Environmental Health: Drowning

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Abstract

Background: Drowning is a common, preventable injury, especially in childhood, and with the large coastline of Australia is of special concern to General Practitioners.

Objective: To present relevant information on epidemiology, prevention and treatment of drowning for the General Practitioner.

Discussion: In children drowning is the second most common cause of death by accident in Australia, with 0-4 year olds comprising 22% of all drownings. Commonest sites for drowning are non-tidal lakes and lagoons; private swimming pools (especially pre-school children); ocean/estuary and surfing beaches; bathtub and bucket drownings (especially in infants and toddlers) with up to 10% of bucket drownings due to child abuse. Despite prevention strategies including pool fencing, drowning rates in young children have remained relatively static: in older children, drowning rates have declined dramatically despite the lack of prevention. The indigenous population have a much higher rate of drowning than the overall figure and their toddler rate was very high. Approximately 70% of near drowning victims will have complete neurological recovery, 30% will suffer some selective deficit), and 3% survive in a permanent vegetative state. Alcohol has been strongly implicated in drowning and banning alcohol from adjacent swimming areas has reduced drowning rates. Overseas tourists were 4.7% of all non boating drownings with 89% of these drowning in the ocean. Further funding for drowning prevention strategies are essential yet noticeably lacking.

Definition

Drowning is death from suffocation by submersion in a liquid, which is usually freshwater or seawater. Near drowning is the term used to describe submersion in a liquid in which the victim survives, at least temporarily(1).

Introduction

Drowning is a significant accidental cause of death and neurological damage, particularly in children, and is usually preventable(2). It is currently the 20th most common cause of death worldwide(3) and the most common cause of death children under 5 in Australia(4).

The main problems in drowning are caused by hypoxia, which causes a number of haemodynamic effects(5). These effects then predispose towards the neurological morbidity in survivors of near-drowning, which includes difficulty in learning, memory, attention and planning.

The economic costs to the community from drowning in Australia are considerable (4).

Pathophysiology

Haemodynamic effects are significant and are similar in both seawater and fresh water with a rapid drop in cardiac output and an increase in pulmonary capillary wedge pressure, central venous pressure, and pulmonary vascular resistance. Very few electrolyte abnormalities occur in drowning survivors (6) with the reduction in the dynamic compliance of the lungs similar following inspiration of all types of solutions and the main cause of morbidity and mortality (5).

Freshwater vs seawater immersion

Aspiration of large volumes of hypertonic seawater draws fluid from the circulation to the lung by osmosis. This results in fluid-filled alveoli, which cannot perform the normal gaseous exchange. In freshwater aspiration large amounts of hypotonic freshwater are rapidly absorbed into the circulation around the alveoli and cause initial acute hypervolaemia. Within an hour redistribution of fluid and pulmonary oedema occurs, which results in a decreased circulating blood volume(7). Conn calculated that almost 10% of body weight of water can be absorbed from the lungs in fresh water drowning(7).

With no cerebral blood flow the brain suffers irreparable damage and death or severe neurologic impairment occurs after submersion of more than 5-10 minutes(8). Usually bystanders have little or any idea of actual submersion time and whereas this may affect prognosis it must not affect judgments on treatment.

Hypothermia

Hypothermia is less of a problem in Australia, where few bodies are cold enough for this to be an issue. However, it is worth mentioning that there is a marked difference in hypothermia caused by sudden total submersion in cold water and hypothermia caused by prolonged immersion after drowning in warmer water.

Rapid body cooling occurs as a result of total submersion in ice-water with associated hypothermia. Continuous aspiration of cold water from breathing attempts results in rapid body cooling, whilst the circulation remains efficient(7). Some victims can survive with little or no neurological deficit after long submersion with extreme anoxia(2). A good outcome could be predicted in over 95% of victims submersed in water of 16^0celsius or less with maximum submersion for 10 minutes or less, (9).

The effects seen from total submersion in cold water do not apply to drowning in warm water where rapid body cooling and brain preservation does not occur. Resuscitation with intact neurological function of victims immersed in warm water is highly dependent on short immersion times and rapid, effective resuscitation.

Although swimmers in difficulty may be able to shout for help, contrary to public opinion, those drowning do not. Most drowning victims adopt a characteristic vertical position in the water: - legs hang vertically, head tilted back for quick exhalation and inhalation before bobbing underwater,. Because of the short surface time with rapid exhalation and then inhalation, there is neither time nor sufficient breath to actually call for help. Victims may take only 20-60 seconds before quietly submerging permanently (10).

Treatment

Hypoxia is the major problem in the victim of near-drowning together with the resulting acidosis. A successful outcome depends on early effective resuscitation at the scene and on competent intensive life support. Surf Life Saving Australian teaching has shown that early respiratory resuscitation in deep water can be effective(11).

Resuscitation at the scene should be prompt and with efficient resuscitation to increase the success of later resuscitation and intensive care as some 25% of drowning victims arriving at the Emergency Department will die and 31% will have remaining neurological problems(12). Supplemental oxygen is necessary as quickly as possible. If the victim is unconscious an oropharyngeal airway or endotracheal tube should be inserted and oxygen using positive airway pressure (bag-valve-mask) used, if suitably qualified personnel are present. Vomiting and regurgitation are a frequent risk in early resuscitation(11,13). IV access with plasma expanders is essential as soon as possible.

On arrival at the Emergency Department, after further assessment of airway breathing and circulation, IV access should be obtained if not already present and pulse oximetry for the immediate assessment

of $Pa0_2$ whilst arterial blood gas tensions and pH are measured. Patients with severe hypoxaemia may have irreversible cerebral ischaemia.

In conscious impaired victims with poor breathing or vital signs, positive end-expiratory pressure or continuous positive airway pressure using mechanical ventilation may be necessary and a central venous catheter or pulmonary artery catheter will measure effective circulating blood volume to suggest necessary IV fluid therapy. Usually large volumes of intravenous colloid are needed in both freshwater- and seawater-aspiration whilst circulating blood volume and cardiac output are estimated(14). If the blood pressure fails to stabilise with IV replacement (20ml/kg) then inotropes (dopamine or dobutamine) are necessary. Steroids do not appear to improve chances of survival(6). The risk of secondary pneumonia is high, especially if mechanical ventilation is necessary. Although prophylactic antibiotics are not recommended broad- spectrum antibiotics may be required in self-determined cases.

Adult respiratory distress syndrome (ARDS) (similar to that in infants and children) has been reported after near drowning(15) and usually occurs within 6 hours of admission: Extra-corporal membrane oxygenation has proved effective, reversing the pulmonary injury. Artificial surfactant used to replace the victim's natural lung surfactant washed away in near drowning, has proved effective in necessary cases (16)

Mild reversible renal impairment, although rare, may occur and serum creatinine, blood pH, abnormal urinalysis, or significant lymphocytosis should be assessed, as they may predispose to acute renal failure(17).

Drowning, especially in children, has significant impact – especially if it involves death. An essential part of all General Practice involves the counselling of all parties involved. Professional counselling may need to be considered for difficult cases.

BOX 1
Epidemiological facts

- Commonest sites for drowning are non-tidal lakes and lagoons (19%), private swimming pools (17%), ocean/estuary (16%), surfing beach (10%) bathtub (7%) followed by buckets, bins, sinks and fishponds (18).
- In both Australia and worldwide, in infants and toddlers under the age of 12 months, bathtub and bucket drownings are the most common(18).
- Drowning remains a serious problem, particularly for the 0-4 year olds who comprise 22% of all drownings with a rate of 4.4 per 100,000 population (18).
- Swimming pool drownings are the major cause of preventable death affecting pre-school children in some regions of Australasia(4).
- Despite prevention strategies including pool fencing drowning rates in young children worldwide, many of whom are unsupervised, have remained relatively static(19)
- Despite the lack of prevention strategies in older children, drowning rates have declined dramatically in the last decade(19).
- Up to 10% of fatal bucket-tub immersions are the result of child abuse (18).
- In children drowning is the second most common cause of death by accident in Australia. (20).
- In South-east Asia and Australasia, accidental immersion accidents rank highly among the causes of preventable child trauma.
- The indigenous population have a much higher rate of drowning than the overall figure and their toddler rate was very high. Drowning due to suicide was more frequent than from boating incidents (18)
- Approximately 70% of near drowning victims will have complete neurological recovery, 30% will suffer some selective deficit), and 3% survive in a permanent vegetative state (4).
- Ocean drownings are less common than freshwater drownings. Fewer children swim unsupervised in the ocean, and preventative and rescue efforts of lifesaving and lifeguard associations guarding the beaches are particularly effective, especially in Australia (11,13).
- Aspiration is usual in drowning and near-drowning although in approximately 10-20% cases laryngeal spasm occurs and aspiration is prevented, or occurs in minute amounts ("dry" drowning) (1)
- Vomiting and regurgitation were major problems during resuscitation (11).
- Respiratory and cardiopulmonary arrest occurred after apparently- successful rescue; this highlights the necessity for the close observation of victims and the early administration of oxygen to all immersion victims(11).
- Resuscitation in deep water has been shown to be effective, and instruction in these techniques is now standard teaching within the Surf Life-Saving Association of Australia(11).
- Early expired air resuscitation (EAR) and/or Cardio-pulmonary resuscitation (CPR) has a success rate of 67% in Surf Life Saving rescues in patrolled areas. Resuscitation success rates fell with increasing distance from patrolled areas (13).
- Differences in drowning rates are influenced by the climate; availability of beaches, lakes, and other natural and artificial water sources; presence of lifesavers/lifeguards; water recreational equipment (including personal watercraft ("jet skis"); the non-use of lifejackets; and in hobbies, pastimes and professions (especially rock fishing).
- Alcohol has been strongly implicated in drowning (13,21). It affects judgement, vision, balance, and movement and is a major risk factor in drowning for both adolescent and adult swimmers. It also has major implications for boat operators and passengers, who may fall overboard while intoxicated.
- 25-50% of adult drowning victims had some exposure to alcohol at the time of rescue, resuscitation or death(13,21). Banning alcohol from being adjacent to swimming areas reduces drowning (Quan et al 1999)
- Overseas tourists were 4.7% of all non boating drownings with 89% of these drowning in the ocean (18).
- There were 80 persons drowned in motor vehicle crashes between 1990-1996 (18).

BOX 2
Causes of drowning

Drowning is caused by many factors, including : -

- Rip currents* (common in countries such as Australia with large coastlines or bathing beaches)
- accidental immersion with poor, or nil, swimming ability,
- head and neck injuries,
- cardiac emergencies
- neurological emergencies (including epilepsy)
- drug and alcohol causing impaired ability
- metabolic disease (including hypoglycaemia)
- Road traffic crashes and water
- suicide
- child abuse
- murder

* NOTE: In both drownings and rescues in rip currents swimmers are caught up in sideways currents that carry them into rip currents, which are large volumes of water returning back out to sea after onshore wave action. They are more common on beaches with large surf. Mention is often made of an "undertow" but there is effectively no such thing. All undertows are actually rip currents.

BOX 3
Clinical features

Factors that influence survivors with nil or reduced neurological complications include:-

Good outcomes may be associated with: -

- Normal chest X-ray on admission.
- Normal arterial oxygen tension values (PaO2) (these values may not relate to the chest X-ray appearances) (22).
- Good cardiovascular status. Mortality is high in victims with circulatory arrest on admission.
- Reactive pupils and neurologic responsiveness at the scene have good outcomes(8).
- Those alert on arrival have a survival rate approaching 100%

Poor outcomes may be associated with: -

- Victims who are asystolic on arrival at hospital and remain comatose for more than 3 hours have a poor outcome unless they are hypothermic(23).
- comatose victims with fixed dilated pupils have a poor prognosis - approximately 40-50% victims who are comatose on arrival have significant incapacitating brain damage
- Victims with no spontaneous limb movements and abnormal brain stem function 24 hours after the accident have a poor neurological outcome(24).
- Fixed dilated pupils or those with total flaccidity are associated with a high mortality.

Other factors

- Serum electrolytic concentrations and values for haemoglobin level and haematocrit are unhelpful in predicting survival(6).
- Victims with blunted consciousness have a survival rate of 87% with no neurological defects, 2% with minor defects and 11% die(1).
- A modified Glasgow coma score is helpful in evaluating neurological injury. A Glasgow coma score of 5 or less predicts a mortality risk of over 80%(25).
- Victims with any motor activity, even posturing or seizures in the immediate post resuscitation period had a higher incidence of intact survival (26).

BOX 4
Prevention of drowning

- Parent education and supervision. Up to 30% of children under 5 are unsupervised or poorly supervised on surf beaches (research figures, SLSA 1999)
- Adult supervision of children under 3 in the bath is essential - 89% of children aged 35 to 59 months and 6% of those younger than 3 years of age are sometimes bathed without adult supervision(27).
- Swimming pools and natural bodies of water present the greatest risk to young children.
- Public media education and campaigns – in Australia in the surf only 17% rescues and resuscitations occurred within patrolled areas (up to 95% successful resuscitation), whilst 55% were saved and resuscitated outside patrolled areas (62% successful); resuscitation success rates fell with increasing distance from patrolled areas(13).
- Training and skills in EAR and CPR.
- Better safety standards and safety devices, including pool fencing, are necessary(4). Pool drownings incidents in Brisbane (Australia) improved after legislation for compulsory pool fencing(28).
- Strategies for the prevention of drowning should also consider hazards in rural living (In Tasmania more childhood drownings occur in dams than in swimming pools (29)
- Swimming ability and safety skills of young children may be improved by training, providing some protection against risk of drowning. So called “drown-proofing” is NOT effective (18).
- All epileptic children in the bath should have adult supervision.
- Adult epileptics should shower and leave the door open or unlocked.
- Personal flotation devices (PFDs) should be used on all boats and personalised watercraft (PWC). Up to 50% of boaters do not use PFDs(30).
- Avoid alcohol at sights adjacent to bathing areas. Men have higher drowning rates than women for most age groups, probably due to an overestimation of their abilities, and often with alcohol use (13,21).
- Bath where there are lifesavers or lifeguards present - drownings are rare at supervised venues.
- safety legislation (e.g. pool fencing and maintenance) can reduce both the population risk and the individual clinical severity of immersion accidents.(4).

Conclusion

Drowning in Australia is an important preventable cause of death, remaining the second most common in Australian children. More funding for preventative measures is essential. The recent dramatic reduction in surf-related drownings in Victoria after $3 million dollar Victorian Government incentive was effective. Efforts to encourage the Australian Government to do similar fell on deaf ears, despite the recent influx of visitors to the Olympic Games.

Banning alcohol near water in water parks and pools in the United States resulted in a dramatic decrease in the incidence of drowning. This finding and other preventative factors need to be studied and implemented: research and money are required.

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