Dame Cicely Saunders has often emphasised that the modern hospice has its historical roots in the mediaeval institutions which took in the poor, the sick, and the indigent—in a non-judgmental way. That tradition of giving has been maintained in the modern setting, with all its technological innovations. She reminded the conference, however, that patients and families should know they were equally valued whether they believed or not. The inheritors of the Christian tradition recognise this, bringing to their work in hospices concern with realism and love but not piety—and remembering, too, the pagan maxim, primum non nocere.

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Regular Review

Medical problems of sport diving

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Sport diving is now so popular that there are about 50 000 scuba divers in Britain (scuba is an acronym for self contained underwater breathing apparatus). About 1500 commercial divers work in the North Sea, but their medical care is strictly controlled by law and is provided by a few specialists in diving medicine. Sport divers, on the other hand, do not come under the same legal control, and they may attend any doctor working in general practice or an accident and emergency department. General practitioners may also be asked to examine people planning to join a sub aqua club or to deal with simple problems such as aural barotrauma.

Furthermore, any doctor working in general practice or in an accident and emergency department may be asked to see a diver with vague symptoms after a dive. All such clinicians ought to know the signs and symptoms of neurological decompression sickness—a condition which will cause permanent spinal paralysis if not promptly and adequately treated. Missing the diagnosis might easily result in litigation.

This article is concerned with the problems which affect shallow water divers, who dive using air to a maximum depth of 50 metres. They include sport, harbour, clam, scientific, and police divers. The British Sub Aqua Club and Scottish Sub Aqua Club set high standards of training and dive practice for sport divers in Britain. Their continued voluntary vigilance in improving safety standards for their sport is an example to many other adventure sports. Despite their efforts, however, each year there are about 12 deaths and 70 episodes of decompression sickness requiring recompression.

Immersion phase

Water conducts heat 25 times more quickly than air. A diver is, therefore, usually in negative thermal balance despite wearing a wet suit or dry suit for thermal protection. Thus after only 40 minutes' exposure during the summer months in Britain at an average sea temperature of 11°C a diver may be shivering with the cold despite wearing a wet suit. The heat loss may be accelerated on the surface by wind chill while riding around in fast inflatable boats.

One of the most common hazards in sport diving is to be swept away from the boat in deteriorating weather conditions.

The diver will be supported by his life jacket and be partly insulated against the cold by his wet suit, but by the time he is recovered he will almost inevitably be hypothermic. At that time insulation of the head and neck is particularly important as this is the area of greatest heat loss. The victim should be rewarmed in a bath, if one is available within a few minutes, but it should not be hotter than the rescuer can keep his own hand in. He should be removed from the bath as soon as his temperature has reached 36·5°C (rectal) or he is clearly recovering rapidly.[1] During rewarming the core temperature may initially keep dropping, and when the rectal temperature reaches 32°C there is a real danger of ventricular fibrillation and cardiac arrest. Failing a hot bath, a warm room or even a sheltered place with plenty of blankets will enable almost all mildly hypothermic people to recover. Throughout the warming, the patient must be kept flat as postural hypotension in the upright position may precipitate ventricular fibrillation.

Descent

With practice using a snorkel a diver can hold his breath to 10 metres. Self contained underwater breathing apparatus uses a compressed air cylinder carried on the back; its pressure is reduced with a demand valve so that the pressure of the air breathed by the diver is exactly equal to his surrounding water pressure.

The water pressure increases by one atmosphere absolute for every 10 metres, so that the pressure of the air breathed by the diver has to be increased by one atmosphere for every 10 metres that he descends. At a depth of 30 metres the diver has to breathe air at a pressure of four atmospheres absolute. Boyle's law states that if the temperature remains constant

the volume of a given mass of gas is inversely proportional to the absolute pressure, so that 10 litres of gas at sea level pressure (one atmosphere absolute) will be compressed to five litres at two atmospheres absolute and to one litre at 10 atmospheres absolute.[2] Conversely gas has to be added if the volume of a container (or gas space within the body) is to remain constant as the pressure is increased. The effects of this law are important in many aspects of diving medicine (fig 1).

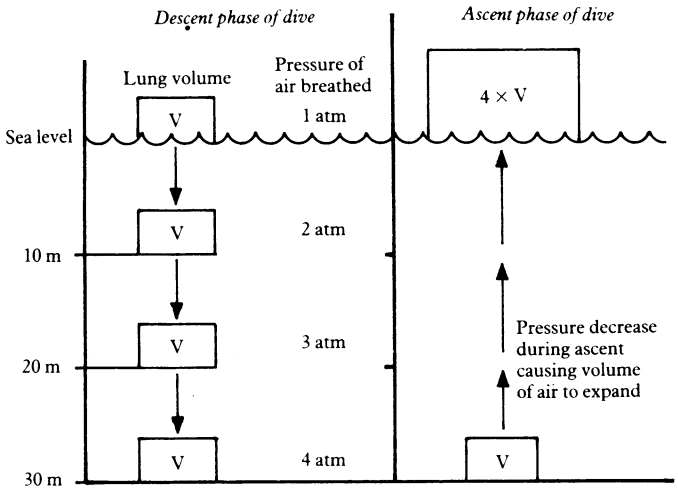

FIG 1—Boyle's law: $P_1V_1 = P_2V_2$

The most obvious effect of the increase in the pressure of the air breathed during the descent is that equalisation of pressure has to occur in the middle ear spaces, sinuses, and lungs. Poor function of the eustachian tube will cause aural barotrauma, giving a bruised appearance or rupture of the tympanic membrane. If rupture has not occurred, decongestants are normally adequate treatment and the symptoms should resolve within two weeks. If the tympanic membrane does rupture antibiotics should be given and the diver advised not to dive until the drum has firmly healed and eustachian function returned.

Functioning at depth

Air consists of 21% oxygen, 76% nitrogen, 0·03% carbon dioxide, and inert gases. As the partial pressure of nitrogen increases it begins to exert a narcotic effect on the body. At depths below 30 metres it seems to act in a similar manner to anaesthetic gases and slow down neural transmission.

Nitrogen is very fat soluble, and it is probably dissolved in the lipid component of nerve cell membranes: the effect on the diver is similar to alcohol intoxication and a serious hazard to personal safety. Nitrogen narcosis is manifested by euphoria, overconfidence, poor mental judgment, and aggravation of panic. The effect increases with depth, making air diving unsafe below 50 metres. In commercial diving below this depth helium is used to dilute the oxygen instead of nitrogen, as helium has no narcotic effects. The symptoms of nitrogen narcosis are potentiated by alcohol and other sedative drugs. All prescribed drugs which act on the central nervous system and many over the counter preparations such as decongestants are contraindicated with diving. Nitrogen narcosis resolves spontaneously without any hangover on ascending to a shallower depth. Air divers need to plan their deep dives carefully to take account of the predictable effects of nitrogen narcosis.

A second effect of increased pressure is that air breathed at depth has a higher density than on the surface. The gas is therefore thicker and increases the physical work of breathing. In consequence sport divers with impaired lung function may be at considerable risk.

Ascent phase of dive

During the ascent phase of the dive pressure decreases, and gas within body spaces will expand in volume. Unless this gas is vented as it expands it will exert pressure on the surrounding tissue and eventually damage it. The same volume changes with pressure occur in any bubble in tissue or blood (fig 2).

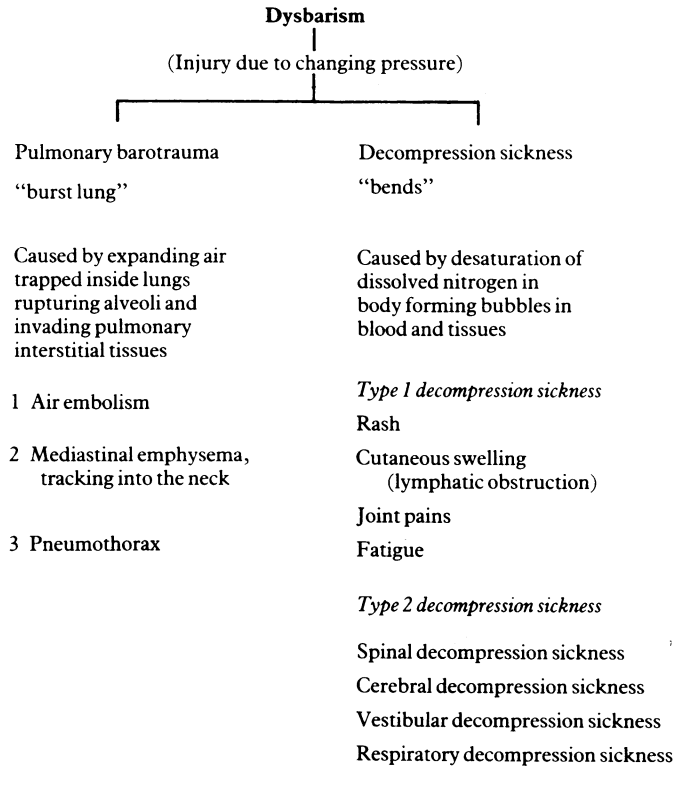

FIG 2—Ascent phase of dive

If the diver holds his breath during the ascent the expanding air may rupture alveoli, with tracking of air to the mediastinum or into the pulmonary venous system. The consequences of such pulmonary barotrauma are cerebral air embolism, pneumothorax, or subcutaneous emphysema of the neck. Pulmonary barotrauma is a life threatening condition and is usually associated with rapid and uncontrolled ascent or the rescue of an unconscious diver whose airway remained closed during the rescue. Air trapping diseases such as asthma and bronchitis and congenital bullae predispose people to pulmonary barotrauma. Medical screening to exclude such illnesses is therefore vital.

Cerebral air embolism causes symptoms as soon as the diver surfaces—chest pain and collapse, and in about 40% of cases coma, with or without convulsions.[3] Stupor is the next most common presentation. Motor or sensory deficits are less common as presenting signs and symptoms but tend to be unilateral and unimodal, in contrast to the symptoms of

spinal cord decompression sickness, which are usually bimodal and bilateral. The only effective treatment is recompression in a recompression chamber. The victim should be transported to the recompression chamber in a head down position on his left side. Oxygen and intravenous steroids should be given immediately if available.

Pneumothorax presents with its standard symptoms and signs after a dive and requires treatment with an intercostal drain. Mediastinal emphysema may rarely cause respiratory embarrassment and require recompression but will usually resolve spontaneously if there is no associated air embolism or pneumothorax. Pulmonary barotrauma may occur while using an aqualung in a swimming pool if the diver attempts to hold his breath during the ascent from the bottom of the pool.

At sea level a man's body tissues contain about one litre of gaseous nitrogen in solution. If he dives to 10 metres and thus breathes air at two atmospheres absolute he will eventually reach equlibrium again and have twice as much nitrogen in solution in his body. During the dive the nitrogen dissolves in the body's tissues. When the diver returns to the surface this extra nitrogen load must be expelled from his body in a controlled manner or decompression sickness will result. Bubbles of nitrogen form in the cells, tissues, and blood causing the multisystem disease of decompression sickness. This may occur even in divers who have followed the procedures recommended in the decompression tables, which calculate a safe rate of ascent from the deepest depth attained and the length of time from leaving the surface to the beginning of the ascent. Exercise, obesity, and cold water make decompression sickness more likely.

Clinically the manifestations are divided into minor and serious decompression sickness.[4] The colloquial name "bends" refers to acute joint pain after a dive. Serious decompression sickness occurs when the central nervous system is affected. Spinal decompression sickness often produces initially trivial symptoms during the hour after the dive. But backache, paraesthesiae in the feet, loss of motor power, and urinary retention all signify impending disaster. Girdle type abdominal pain is especially sinister and usually precedes serious decompression of the cord. Abdominal pain after a dive is rarely due to other causes.

Impaired balance, vertigo, and vomiting indicate cerebellar damage—"the staggers." Respiratory decompression sickness, producing acute respiratory embarrassment after a dive, and vestibular decompression sickness, which presents with vertigo and nystagmus, are rare manifestations of serious decompression sickness. They should also be treated with prompt recompression. Acute postdive vertigo may also be caused by aural barotrauma leading to rupture of the cochlea round window. Finger pressure on the tragus will exacerbate the vertigo and nystagmus, which then requires an urgent surgical opinion on operative intervention.

The diagnosis of decompression sickness may be confirmed only by the response of the symptoms and signs to recompression. Patients with minor decompression sickness may often try to explain their symptoms by claiming a muscle strain during the dive, but recompression must still be given. The patient is usually recompressed to 18 metres breathing 100% oxygen and then slowly decompressed with a standard hyperbaric oxygen regimen.

If recompression is delayed the risk of permanent damage to the brain and spinal cord is greatly increased. When delay has occurred drugs may be given to stop the activation of blood clotting mechanisms by the inert gas bubbles in the spinal venous plexus. Disasters still occur, however, and the only safe approach is to assume that any symptom presenting in a diver within 24 hours of surfacing is dysbaric until proved otherwise. Many divers will know more about diving related illnesses than the attending doctor (fig 2), and the latter should listen carefully to the patient and seek specialist advice if he is in any doubt.

In air embolism and decompression sickness 100% oxygen should be administered during transport to the recompression facility. Analgesics and Entonox are contraindicated. Military and civilian recompression chambers are located around Britain, and HM Coastguard keeps lists of their locations and the personnel to contact.

HM Coastguard (999) will provide a useful communication link for a doctor in a remote location faced with a seriously ill diver. The Royal Navy's duty diving medical specialist may be contacted at HMS *Vernon* in Portsmouth (0705 818888) for advice. In the Plymouth area the duty doctor may be contacted via an Air Call bleeper (0752 261910). In Scotland the duty diving medical specialist in Aberdeen (0224 871 848) will also help doctors. In Northern Ireland the regional compression unit is available for consultation (0762 336711).

Medical examination for diving

All commercial divers must have an annual medical examination performed by a government approved doctor. Examination for sport diving is mandatory on joining a sub aqua club and is the cornerstone in preventing diving accidents. General practitioners are asked to perform the examination to exclude serious illnesses and in particular epilepsy, asthma, diabetes, heart disease, and psychiatric disease. A chest *x* ray film is essential, and many commonly prescribed drugs are contraindicated in diving. β Blockers may cause bronchospasm and predispose to pulmonary barotrauma. Centrally acting drugs such as antihistamines and psychotropic drugs will exacerbate nitrogen narcosis at depth and slow reaction times. The medical examination forms contain notes for guidance and lists of medical referees who are willing to give advice in doubtful cases.

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