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THE DEEP FROZEN DIVING PHYSICIAN

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Introduction

I was scheduled to lecture on diving environments, but the abbreviated time available has obliged me to reduce the extent of the lecture. I have decided therefore to discuss only one environment, which greatly appeals to me, and discuss the lessons which have been learnt from it. The environment that I wish to share with you is that of the Antarctic.

The Antarctic is almost twice as large as Australia. It is the highest, driest, coldest, windiest continent on earth. This massive land mass has an ice covering which, if spread over Australia, would form a layer 2 km thick. If it should melt, the ocean would rise by as much as 60 metres, causing devastation to my harbourside home in Sydney.

Throughout the history of Antarctic exploration, Australians have cloaked themselves with honour. Names such as Sir Douglas Mawson, Sir Edgeworth David, Dr Forbes Mackay, and many others are entwined in the history and development of this magic land. Australia now lays claim to 40 per cent of the continent and modern day pioneers, geologists, engineers, biologists, metallurgists, meteorologists and physicians, staff our four permanent bases, three on the mainland and one on Macquarie island. The Department of the Antarctic is responsible for administering these, whilst adventurers such as Dick Smith and Dr David Lewis add a touch of glamour and excitement to our involvement. The Oceanic Research Foundation is a privately run organisation that is determined to preserve our contribution to that continent.

My reputation in the world of diving medicine is unfairly associated with the development of a method of treating decompression sickness (bends) in remote localities. Specifically, this system involves giving oxygen underwater, and was devised to be used in the tropical waters of the Pacific Islands, an area which does not have a surfeit of recompression chambers. Most people would agree that the treatment is not appropriate to the colder waters of Sydney and Melbourne (where there are recompression chambers available).

It was therefore somewhat perplexing when I was invited to contribute to the development of a diving facility in the Australian Antarctic. Could my underwater oxygen treatment, especially designed for the tropics, be used in the event of a decompression emergency? As I am not an armchair researcher, there was only one way to find out. I packed my woollen undies, hot water bottle, guitar and windsurfer (the last item was denied passage on the otherwise serviceable vessel, the “Nella Dan”), but before embarking into the Southern Ocean, I decided to obtain advice about the potential problems of working in this region.

The information was gained mainly from the Department of the Antarctic, which has expertise in a whole range of scientific fields, including a most knowledgeable Department of Medicine, effectively run by Dr Des Lugg. I also received information from the US Navy, especially from their “Project Deep Freeze”. Other data was obtained from some sleazy bars in Hobart, but this perhaps should be the subject of a different dissertation.

As I was travelling to the Antarctic in summer, I was to expect almost constant daylight, temperatures from between 0°C and -30°C, winds up to 100km per hour, waves up to 15 metres high and a sideways roll of the ship to approximately 100 degrees. Under such circumstances, the possibilities of frost bite, hypothermia, seasickness and hangovers were to be expected. Special clothing had to be worn to protect against the temperatures, the sun, blizzards and the effects of snow.

Vehicles wear out approximately 10 times faster in the Antarctic. Brakes often do not work, and handbrakes tend to freeze on if they are applied. Pedestrians are protected from hearing and seeing vehicles before the collisions, by wearing a large woollen hood. Cameras play silly games. I attempted to clean the lens by breathing heavily over it, as a prelude to wiping it with Kleenex. An almost transparent lens became totally fogged with ice crystals. Similar condensation occurs when the camera is taken from a warm environment to outside. The more intricate and complex the camera, the more likely the mechanism is to freeze. Batteries have a short life, and the cold, dry conditions result in film either breaking, if wound on too fast, or having static “flashes” on the negative due to the very low moisture content of the air.

Equivalent problems seem to occur with all other equipment. The low temperature changes the strength, elasticity and hardness of metals and reduces their impact resistance. Metal becomes so cold that it, if touched without the protection of gloves, may freeze to the skin.

Leather, fabrics and rubber become rigid and break. Glass (being a poor conductor) may crack if exposed to the sudden temperature changes from the habitat to the environment. Lubricants must be specifically developed for subzero conditions, and static electricity affects everything, including hair, giving the expeditioners a rather startled and woolly appearance.

Injuries From Cold

The two major types of injury are frost bite and hypothermia. I intended to avoid both these by always staying indoors, overdressing, growing a beard (this allows an ice layer to form on the surface of the beard, enclosing an air space which gives good insulation and protection to the face), and following all the rules. I soon found out that the rules were frequently the opposite to what I had planned.

One of the most dangerous errors, and one likely to induce cold injury, is the wearing of excess clothing. When coupled with exertion, this causes sweating and increased heat loss, as well as a loss of insulation in the clothing when the sweat freezes or evaporates. Any sweat, water, snow or frost must be removed to prevent it wetting the clothing and reducing insulation. Even boots must be dusted off and hung up, never laid on the floor where they may get damp from the melted snow and freeze when re-exposed to the environment. One absolute requirement to prevent hypothermia and frost bite is to remain dry. Hardly encouraging advice for the aspiring diver.

The lips, nose and other protrusions, are particularly vulnerable to exposure, and need protection. Especially dangerous is the loss of gloves, mittens or headgear. These are often removed for various reasons, only to be whipped away by the wind or lost down a ravine, so they have to be firmly attached to the rest of the clothing when the weather conditions are difficult. Wind, with its more terrifying cousin, the chill factor, aggravates any of these exposure conditions, and produces frostbite. Constant vigilance is needed in checking each other to ensure that the face is not affected (looking for ischaemic white patches). Each expeditioner is responsible for his own hands and feet.

Included in protection is the use of ultraviolet blockout skin preparations and good quality sun goggles (not those with the clear lower half, as most of the light is reflected upwards from the snow). Glasses do not work very well, as they tend to become fogged up by condensation from the breath. Exposure to the very bright ultra-violet light arid its reflection from the snow, produces a painful and disabling “snow blindness”. A “whiteout” is an entirely different phenomenon, but causes a similar inability to visualise the environment. It develops because of a diffuse shadowless illumination, against a white snow background. With blizzard conditions or clouds, the sun is not visible, and, as everything is covered with a bright white mat, it is impossible to perceive depth or discriminate articles or topography.

Diving Operations

There were US Navy diving expeditions in the Antarctic as early as 1946. Their ability to operate in extremely cold waters (-1°C) has also been repeated by Canadian work in the Arctic circle and early Australian dives in the Antarctic.

Diving suits for the Antarctic need some special features. Almost every part of the body needs to be protected by the suit, so that only the lips are exposed - and these are covered by a thick layer of Vaseline, which can also be put over the beard to help form a seal with the face mask. Velcro is easier to use than zippers, which often freeze.

Three types of suits are available. The dry suit, which is made of closed cell neoprene and a nylon lined interior, is a one piece suit and can be inflated to produce an air layer over the body and ensure good insulation. Unfortunately, the valves on these suits are subject to freezing, and if the air inlet valve freezes in the open position, the diver faces a potentially hazardous and uncontrollable ascent to the surface. Most divers wear these suits.

Wet suits are also available and are made of foam neoprene, which produces an effective insulation for shallow dives. A small but invigorating trickle of water runs between the skin and the material when the diver immerses himself. These suits lose some of their insulation as the diver descends, because the air spaces within the neoprene tend to collapse. Because I had no other, I used this type of suit, and as it was very well fitting, it worked effectively for me. Non-compressible wet suits are available, but because of price can only be afforded by the Americans.

Dive Equipment

To breathe the air underwater, it needs to be decompressed via a regulator, from a high pressure (Scuba) cylinder. Then it is passed through a low pressure hose to a demand valve (mouth piece) where it is reduced again, to environmental pressure. This decompression results in a very severe drop of temperature, probably about -40°C, in the Scuba regulator.

Because of the very low temperature and the sometimes small amounts of water vapour in the compressed air, or water in the equipment, it is possible for the regulator to freeze up with ice particles. When this happens it either totally occludes the air supply or results in “free flow”, a very large air loss which then “freezes” the low pressure part of the system, the demand valve at the diver’s mouth. In either event, the diver loses his air supply and may be in a precarious situation if he is under an ice shelf or on a ‘deep dive. Special cold-water regulators are available, the most sophisticated and expensive being that one that froze first!

Much of the other diving equipment was routine and caused no problems, but there were potential difficulties wherever there was a valve, and especially when there was a rapid flow of gas. Thus there were potential difficulties with buoyancy vests, which use either an air feed supply or a carbon dioxide cylinder attachment. The one bit of diving equipment we did not have to worry about was the compass. Colleagues supplied me with a compass with the needle fixed to read North, no matter which direction one turned the compass. An excellent modification for diving at the South Pole.

Results

With this background for disaster, it may interest people to know what major problems I encountered while diving on air and oxygen, using a wet suit and conventional diving equipment for periods of up to 75 minutes and at depths of up to 18m (60 feet).

The main reason for visiting the Antarctic was to test the underwater oxygen unit. I certainly tested it. I put it onto the oxygen cylinder, screwed it on with a spanner, and it snapped into two pieces.

Metal in the Antarctic is very fragile because it is so brittle with the reduced temperature. Here was a fairly average type medico, not particularly strong, breaking a stainless steel regulator, merely by turning it on! This had to be modified. We acquired an old oxywelding unit, and put that on the oxygen cylinder, and it worked wondrously well. Tony Dick was the Antarctic doctor when I was down there. We tossed up as to who would get the dry suit, and who would go on oxygen. The lucky person would achieve both. The loser would obtain the wet suit and compressed air.

Tony is still not sure if he won or lost. He used the dry suit and the oxygen, and I was dressed in a very routine type wet suit, fairly thick, and very tightly fitted.

The results were very informative. A dry suit, not closely fitting and not tailor made, tends to become compressed in its lowermost area and we were in the vertical position, it meant that Tony lost a lot of heat from his legs and lower abdomen. My wet suit was much more effective, and I really did not get as cold as Tony did. Thus the value of a well fitting suit.

It is true that Tony was probably a little hypothermic at the end of the dive, and he could not even be bothered taking his gear off when we were hauled on board.

The diving was sometimes spectacular, usually beautiful, and always interesting. There were iridescent blue ice caves to negotiate, free floating ice packs to dive under, and large irregular shaped icebergs floating by us. Hundreds of penguins, demonstrating a speed and dexterity that they lack on the surface, joined us during the dives and welcomed their underwater visitors.

It is true that we encountered some minor problems with cold fingers and toes. To prevent this, we experimented with the CSIRO heat producing iron/magnesium sachets. Held in gloves and bootees, these produced enough warmth when contact was made with sea water to allow us to continue the dive. Although they look and feel almost the same as commercial tea bags, they produce only a lukewarm beverage of inferior quality, very metallic and devoid of the tannin aroma.

These little heat producing sachets can also be interspersed through the wet suit, ensuring that the whole body is kept warm throughout the dive. If the particle size of the iron and magnesium is too small, excessive heat is produced and burns can be experienced to the skin.

With Antarctic diving, if Scuba gear is used, it as essential to have a line connecting the surface to the diver. It is of value in finding the body afterwards. It may even help the diver retrace his pathway, in the event of accidents. Another similar approach is to use a compressor with a surface supply. It works the same as the safety line, and ensures an adequate supply of gas. With either Scuba or the surface supply, a bale-out or pony bottle is essential.

It was not relevant in the summer diving, but in winter a real problem is to ensure that the hole in the ice is kept open. The water freezes over rapidly even though it is only zero degrees, because the air is at -30° or -40° Centigrade. In the Australian base we had a large shelter which protected the surface crew from freezing, and also allowed a heater to be used which tends to keep the ice hole open. The hole must also be capable of taking at least two people so that a rescue procedure can be conducted in the event of incapacity of one of the divers.

Diving is now being performed throughout the year, and if needed they can use the underwater oxygen unit for emergency treatment of decompression sickness. Of course, the ideal is to ensure that one does not get this illness, by remaining well within depth and duration guidelines.

There are other ways to keep warm, and these are very effective. If you wear a wet suit under a dry suit, this is the most effective. Another technique is to have a hot water supply similar to that used by the abalone divers, ie. with that water being heated from the outflow of the compressor, and being pumped from the ocean around the outflow and then back down to the inside part of the wet suit of the diver. The degree of heat then is related to the gearing up of the compressor.

No-one goes to the Antarctic without falling in love with it. Everyone wants to go back, and many expeditions have been down there on numerous occasions. The attraction is in the beauty and majesty of the land. I was fortunate enough to extend the experience to include the underwater scene.

DROWNING

John Doncaster

Drowning can be defined as death through asphyxiation following immersion in a liquid medium.

Near drowning refers to the survivor of submersion, to which may be added resuscitation and survival, for 24 hours, whether or not fluid has been aspirated into the air passages.

INCIDENCE

The incidence world-wide is roughly three to ten per 100,000 depending on the figures given. In our Geelong area, in the past 24 years, we have had 258 deaths from a population in the summer which is around 200,000 and that gives a yearly average of about 5 per 100,000 per year. Less than 10 per cent of the deaths have occurred from our surrounding beaches. Since 1964, we have had 5,000 admissions to our Intensive Care Unit at the Geelong Hospital, and of these 43 were immersion victims. There were four moribund on admission, the remainder survived.

Not everyone who enters the water drowns, some come out of it in a delightful way. There is usually some problem which helps set the scene, such as alcohol, boats, poor swimming ability, unexpected currents, fatigue, waves, cramp or entanglement in wires, ropes, etc. While increasing the bravado, alcohol lessens the ability to cope, and it impairs intellectual and motor function and reaction times lengthen. Haight and Keating have shown that small volumes, just 30 ml of alcohol, without any carbohydrate ingestion, superimposed on exercise will lead to marked hypoglycaemia, with resultant weakness and confusion. Impaired temperature regulation is also associated with alcohol ingestion leading to a rapid cooling. At Easter, just before coming away, we had a chap who wandered off the edge of the pier falling into the bay. He was drunk, even though it was only 10.00 am. He was rescued virtually immediately by a bystander, who jumped in after him and dragged him out of the cold water. By the time he got to the Casualty Department of Geelong Hospital, which was half a kilometre away, his rectal temperature was 33° which shows how the cooling effect can occur quite rapidly.

Plueckhahn in the Geelong Studies of 238 drownings, found that 168 were accidental, with 117 deaths occurring in adults. Thirty-four were associated with boating accidents: overcrowding, overturning, inexperience, lack of lifejackets and inability to swim. Seventy two were swimming, surfing or in falls from wharves, jetties and rocks, or diving or in vehicles. In more than 50 per cent of the accidents, there was an association with alcohol. In 58 males in the over 30 age group, 53 per cent had blood alcohol greater than 0.08% and 45 per cent were greater than 0.15% at autopsy, and figures from the Surf Life-saving Association of Australia suggest that about one third of near-drowning adults had recently ingested alcohol.

Panic may well be the response to the problem, what ever it is, and this can lead to purposeless struggling, with consequent rapid shallow breathing and this can lead to loss of buoyancy, and submersion, exhaustion and collapse follow. Especially with water in the pharynx in the vicinity of the larynx, breath-holding will occur, water in the pharynx is swallowed, which could well lead to vomiting and gasping with subsequent aspiration into the lungs, leading to blood stained, frothy sputum. Drowning without aspiration occurs in about 10-20 per cent of victims due to laryngo-spasm