Chapter 25

DROWNING SYNDROMES

It is vital for divers to understand the management of near-drowning because it is the final outcome of a large number of diving accidents.

GENERAL

Drowning is defined as the death of an air breathing animal due to immersion in fluid. When patients lose consciousness due to immersion and aspiration, but subsequently recover, the term 'near drowning' is used. When symptoms are not severe enough to classify as near drowned, another term the 'aspiration syndrome', is employed. There is a continuous progression between aspiration, near drowning and drowning cases.

Aspiration syndromes merge with near drownings - often the intensity of the symptoms and the degree of consciousness depending on various circumstances, the activity of the victim and the administration of oxygen.

"Near drowning" cases sometimes die hours or days later, thereby having to be re-classified as secondary or delayed drowning.

Some of the apparently "drowned" victims, because of enthusiastic CPR and capable intensive care, surprisingly recover without serious sequelae.

The incidence of death by drowning appears to be diminishing in the more civilised countries, from 7 per 100,000 in 1970s to around 2 per 100,000 now. Drowning is second only to motor vehicle trauma as a cause of accidental death in Australia and the USA, and is the major cause in some age groups (since the introduction of seat restraints in motor vehicles).

There is an over-representation of young males in most drowning series and there is a predictable age distribution for specific types of drowning. Most swimming pool deaths

occur in the very young, surf deaths mostly in teenagers and young adults, ocean deaths of sailors and fishermen throughout the whole adult range, and bathtub drownings are in either babies, the infirm or homicides.

When a fully conscious human accidentally falls in the water, he usually fights to survive, involving a panic reaction with violent struggling followed by automatic swimming movements. There may be a period of breath holding and swallowing of large gulps of water. Vomiting may occur, followed by gasping and aspiration of water and stomach contents. Blood stained froth develops in the airways and may be coughed up. Finally the patient convulses and then dies from cerebral hypoxia.

Drowning was traditionally associated with a "fight for survival" response but in other circumstances drowning may proceed in a quiet and apparently unemotional manner. In these cases loss of consciousness occurs without any obvious warning, and the underwater swimmer/diver then aspirates and drowns quietly. Examples of *quiet drownings* include:

1. Hyperventilation and hypoxia of ascent in breath-hold diving. This is a common cause of drowning in otherwise fit individuals who are good swimmers. Se Chapter 4.

2. Hypothermia and/or cardiac arrhythmia cases.

3. Drugs and alcohol effects. These increase the incidence of drowning by impairing judgment and reducing the struggle to survive. It is likely that nitrogen narcosis may have a similar effect in divers.

4. Diving equipment problems may produce hypoxia. These include the dilution and ascent hypoxias with rebreathers and carbon monoxide toxicity, interfering with oxygen metabolism. They are all likely to cause loss of consciousness without excess CO_2 accumulation, dyspnoea or distress. See Chapters 6, 20 & 43.

5. The salt water aspiration syndrome of divers. See Chapter 26.

6. Other causes of unconsciousness in divers, leading to drowning, have been described in Chapter 33, e.g. cerebral arterial gas embolism, some marine animal envenomations, and coincidental medical illnesses such as head trauma, epilepsy, insulin-induced hypoglycaemia in diabetics, cerebral haemorrhage etc.

Fresh or salt water entering the alveoli (air sacs of the lung) appears to wash out or damage the surfactant lining them, causing alveoli to collapse and become unavailable for gas exchange. Damage to the walls of the alveoli also causes the capillaries to leak blood and protein into the lungs. This interacts with air and water producing a foam which the victim may cough up in copious amounts. This is called pulmonary oedema.

The **sequence of events** in a near-drowning diving incident often goes as follows:

The degree of **panic** behaviour is variable, and may be reduced by such factors as personality, training, drug intake and nitrogen narcosis. If some air is still available from the regulator, the diver may persist with attempting to breathe from this (even at the cost of aspirating some water), and request assistance. Even if an alternative air supply is made available, **hypoxia** may still develop because of the water aspirated. Coughing and gasping may be voluntarily suppressed until the diver

reaches the surface. If the diver is totally deprived of his air supply for some reason, he initially breath-holds until the "break point" is reached and then takes an involuntary breath.

The resulting inhalation of a bolus of water usually provokes **coughing** and **closure of the larynx** producing involuntary breath-holding followed by unconsciousness. It is unusual for large amounts of water to enter the lungs after the victim loses consciousness as the tongue and loose tissues in the throat tend to close the airway. Instead, there is often swallowing of sea water, which makes the diver susceptible to vomiting and aspiration.

CLASSIFICATION of the Drowning Syndromes.

There are many ways of classifying the drowning syndromes.
The one used in this text relies on the dictionary definition of drowning as death due to submersion. The corollary of this is that near-drowning does not lead to death, but was close to it - and usually implies unconsciousness. Salt water aspiration is exactly what it implies and is less serious.

Others, based on the Alice in Wonderland principle that words mean whatever you want them to mean, have re-defined the classification and allow drowning victims to survive, near-drownings to die (delayed or secondary drownings) and others added a series of subdivisions (drowning without aspiration, drowning with aspiration, near-drowning with or without aspiration, the drowning process, etc.). Some classify them as to the aetiology – fresh or salt water drownings.

Clinicians have classified the drowning syndromes depending on their presentation at hospital emergency care units, and the ultimate prognosis is based on this essentially neurological classification, but with other factors being considered. Sensible and practical – for them.

Life-guards, first aid workers and other paramedics have an analogous, but different, classification based on what should be done at the scene of the recovery of the victim. Sensible and practical – for them.

CLINICAL FEATURES

Fig. 25.1

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The commonest ultimate cause of death in recreational scuba divers is drowning.
For example, any loss of consciousness or capability when engaging in terrestrial activities is unlikely to cause death. It would do so more frequently if the victim was diving under water.

When first rescued the condition of the near-drowned victim may vary from fully conscious to unconscious, with normal, laboured or absent respiration. The initial effects are on the respiratory system, but later damage is due to hypoxia on the brain.

If the victim is breathing, the stiff lungs cause laboured respiration and it is common for foam, often copious and blood stained, to be coughed up or to exude from the nose or mouth. Vomiting is also common, as is aspiration of stomach contents, either spontaneously or during resuscitation attempts. Cyanosis (bluish coloration of lips, tongue, ears) from hypoxia is frequent. The jaws may be clenched.

TREATMENT

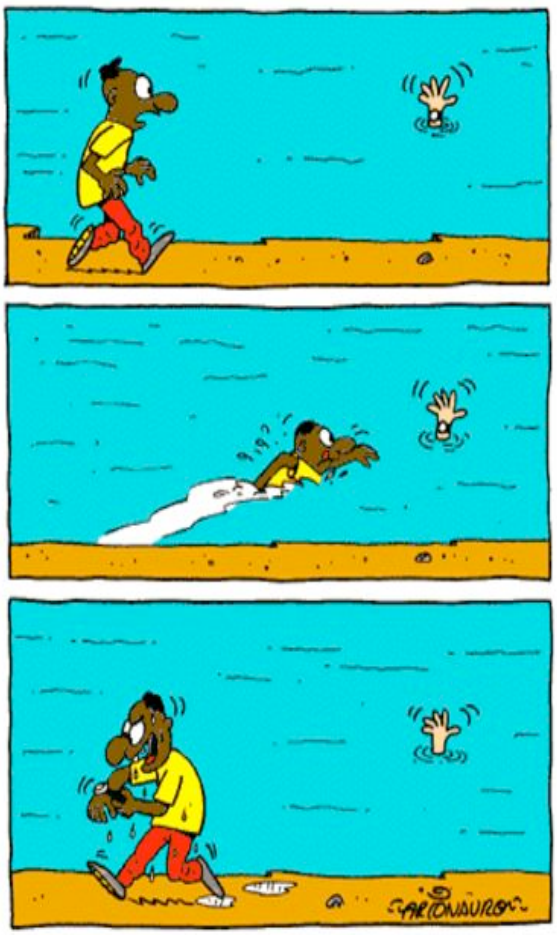

Fig. 25.2

Rescue and recovery from the water is the top priority and time should be spent in the diving course in this training. Success is reliant on buddy behaviour, acquiring positive buoyancy during ascent and on the surface (including ditching of weights) and attracting attention.

Treatment at the scene of an accident will often determine whether the victim lives or dies. The standard of first aid and resuscitation training of the rescuers therefore influences outcome.

The temperature of the water and thus the degree of hypothermia may also be a factor. Poorer results are achieved in warm bath water drownings. Other factors which influence outcomes include: the presence of chlorine and other chemicals and foreign bodies, the aspiration of stomach contents, the subsequent development of pneumonitis, respiratory infection and lung damage, haemolysis, renal failure and coagulopathies. These complications are for the intensive care physicians to cope with.

In exceptional circumstance, near drowned victims have fully recovered after periods of total immersion of over 15-45 minutes (especially so in children in cold waters), so it is worth attempting resuscitation even in apparently hopeless cases.

If the patient is unconscious the basic life support (**BSL**) priciples take precedence and should be followed (see Chapter 42). **Oxygen** in the highest concentration available should be given by mask to offset hypoxia. Masseter spasm ("jaw clenching") is a common feature of hypoxia, and may obstruct artificial respiration.

Near drowned cases are liable to deteriorate many hours after making an apparent recovery, so all near drowned victims should be taken to **hospital** and must remain there for at least 24 hours under observation.

The World Congress on Drowning, in 2002, made the following recommendations, which may also be applicable to divers, where the submersion time is unknown or is known to be less than 15 minutes.

Whenever a non-breathing victim is found in the water, the rescuer should bring the victim's face out of water and extend the neck to open the airway. In either shallow or deep water, if two or more rescuers are present, or a single rescuer is equipped with a floatation device, the victim should then be checked check for breathing. In the absence of spontaneous breathing, rescue breathing should be carried out for approximately one minute.

If breathing is restored, the victim's airway should be kept open during recovery and removal to dry land or boat. Only a brief stop should be made to monitor breathing and restart rescue breathing if necessary.

If breathing is not restored or there is no circulation, the rescuer should recover the victim to shore or boat without further attempts at rescue breathing. Rescuers should not check victim's pulse or start compressions while in the water. Cardiac compression in the water has been shown to be ineffective and pulse checks are both unreliable and slow the rescue process; even if CPR is necessary, this may place the victim in further danger of aspiration of water and needlessly tire the rescuer. After successful resuscitation the victim should be kept under observation for 5 to 10 minutes in case breathing stops. Even trained lifeguards cannot always accomplish in-water resuscitation technique effectively, especially in deep water.

Of course, resuscitation and then observation must be continued until professional medical assistance supervenes, as describer earlier.

In the diving situation it may sometimes be possible to improve on these measures, and it is strongly recommended to all competent divers that they should take advantage of some of the excellent Rescue and Resuscitation courses available through the diver training organizations and/or DAN.

PREVENTION

It is paradoxical that drowning, which causes more than 80 times the number of deaths in recreational divers than either decompression sickness or contaminated air, does not rate more than a paragraph or two in some diving medical texts.

A normally functioning diver, with adequate equipment in a congenial ocean environment, is protected from drowning as he carries his own personal life support system with him - his scuba. Drowning only occurs when there is;

- diver fault (pathology, psychology or technique),
- failure of the equipment to supply air, or
- hazardous environmental influences.

A survey was conducted of 100 recreational scuba deaths from drowning and compared these with near drownings, and it demonstrated that simple measures were available to avoid the fatal drowning cases. They were:

1. Diver health and fitness.
Ensure both medical and physical fitness, so that there is no increased likelihood of physical impairment or loss of consciousness, or difficulty in handling unexpected environmental stresses.

2. Experience.
Ensure adequate experience of the likely dive conditions (become trained and dive under the supervision of a more experience diver, when extending your dive profile).

3. Equipment.
Absence of appropriate equipment is a danger, but not as much as equipment failure and misuse. The latter includes the practice of overweighting the diver, and his over reliance upon the buoyancy compensator.

4. Environment.
Hazardous diving conditions should be avoided, using extreme caution with tidal currents, rough water, poor visibility, enclosed areas and excessive depths.

5. Neutral buoyancy (during the dive).
Ensure neutral buoyancy whilst diving. This implies not being overweighted and not being dependent on the buoyancy compensator.

6. Air supply.
An inadequate supply of air for unexpected demands and emergencies may convert a problematic situation into a fatal one. It also forces the diver to experience surface situations that are worrying and conducive to anxiety, fatigue and salt water aspiration. Equipment failure is not as common a cause of inadequate air supply as diver error -

failure to monitor the contents gauge and/or a reprehensible decision to breathe the tank down to near-reserve pressure.

7. Buddy diving.
Use traditional buddy diving practice - 2 divers swimming together. Solo diving, for the whole or part of the dive, is much more likely to result in an unsatisfactory outcome in the event of diving problems. It is the divers who are committed to the traditional buddy diving practices who are likely to survive the more serious drowning syndromes.

8. Positive buoyancy (post incident)
Positive buoyancy is frequently required if problems develop.
Failure to remove the weight belt during a diving incident continues to be a major omission, and must reflect on training standards. In most situations, unbuckling and then ditching (if necessary) the weight belt is the most reliable course of action once a problem becomes evident.
Buoyancy compensators cause problems in some emergency situations, and not infrequently will fail to provide the buoyancy required. They are of great value in many cases - but are not to be relied on.

9. Buddy communication.
If feasible, inform the buddy prior to ascent. If correct buddy diving practice is being observed, the buddy will automatically accompany the injured or vulnerable diver back to boat or shore.

10. Rescue
Employ the rescue, water retrievals, first aid facilities (including oxygen) and medevac systems which were planned before the dive. See Chapters 5 & 39.

These factors differentiate a drowning fatality from a successful rescue.