Current Practice

Drowning

STANLEY MILES,* C.B., Q.H.P., M.D., M.S.C., D.T.M.&H.ENG.

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The annual incidence of drowning varies greatly between different parts of the world as well as within individual countries. Approximately 140,000 persons drown each year, representing a rate of 5.6 deaths per 100,000 of the world's population, the highest incidence occurring in the overcrowded islands of Japan, where much of the population is closely associated with fishing and aquatic sports.

Accurate statistics of the incidence of drowning are not easy to come by, but in 1961 the Royal Life Saving Society published a very comprehensive report¹ on 1,327 deaths by drowning in the United Kingdom. Of these 290 were suicides, but of the remainder 76.5% occurred in inland waters and 23.5% in the sea. A large proportion of the accidents occurred to persons on holiday or at play, and more than half were young adults and children. The figures for the winter months and summer months did not vary as much as might be expected—the former accounting for 6.5% of the year's total each month and the latter about 11%.

Though loss of life by drowning is considerable the problem has not received a great deal of study or research. However, with the growing interest and increasing activity in aquatic sports the incidence of drowning is likely to increase, and it is thus important to study the facts as they are known and to put forward recommendations for prevention and treatment.

Definition of Drowning

Books on forensic medicine usually define drowning as "asphyxial death due to submersion in water."^{2,3} This is, however, by no means adequate, as the condition may present itself in different ways according to the circumstances. The term drowning should be used to denote the process resulting from submersion in water in which there is loss of consciousness and threat to life. When drowning results in death the term drowned should be used. It is possible to recover from drowning, but to be drowned is final. There are also many cases where the victim shows an initial apparent recovery from drowning but then dies hours later owing to complications. This is termed secondary drowning. Drowning itself may be further subdivided into types depending on whether or not water enters the lungs (dry or wet drowning) or on what type of water, if any, is inhaled (salt or fresh). Finally there is the immersion syndrome, in which sudden death occurs immediately after entering the water. This condition has also been described as hydrocution, a dramatic neologism but one not really to be recommended.

Physiology and Pathology

Drowning occurs when an individual is unable to remain afloat in water—a situation depending on the skill and endurance of the swimmer and personal buoyancy. Most people will, if they take a full breath, remain on the surface in fresh water

with a small area of the scalp exposed—just positively buoyant—while about 10% will sink—the negatively buoyant. Bodies are more buoyant in sea water and only 2% will sink. When failure to remain afloat occurs there is usually a period of apnoea and struggling, which may be followed by a violent inspiratory effort. Water enters the mouth and is at first swallowed in large quantities. In a fit individual whose laryngeal reflexes are brisk, spasm may prevent inhalation of water. If this is maintained until the resulting cerebral anoxia causes paralysis of the respiratory centre the casualty can lose consciousness without water entering the lungs.

Dry Drowning

It is very difficult to estimate the number of drowning victims who are lucky enough to experience dry drowning, as this is the group giving the highest recovery rate, and consequently many such cases are not reported. It has, however, been estimated^{4,5} that between 20 and 40% of all drownings fall into this category.

Clinically cases of dry drowning present a picture of simple asphyxia. If the victim can be rescued from the water and revived he may remember experiencing pleasant dreams and panoramic views of events in his past life before losing consciousness, and as a result suffers little distress.

Wet Drowning

If inhalation of water occurs before consciousness is lost the victim may experience a severe and searing pain down the middle line of the chest. This is quite an agonizing experience and if the victim survives and remembers the incident it will completely obliterate any pleasant hypoxic hallucinations.

Any inhalation of water complicates the picture, and until recently it has been thought that sea water and fresh water drowning produce completely different clinical pictures, the latter resulting in a more rapid death. A great deal of experimental work has been carried out on animals in recent years,^{6,7,8,9} the results showing the following differences.

Sea Water Drowning.—Because the tonicity of sea water is greater than that of blood, when sea water enters the alveoli water is drawn out of the blood into the alveoli and ions of sodium, magnesium, and chloride pass into the blood. At the same time there is a transfer of protein into the alveoli. All this results in a rapid haemoconcentration, and thus an increased load on the heart producing a slowing of pulse, fall in blood pressure, and death in four to five minutes from a hypoxaemia with a dilated heart. At the same time there is a rapid onset of pulmonary oedema.

Fresh Water Drowning.—When fresh water enters the alveoli the situation is reversed. Because of the blood's greater tonicity the inhaled water is immediately absorbed into the circulation, producing a marked haemodilution and haemolysis of the red

* Surgeon Rear-Admiral, Royal Naval Hospital, Plymouth.

cells. The latter liberates potassium ions into the plasma and in conjunction with the consequent overloading of the circulation produces a ventricular fibrillation within two to three minutes.

Drowning in Man

The theoretical and experimental differences between the effects of inhalation of salt and fresh water have tended to confuse the issue as far as man is concerned, since full haematological investigations during recovery from drowning have rarely been made. Post-mortem findings do not reflect the condition at the time of death, as electrolyte transfer will continue after this. Where it has been possible to carry out such examinations no significant evidence of electrolyte transfer, haemoconcentration, or haemodilution has been found,¹⁰ and clinically no difference is seen between the fresh water and salt water victims. There is, however, a general indication that more cases survive drowning in sea water. The mortality rate of drowning in the author's series of 172 cases where consciousness was lost in the water is 40%. However, only 19 of these cases were in fresh water and of these only four survived (a mortality of 80%). Donald⁷ hinted at this when he said, "It is difficult to avoid the sinister interpretation that the aspiration of any marked quantity of fresh water into the lungs is fatal." It must be born in mind, however, that the circumstances surrounding drowning in fresh water are generally very different from those in the sea. Firstly, sea water gives much greater buoyancy, and, secondly, sea water bathing usually takes place in conditions where rescue is more likely. Fresh water drownings, with a few exceptions, tend to occur when the victim is alone; they are frequently suicidal; and there is greater likelihood of entanglement in weeds or other underwater obstructions and less natural buoyancy.

An exceptional case, however, is that reported by Kvittingen and Naess,¹¹ in which a child was rescued after prolonged submersion in fresh water with respiratory failure and cardiac arrest. Though recovery was achieved there was evidence of gross haemolysis and haemodilution. The important factor here was that this incident occurred in extremely cold water which protected vital tissues and thus facilitated survival. Drowning in extremely cold water should be considered separately, as it presents a specific problem in man.

Though there is no conclusive evidence on the exact sequence of events when water is inhaled by man, they are not the same as those observed in experimental animals.

If gross inhalation of fresh water leads to absorption and rapid death there is, nevertheless, evidence that smaller amounts are not completely absorbed. The protection afforded may well be associated with the lipoprotein lining of the lung described by Pattle¹² and Clements.¹³ Without this lining there would be a natural tendency for small alveoli to contract and larger ones to expand. This process might also occur if the lining substance was neutralized by inhaled water, fresh possibly being more effective than salt. If this occurred the diminished capillary circulation in expanded alveoli would limit absorption, as would the emptying of others in spite of increased circulation. This is a subject needing a great deal more research, but might be a possible explanation of the apparent discrepancies between the somewhat delayed findings in man and animal experiments where it is possible to observe the immediate effects of introducing large quantities of water into the lungs.

Water entering the alveoli must act as an irritant whatever the tonicity and whichever way the electrolytes flow, and in both cases there will always be a considerable loss of protein from the blood. In both fresh and salt water drowning this plays an essential part in the creation of the characteristic foam found in the lungs and respiratory passages. In a case of drowning in man it is therefore essential to consider the case from a purely clinical point of view and to treat the victim accordingly.

Drowning in man falls into four categories: (i) with no inhalation of water—dry drowning, (ii) with inhalation of water—wet drowning, (iii) pulmonary complications following apparent recovery—secondary drowning, and (iv) the effects of sudden immersion in cold water—the immersion syndrome.

When examining a patient in the early stages of drowning it is often extremely difficult to decide whether or not any water has entered the lungs, and only the subsequent course of events will show whether or not this has occurred. Medical care commences once the victim has been removed from the water, though under certain circumstances first-aid treatment may actually be given by the rescuer to the victim while still in the water.

The outstanding sign of drowning is respiratory failure invariably associated with a marked degree of cyanosis (occasionally this may be replaced by a pallor) and frequently a white or blood-stained fine foam issuing from the nose or mouth. Evidence of recent immersion confirms the diagnosis. A further complication in more extreme cases is circulatory failure.

Clinical Findings in Human Drowning

The period between respiratory failure and cardiac arrest rarely exceeds three to four minutes, and is believed to be even shorter in fresh water, though this has not been proved. The longer cardiac arrest continues the less likely is resuscitation to be effective; the resulting cerebral hypoxia causes a cerebral oedema which may have prolonged after-effects.

Drowning without Inhalation of Water.—Whether or not water is inhaled depends to some extent on the circumstances of the accident and the state of the individual at the time of drowning. When water enters the mouth it is swallowed in copious amounts, this in itself lessening the urgency of the desire to breathe, and if the laryngeal reflex is brisk laryngeal spasm will protect the lungs from the entry of water. This is more likely to happen to individuals who fall into the water accidentally and are not exhausted by prolonged struggling, but is also a common accident in snorkel swimmers engaged in spear fishing. These swimmers, when trying to chase fish under water for as long as possible, may increase their breath-holding time by hyperventilation. This can be done to such a degree that the residual oxygen in the lungs is gradually depleted to the point that when the swimmer surfaces the redistribution of blood and the reduction in oxygen partial pressure may result in unconsciousness. The importance of this form of drowning has been underlined by Craig.¹⁴ Though these patients undoubtedly have the best chance of survival if rescued and are technically to be regarded as cases of simple asphyxia, the hypoxia if prolonged may produce not only cerebral oedema but also pulmonary oedema, giving ultimately a picture not unlike that produced by actual inhalation of water.

Drowning with Inhalation of Water.—The main picture of asphyxia with or without cardiac failure and cerebral oedema will still occur. The entry of water into the lungs, whether fresh or salt, immediately acts as a foreign body, diminishing the oxygen-absorbing area and disturbing the patency of the alveoli, on which will depend the degree of electrolyte transfer. In all such cases there is a marked loss of protein from the blood, an essential factor in foam production. The amount of water inhaled and degree of pollution determines the severity of the condition and the urgency of treatment. In these cases a chest radiograph will frequently show diffuse, small, irregular shadows in the lung fields.

Secondary Drowning.—In most cases the water inhaled contains debris such as small marine growths (diatoms), sand, mud, fuel oil, sewage, or other pollution, all of which increase the hazard to the lungs. Without vigorous treatment directed at preserving the lungs and maintaining adequate oxygenation—even when there has been apparent recovery as a result of resuscitative measures—the patient may rapidly worsen. A

patient who has recovered consciousness and seems to be progressing favourably may within a few hours show increasing evidence of respiratory distress with progressive restlessness, breathlessness, pain in the chest, increasing cyanosis, and cough. Clinically there will be evidence of a severe and progressive pulmonary oedema and pneumonitis, and an x-ray will show shadows over large areas of the lung field (Fig. 1). Death

FIG. 1.—Early radiological appearances in secondary drowning.

may be heralded by a massive haemoptysis. If restoration of the circulation has also been delayed complications of cerebral oedema evidenced by sensory or motor changes may occur.

The necropsy appearances of secondary drowning are characteristic. There is a distortion of alveolar outline and presence of large mononuclear phagocytic cells, gross exudate, and ultimately consolidation (Figs. 2 and 3). Petechial haemorrhage may be found in the brain and other tissues. Special staining techniques, which may be required for forensic reasons, will commonly show the presence of marine organisms, though it is possible for water containing these organisms to enter the lungs after death.

Secondary drowning may also occur without the primary asphyxia. Jack¹⁵ reports a case of a sailor who fell off a narrow gangway while boarding a ship. He landed on a ballast tank, struck his head, and lay unconscious with his face under water. He was rescued almost immediately, still breathing strongly, and recovered consciousness in a few minutes. He died two and a half hours later with respiratory complications, and a necropsy showed heavy waterlogged lungs typical of drowning. He had apparently inhaled water, but had had insufficient

FIG. 2.—Post-mortem appearance of lungs in drowning. Note loss of alveolar outline, large mononuclear cells and extensive exudate.

immersion to produce asphyxia. Intake of alcohol was a predisposing factor in this case.

The Immersion Syndrome.—On rare occasions cases have occurred in which individuals, usually young adults, have died immediately on plunging into cold water. This is believed to be due to a vasovagal attack precipitated by the impact of cold water on the occipital area or on the pharynx, and it is most common in persons who have taken excess alcohol. Work by Keatinge¹⁶ on human volunteers has shown disturbances in cardiac rhythm and the presence of extrasystoles on sudden immersion in water at temperatures of 5° C. The condition is fortunately rare. It does not appear to occur in fit, experienced swimmers who habitually plunge into cold water, nor in the cold immersion following the sauna bath.

On the other hand immersion in cold water does influence the progress of normal drowning by lowering deep body

FIG. 3.—Consolidation of lung tissue in death from secondary drowning.

temperature. The resulting hypothermia protects brain and lung tissue and enables cardiac and respiratory resuscitation to be effective after quite long periods—20 minutes or more in the case described by Kvittingen and Naess.¹¹ Further details of this effect are given by Farthmann and Davidson.¹⁷ In these cases haemodilution in fresh water drowning may be quite marked.

Treatment

First Aid.—The most important single requirement in treatment for all cases of drowning is the restoration of effective ventilation and the maintenance of circulation. Seconds count and no time should be lost before starting exhaled air resuscitation. Experienced rescuers who are strong swimmers may be able to carry this out while the victim is still in the water and most certainly when he is brought into the shallows. However, return to the shore or a rescue boat should not be unduly delayed. Once the patient is ashore resuscitation must be continued until normal breathing returns. If there is evidence of circulatory failure—no immediate improvement with exhaled air resuscitation, no palpable pulse, and widely dilated pupils—closed chest cardiac massage should be given. These resuscitative techniques will usually allow time for the patient to be transferred to hospital. This should be done in every case, making sure that the resuscitative measures are continued throughout the journey if required. Even when there is apparent recovery hospital admission with close observation for at least 24 hours is essential—failure in this may result in a case of secondary drowning being overlooked, with disastrous results. In view of these possible complications every case of drowning admitted to hospital must be regarded as an acute medical emergency.

Hospital Treatment.—The drowning case admitted to hospital is potentially a medical emergency, for it may not be clear

whether or not water has entered the lungs. Thus all cases need continuous observation. When there is clinical evidence of pulmonary involvement there will invariably be a progressive pulmonary irritation, oedema with protein and fluid-loss to the alveoli, and diminished oxygen uptake. This condition demands positive pressure oxygen ventilation and intravenous injection of half to one-and-a-half litres of plasma. These two measures represent the treatment of choice in all complicated cases of drowning whether in salt or fresh water.

In exceptional cases more specific intravenous therapy, or even replacement therapy, may be indicated as a result of a blood electrolyte examination. Oxygenation is however of extreme importance, and some physicians may prefer to perform a tracheostomy—a process which also facilitates tracheobronchial toilet. In anticipation of subsequent pulmonary complications it is important that broad-spectrum antibiotics should be given and steroid therapy considered. When there has been considerable delay in resuscitation with the resultant possibility of cerebral oedema developing as a result of the anoxia, osmotic therapy with urea or hypothermia may be worth while. Copious amounts of water will have to be swallowed, and as the patient improves vomiting may occur. The patient should be turned on to his side as soon as is convenient, or ideally his stomach should be emptied artificially. The progress of the lungs should be checked from time to time by chest x-ray.

If the patient can be kept alive for 24 hours the chances are that he will make a complete recovery even if brain damage is indicated by convulsions, coma, or other signs. In all cases of drowning it must be born in mind that most of the victims will have suffered severe mental trauma and great care will be needed to steer them away from the psychological fear of further contact with water.

The procedures described above outline the current basic accepted forms of treatment. Further work is needed to study the value of antifoaming agents, hyperbaric oxygen, bicarbonate therapy, and so on.

Prevention of Drowning

The prevention of drowning is somewhat beyond the realm of medicine. There is an urgent need for the appropriate authorities to instruct the general public, particularly those who are increasingly taking part in aquatic sports, to respect the hazards of the sea and inland waterways and to bring home to them that the best single insurance against drowning is to

learn to swim proficiently. Recent techniques of drown-proofing¹⁸ and survival swimming¹⁹ have received considerable publicity, but though they are extremely valuable they should not be allowed to replace conventional swimming training. Other important safety measures include the acceptance of established safety standards as published by the governing bodies of the various aquatic sports.

Finally, a growing contribution is already being made by life-saving organizations such as the Royal Life Saving Society and the Surf Life Saving Association of Great Britain in the maintenance of beach patrols and lifeguards in coastal areas. Training of the general public in exhaled air resuscitation and the encouragement to study techniques including closed chest cardiac massage is also a most important and potentially helpful factor.

In conclusion it can be said that in order to reduce the present toll of deaths from drowning there is an urgent need to encourage water safety, improve first aid at the water's edge, and above all ensure an enlightened and effective application of hospital treatment.

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TODAY'S DRUGS

With the help of expert contributors we print in this section notes on drugs in current use.

Management of Patients with Upper or Lower Urinary Tract Infection

When a patient presents symptoms suggesting urinary tract infection, the doctor has several tasks:

- (1) To confirm the presence of infection.
- (2) To identify the responsible organism.
- (3) To treat the infection.
- (4) To check that treatment has eradicated the infection.
- (5) To decide whether further investigation is necessary.
- (6) To decide whether prophylactic treatment against recurrent infections is necessary.

Confirmation of Infection and Identification of Organism

In acute renal or bladder infections microscopy of the urine is usually decisive. The absence of pus cells in the suspended centrifuged deposit practically rules out acute infection; whereas the presence of more than a few pus cells in a 1/6 field makes it extremely likely that the source of a patient's acute symptoms lies in the urinary tract. More than 10 cells per high power field is conclusive. On the other hand, bacteriological culture of the urine can be misleading. It is not enough to grow *Escherichia coli* from the urine, for example, to prove that a patient with abdominal pain and fever has acute pyelonephritis. The urine should contain pus cells. Otherwise the organism may be a contaminant, and anyway is unlikely to be the cause of the symptoms.

It is necessary to examine the urinary deposit under the microscope because there has to be a considerable amount of