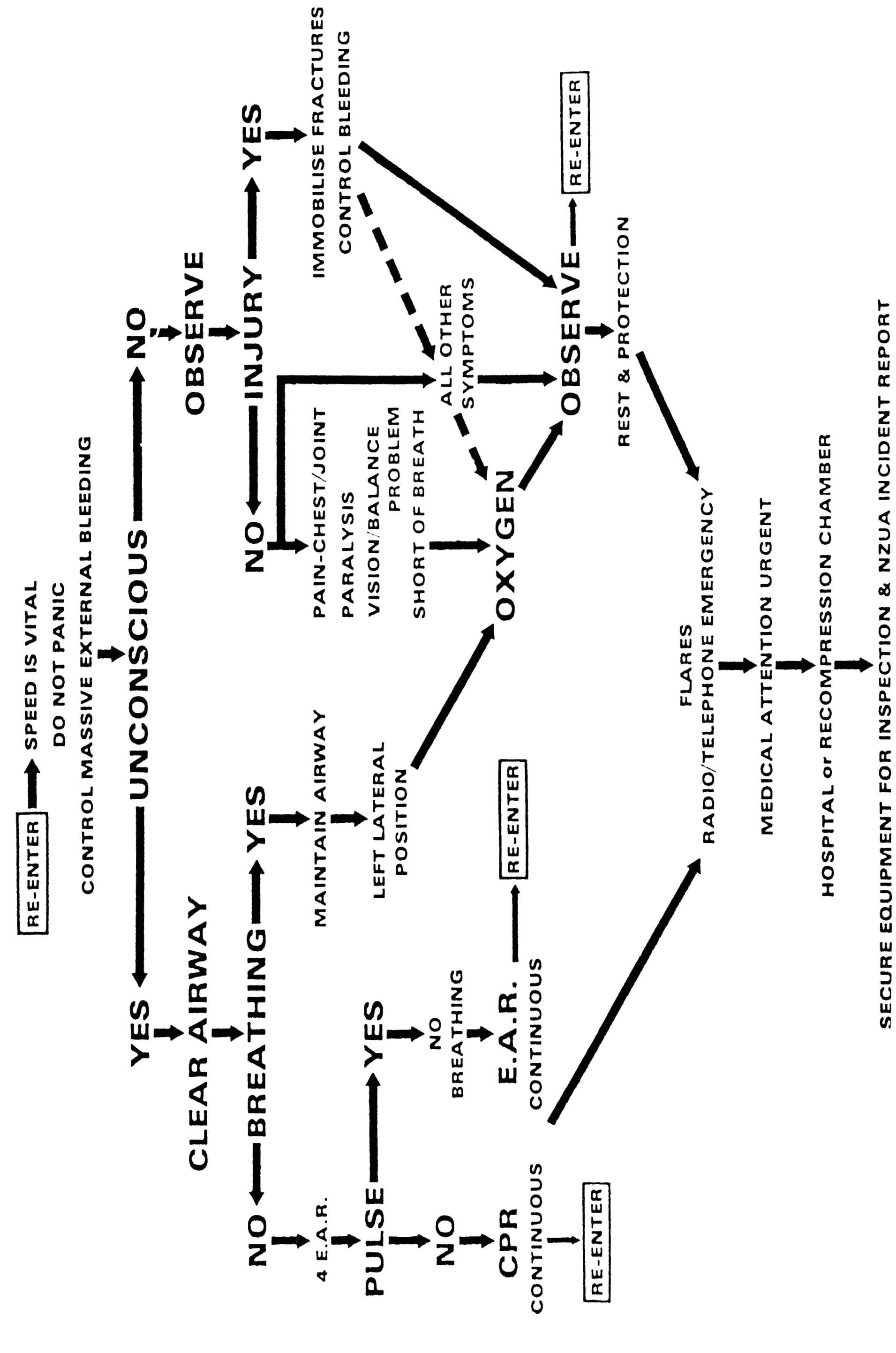

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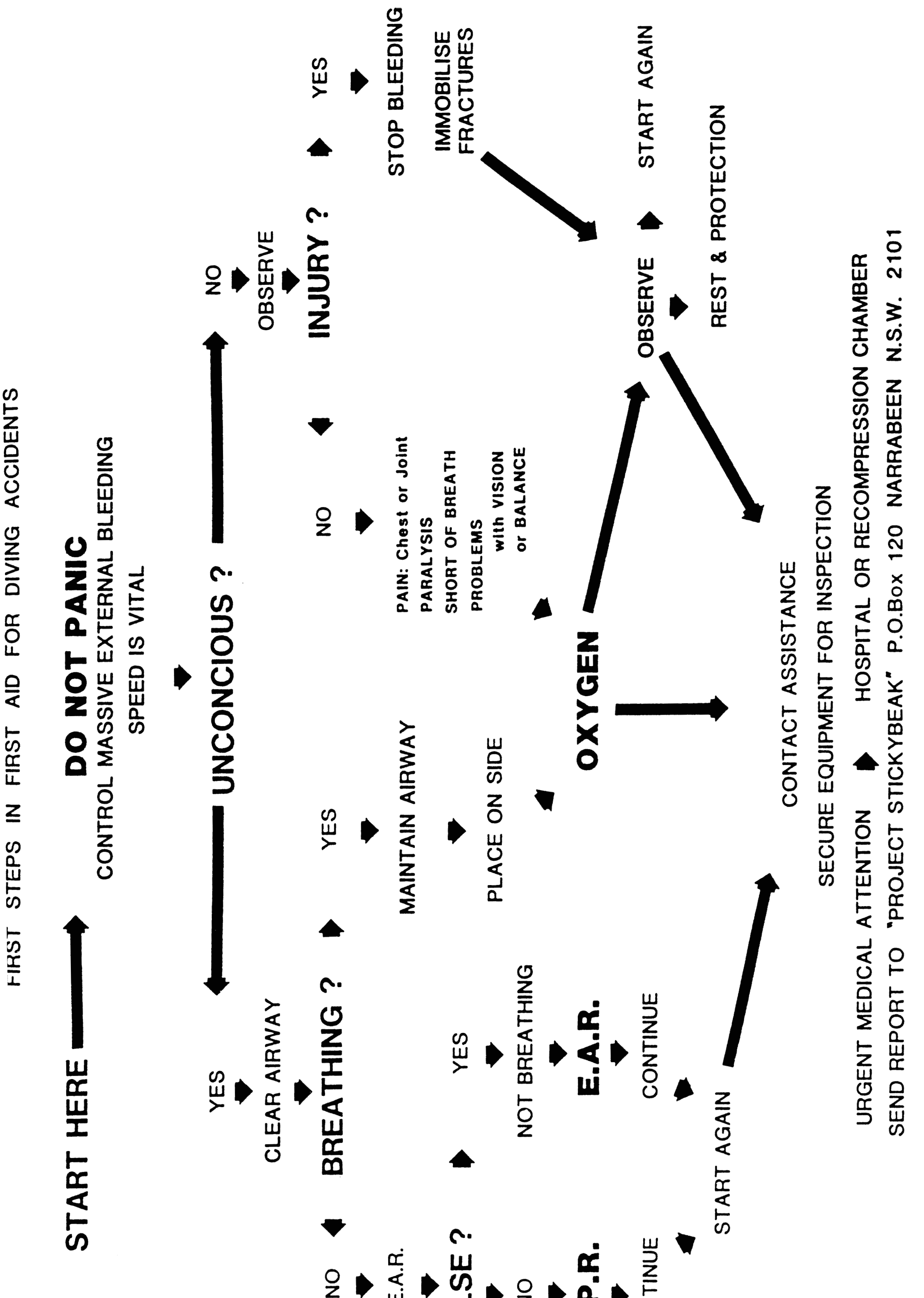

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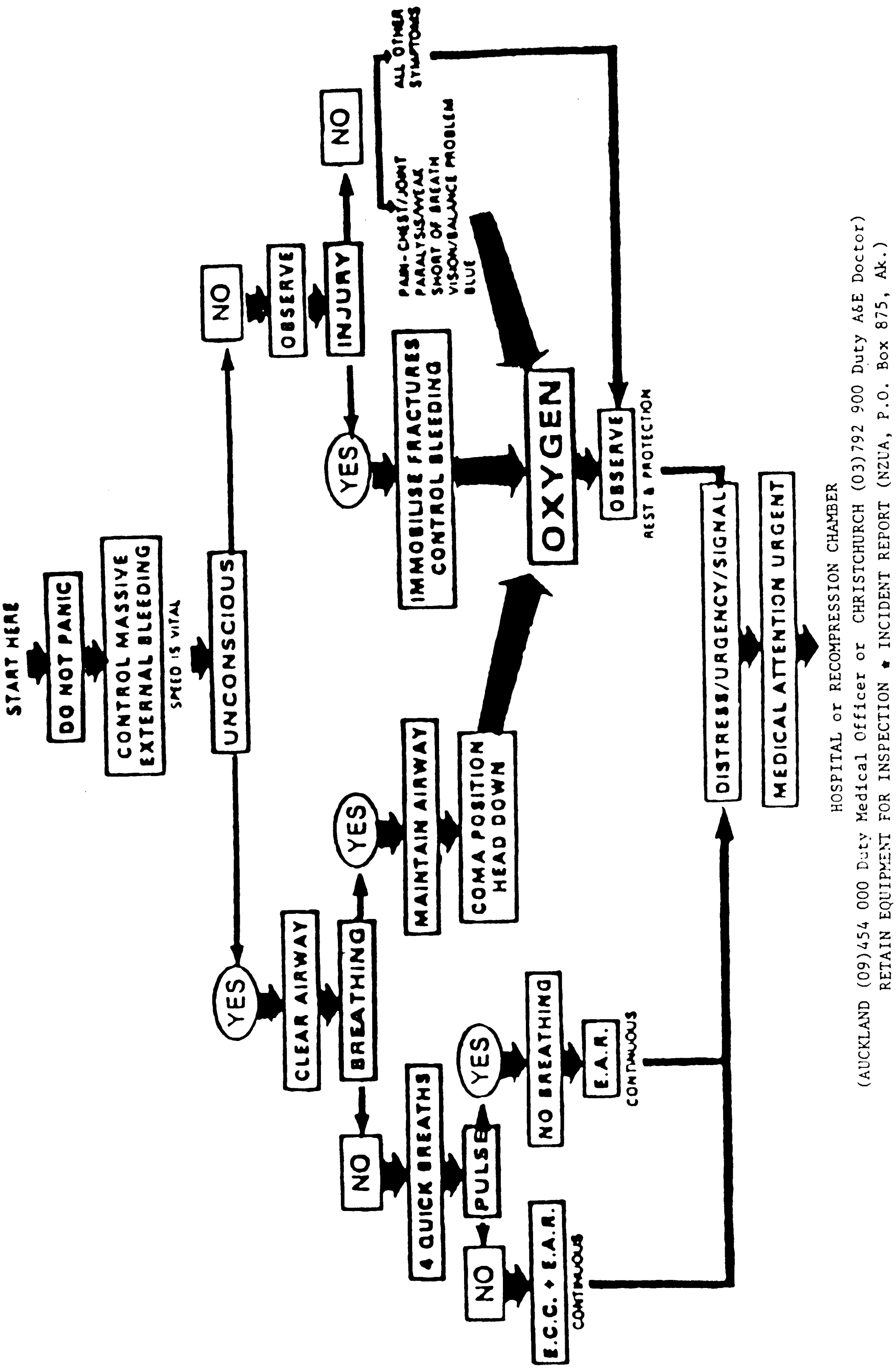

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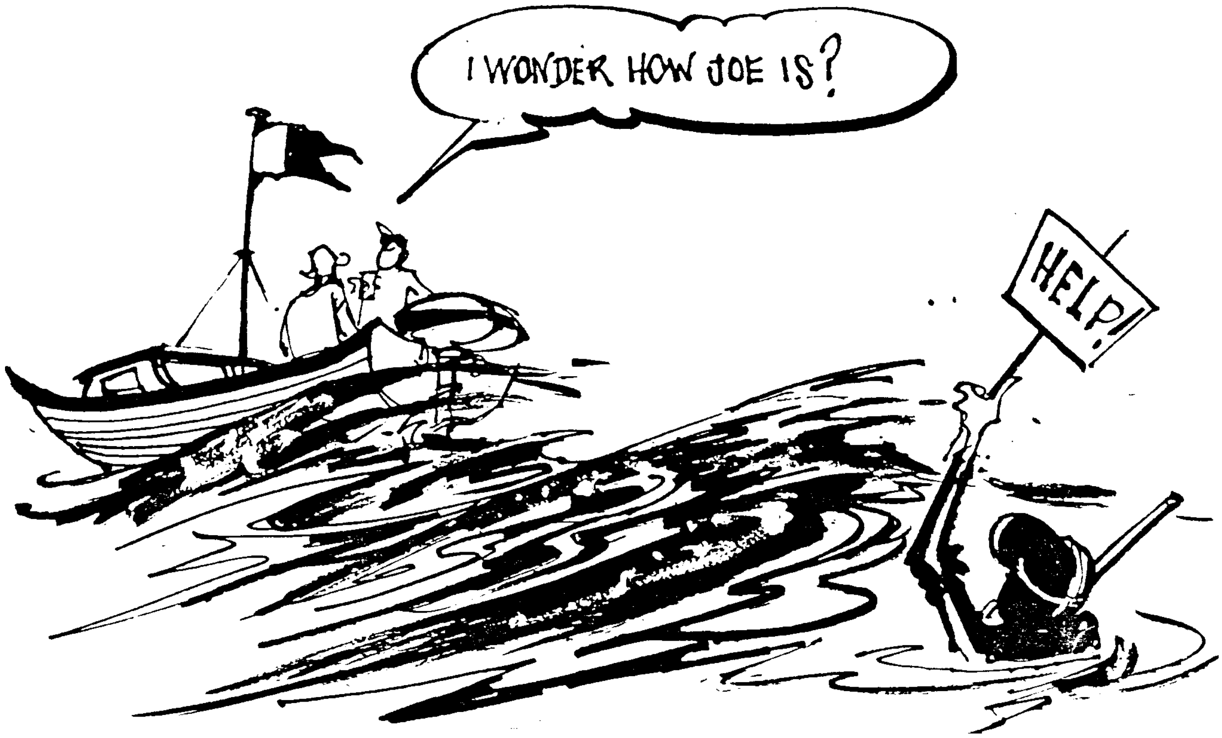

Is this <u>your</u> surface cover ?
(SPUMS J 1987; 17 (4); cover illustration)

Ideal diver rescue by Australians in the know ?
(SPUMS J 1984; 14 (4): cover illustration)

ARTICLES OF INTEREST FROM OTHER JOURNALS

DITCH THE KIT!

Neil Kermode

Key Words
Accidents, equipment, incidents, rescue.

They've stopped breathing! OK, it's buoyant-lift time. What was it? One, good grip. Two, shake them to make sure its for real. Three, air into their suit or jacket, and here we go...

We all hope we will only have to do it in drills, but we are also concerned that we might have to do it for real one day. Which is why we practise it at every level of diver training.

The Controlled Buoyant Lift (CBL) represents one of the biggest advances in diver-training thinking in a long time, and those who devised the system are to be congratulated.

As an instructor I find my charges get to the surface in a fit state to do something more than gasp for air. Through sensible use of buoyancy, the raising of a buddy from depth is now a matter of technique, not brute swimming strength.

It is a pity that the next bit is still back in the Dark Ages, however.

The next bit? Why do we persist in trying to tow someone wearing full kit, only then either to dump the gear in shallow water or hold them against a boat while we strip it off? What does dragging unwieldy equipment along achieve? If you will suspend your indignation for a moment, I offer several scenarios:

At the end of the CBL you surface to see the boat patrolling the dive site. You yell, give the distress signal and see it come towards you. If you swim for the boat you might manage a quarter of a knot, while the boat is probably doing closer to 20. How much is towing going to help?

Let us assume that you do tow your buddy, giving AV (artificial ventilation) until the boat arrives. At this point the crew starts applying AV while you, now dragging hard on your DV (demand valve or regulator), duck down to find weight belt, buckles and so on. All the while the boat is bobbing up and down on the waves and the casualty is bobbing about too, suspended from the boat by the AV team. At last all the kit is clear, your buddy is lifted aboard and AV commences in the boat, probably at least 20 seconds after initial contact was made. Would your buddy not have benefited from being dekitted by the time the boat arrived? Had you concentrated on giving AV and ditching kit in the water as the boat came towards you, the casualty would have received better AV sooner, and you could have climbed straight in to the boat to help.

Ah, you say, but we have to teach towing in case the boat isn't there, don't we? Let's look at scenario 2.

At the end of the CBL you surface to a horizon devoid of boat. "Bother!" you say, particularly as you are several miles offshore. We all know that a mere 250 metres of towing with AV is all but impossible. Are we then to teach people that they should strike out heroically for shore, towing an unbreathing diver and 100 kg of kit?

Do you want this person to die? One assumes not, but because your buddy is not breathing, effective AV represents the sole chance of survival. In your heart you know that you are unlikely to reach the shore while giving effective AV, but you also know that you can provide it while stationary in the water, and also that you can survive the water for several hours.

I therefore suggest that stationary AV with the minimum amount of exertion on your part is the only way of keeping the casualty alive. By keeping some kit you retain survival capability, and by staying still you will not waste effort dragging kit vainly towards the shore only to throw it away in the shallows.

When you see the boat or the chopper coming for you, you can ditch the kit as in Scenario 1.

But you have another card to play, what if there is a boat nearby, or you are close to shore? You need to be able to tow then, don't you?

Yes, but why take the kit too? Scenario 3: at the end of the controlled buoyant lift you surface close to something on which you can give AV, whether a boat, a rock or the beach.

Swimming with kit is difficult and the quarter-knot you can swim with kit can increase to more than a knot without it. Any distance you swim will therefore take at least four times as long with kit (if you can do it at all), so the introduction of effective AV is delayed fourfold. Add to that the possibility of trying to undo kit where the waves break, or while holding onto a pontoon, and I would suggest that the kit has not been useful to you.

Let's face it, how many kit configurations are there that mean a diver in his or her suit in UK waters will sink if you leave them alone? None, so far as I can see, unless your buddy is wearing a flooded membrane suit, something I have never seen in 17 years of diving.

Admittedly, the suited diver will probably end up with head lolling underwater, but the effort in achieving a neck extension is practically zero compared with dragging a set and weight belt around.

So when would you tow a fully suited diver, giving AV? Answer: In drills.

As an instructor, I do not want my kit dumped every time we do AV, but neither do I feel happy teaching the idea of waiting until the boat arrives before removing kit. What comes first, equipment or a life?

I therefore suggest that we teach the skills, because skills they are, of getting a casualty out of his kit while on the surface in mid-water. The drills would not be hard to teach, the logistics of preventing kit loss are not difficult, and we would end up with a skill that will work.

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WHERE I GO, MY BC GOES!

Pete Harrison

Key Words

Accidents, equipment, incidents, rescue

I never really considered myself interested in diving politics, never, that is, until I read Neil Kermode's *Deep Breath* in the May issue of DIVER. It got my back up.

In case you were unlucky enough to miss this eloquent piece of misinformation, I will summarise it for you.

Mr Kermode argues passionately for dropping the victim's equipment during a rescue prior to towing them to safety, and provides us with no end of examples to fit his case.

Anyone can invent a number of hypothetical scenarios to back up an opinion. But most people should recognise the fallacy in Mr Kermode's statement that, in 17 years of diving (I am suitably impressed), he has yet to see a kit configuration that will make a diver sink if left alone.

In my four years as an instructor in the Red Sea, I have encountered several thousand divers who would do exactly that. I am speaking of the vast majority of divers who wear Lycra skins or shortie wetsuits.

If unconscious at the surface, most people, myself included, would sink or float so low in the water as to make effective artificial ventilation impossible.

Add a few little waves to the situation and the result is disastrous. I can only assume that in his 17 years of diving, Mr Kermode has yet to dive abroad.

There are many highly opinionated people who will happily make up the rules for the rest of us, based on their own experience. I know nothing of Mr Kermode's qualifications to preach, but judging by the conclusions he reaches, they are not based on real-life experience.

Much diver-rescue theory would appear to be based on methods practised during diver training on conscious victims. However, where this particular theory falls flat is at this point, a conscious body cannot be compared with an unconscious body.

A conscious body has muscle tone, full lungs and an urge to survive the training session.

An unconscious body, on the other hand, is limp, less buoyant and with empty lungs that will happily ship in as much water as you allow near them.

The only hope for the unconscious body is to be lifted clear of the water by every ounce of buoyancy in its jacket which, if the body was unlucky enough to be buddied with Mr Kermode, is now 200 m away, floating off on the wind.

I was unfortunate enough to discover that an unconscious body is nothing like a conscious one, during the first week in which I worked as a Divemaster in the Red Sea.

I had been allotted a group of three holidaying instructors to take for a check-dive at White Knights. Considering their obvious experience and allowing for the calm, clear waters, I did not think it excessive to lead them to 25 m.

What I did not know was that one of them was a doctor who had forged himself a clean bill of health, despite six previous heart attacks.

Had I known this, I would not have been so shocked when he turned blue and wrapped himself around a coral head.

Being fresh off the course, I welcomed the chance to castigate him for his obvious disrespect for the reef. Approaching, I realised the gravity of the situation and quickly slipped into the lift-and-rescue drill. I was lucky. My victim was an obese 20-stone (127 kg) and was wearing an 8 mm semi-dry. He obviously had more buoyancy than most and, as I dropped his 13 kg weightbelt, I felt his body bob up in the water.

I made good ground, towing him towards the boat 100 m away, performing AV and doing my best to attract attention.

That is, I made good ground until, in accordance with PADI teaching, I ditched his BC. And then it all went wrong. My victim was sinking. Little wavelets lapped across his unconscious face as I struggled to support his head above water.

Every tiny ripple washed over us, threatening to swamp his airway.

I finned desperately, supporting his head and trying to keep the two of us from drowning. By the time I reached the boat I was almost too exhausted and too panicked to continue.

Had the victim been less buoyant, and had the sea been less than mirror-calm, an effective rescue would have been impossible. As it was, it was too late anyway.

I'll be fair, Mr Kermode. I think you were proposing a technique for UK waters only.

Here I will quote you: "We all hope we will only have to do it in drills but we are also concerned that we might have to do it for real one day."

Believe me, when the time comes to do it for real, you are in no state to remember whether you are in the North Sea, the Red Sea or the Timbuctoo Sea.

Mr Kermode, those who do have to do it for real one day will not thank you for teaching them a technique which I believe is better suited to drowning the victim than saving him.

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SURVIVING COMMON DIVE HAZARDS

Peter Armstrong

Key Words

Accidents, equipment, incidents, rescue.

Panicking buddy

Panic can affect divers of any skill level who find themselves in situations outside the scope of their training or ability. Proper training, a well-conceived and adhered-to dive plan, gear checks and diving on a regular basis with a regular buddy, all help reduce the chances of panic.

If you notice your buddy is having problems that seem to be getting worse, stop the dive and regain control. Establish eye contact; often this and a gentle, yet firm hand on the arm is all it takes to calm someone down. Next determine the source of the panic. Is it an equipment problem? Is it a buoyancy problem? Is he injured in some way? Is he having mask problems? Is his weight belt falling off? Is his tank falling out of the backpack?

You will have a much better chance of controlling the panic if you understand the problem. Well understood signals are essential and it is for this reason that we insist on commonly understood signals throughout the Scottish Sub-Aqua Club (SSAC).

Try to control your buddy's breathing. Panic can lead to increased respiration, which can lead in turn to shallow, rapid breathing. This results in a build up of carbon dioxide. Once the pH (acidity) of the blood changes due to the dissolved carbon dioxide, faster shallow breathing occurs anyway.

Once your buddy is breathing properly and slowly, half the battle is over.

Do not endanger your own safety.

The only thing worse than a panicky diver is two panicky divers.

Lost dive boat

It is a very lonely feeling: if you surface to discover that the dive boat is nowhere in sight.

Take a couple of deep breaths and ask yourself what could have happened.

Did you simply swim further from the boat than you thought? If so, when all the other divers are on board the boat will come looking for you. Has the surface become rough and because of the waves, you can't see the boat? Again, when all the other divers are on board they will come looking for you. Has something happened to force the boat to move or leave the area? If so, they will be back; they know you are there.

What if the situation is more serious? What if no one was left on board as a boat handler, or the anchor or mooring line was severed and the dive boat floated away?

First, there is a wide range of surface signal devices on the market, including strobes, flashers, signal mirrors, whistles, sound alerts, power inflator whistles and horns, extension dive flags and flares. If your signal device is dependent on air from your scuba tank, use it conservatively. Save strobes, flashers and under-water lights for evening hours in case it will be after dark when you are picked up

Flares should be fired at 90 degrees to the approaching boat, helicopter or even the shore. This makes the trail of smoke from the ascending flare more visible.

Relax. Stay where you are unless you know where you are going and you are sure you can make it. Drop your weight belt if necessary to make yourself positively buoyant and comfortable. Dry suit divers may want to leave their belt in place to remain upright in the water.

Move slowly. In order to decrease fatigue and the loss of heat, do not use any more energy than absolutely necessary. Movement will give you a false sense of warmth, in reality your skin temperature could rise as your core temperature is falling. Hypothermia is a definite cause for concern.

Assume the "survival" position with the knees drawn up to the chest, head forward and clear of the water and arms clasped around the head. This is the recommended position as it reduces the surface area of the body in contact with the water.

Try to keep the inside of the dry suit dry. Any liquids will pool around the kidneys causing rapid cooling of the body core. Most important, remember that people know you are missing and a search of both bottom and surface will soon be under way

Long surface swim

If you surface from a dive to find that you are a long distance from the boat or shore, take a minute to assess the situation. Are you in physical danger? If so, establish positive buoyancy by adding air to your buoyancy device. Drop your weight belt if necessary, use a signalling device to call for help and wait for assistance.

If you are not in immediate danger, then the situation is merely an inconvenience. If you think you have enough strength for the swim, take your time. I personally find it easier to turn over and swim on my back with my buoyancy device partly inflated.

Sudden loss of visibility

Sudden loss of visibility can be unnerving, to say the least. Silty waters are a reality in muddy places and should not be a deterrent to diving. Wrecks are often silty, especially in their inner recesses.

As your mother told you, there is nothing in the dark that was not there in the light. It may just come out in the dark !

If you find yourself in a sudden blackout, try to keep in mind that your movements probably caused the disturbance in the first place. More movement is not going to help. If you can sit quietly with no quick movements, visibility will often return in a short period of time. Then you can move slowly and safely away from the silted area. If the silt does not clear up quickly, ascend slowly to the surface, but keeping an arm and hand outstretched in your direction of progress to detect anything that might be in the way.

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References

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

1 Anderson T. RAN medical officers' training in underwater medicine. *SPUMS J* 1985; 15 (2): 19-22

2 Lippmann J and Bugg S. *The diving emergency handbook*. Melbourne: J.L.Publications, 1985

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PROJECT STICKYBEAK

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

Information may be sent (in confidence) to:

Dr D. Walker, P.O. Box 120, Narrabeen, N.S.W. 2101.

DIVING INCIDENT MONITORING STUDY (DIMS)

DIMS is an ongoing study of diving incidents. An incident is any error or occurrence which could, or did, reduce the safety margin for a diver on a particular dive. Please report any incident occurring in your dive party, but do not identify anyone. Most incidents cause no harm but reporting them will give valuable information about which incidents are common and which tend to lead to diver damage. Using this information to alter diver behaviour will make diving safer.

To obtain Diving Incident Report forms write to

DIMS,
GPO Box 400, Adelaide, South Australia 5000.

PROJECT PROTEUS

The aim of this investigation is to establish a data base of divers who dive or have dived with any medical contraindications to diving. At present it is known that some asthmatics dive and that some insulin dependant diabetics dive. What is not known is how many. How many with these conditions die is known. But how many dive safely with these conditions is not. Nor is incidence of diving accidents in these groups known.

If you are in such a group please make contact. All information will be treated as CONFIDENTIAL. No identifying details will appear in any report derived from the data base.

Write to
Project Proteus
PO Box 120, Narrabeen, New South Wales 2101, Australia.