CHEST

Management for the Drowning Patient

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Drowning is "the process of experiencing respiratory impairment from submersion or immersion in liquid." According to the World Health Organization, drowning claims the lives of > 40 people every hour of every day. Drowning involves some physiological principles and medical interventions that are unique. It occurs in a deceptively hostile environment that involves an underestimation of the dangers or an overestimation of water competency. It has been estimated that > 90% of drownings are preventable. When water is aspirated into the airways, coughing is the initial reflex response. The acute lung injury alters the exchange of oxygen in different proportions. The combined effects of fluid in the lungs, loss of surfactant, and increased capillary-alveolar permeability result in decreased lung compliance, increased right-to-left shunting in the lungs, atelectasis, and alveolitis, a noncardiogenic pulmonary edema. Salt and fresh water aspirations cause similar pathology. If the person is not rescued, aspiration continues, and hypoxemia leads to loss of consciousness and apnea in seconds to minutes. As a consequence, hypoxic cardiac arrest occurs. The decision to admit to an ICU should consider the patient's drowning severity and comorbid or premorbid conditions. Ventilation therapy should achieve an intrapulmonary shunt ≤ 20% or Pa_{O_2}:F_{IO_2} ≥ 250. Premature ventilatory weaning may cause the return of pulmonary edema with the need for re-intubation and an anticipation of prolonged hospital stays and further morbidity. This review includes all the essential steps from the first call to action until the best practice at the prehospital, ED, and hospitalization.

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According to the World Health Organization (WHO), drowning is a preventable public health threat claiming the lives of > 40 people every hour of every day. With > 90% of these deaths occurring in low- and middle-income countries, it is the world's third leading unintentional injury killer.[1] International data severely underestimate the actual drowning mortality rate in high-income countries,[2] with survey data from some low- and middle-income countries suggesting rates four to five times that of the WHO estimated drowning rate.[3] Almost all nonfatal drowning victims are able to help themselves or are rescued in time by bystanders or professional rescuers, but these cases are rarely globally reported. Coastal drownings are estimated to cost more than $273 million

ABBREVIATIONS: ALS = advanced life support; PEEP = positive end-expiratory pressure; WHO = World Health Organization

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Take-home Points

- Drowning is defined as the process of experiencing respiratory impairment from submersion or immersion in liquid.
- Drowning is a leading cause of injury and death among young people, in whom it has been estimated that > 90% of drownings are preventable.
- Mortality and morbidity are proportional to the hypoxic insult, and the treatment of this insult is the mainstay of therapy.
- Almost all drowning victims return home safely without sequelae, except the post-cardiopulmonary arrest victims in whom outcome is almost solely determined by a single fate factor: duration of submersion and ICU care.
- Concurrent pathologies may "trigger' a drowning event and should be considered.

per year in the United States and more than $228 million per year (in US dollars) in Brazil.[4] Key risk factors for drowning are male sex, age < 14 years, alcohol use, low income, poor education, rural residency, aquatic exposure, risky behavior, and lack of supervision.[1,4]

Drowning involves some physiological principles and medical interventions that are rarely found in other medical situations. Drowning deaths can be prevented by using a series of interventions.[5] It occurs in a deceptively hostile environment that may not seem dangerous and usually involves an underestimation of the dangers or an overestimation of water competency to face them.[6] The first challenge is to recognize that someone is at risk of drowning and appreciate the need for rescue. Early self-rescue or rescue by others may stop the drowning process and prevent the majority of initial and subsequent water aspiration, respiratory distress, and other medical complications. The drowning process happens quickly,[7,8] but removing the victim from this environment has the potential for significant harm to the rescuer. It is therefore essential that all responders are aware of the complete sequence of action steps on drowning process.[9] The details of the drowning event can assist the clinician in the hospital management of the pathophysiology that is likely to occur as a result.

Definition, Data, and Drowning Timeline

"Drowning is the process of experiencing respiratory impairment from submersion or immersion in liquid."[10] If respiratory impairment is not present, then this is just a rescue and not a drowning. The drowning process is a continuum, beginning with respiratory impairment as the victim's airway goes below the surface of the liquid (submersion) or when it splashes over the airways (immersion). If the victim is rescued at any time, the process of drowning is interrupted; it is a nonfatal drowning. If the victim dies at any time, this is a fatal drowning. Terms such as "near-drowning," "dry or wet drowning," and "secondary drowning" should not be used. A uniform way to report data for drowning resuscitation is the Utstein template for drowning resuscitation cases.[11] For nonfatal drownings, the WHO proposed a framework based on morbidity and severity of respiratory impairment (Table 1).[12]

The drowning timeline describes every constituent of the process, triggers, actions, and interventions from a temporal perspective of pre-event, event, and post-event. The drowning timeline constitutes a powerful tool to improve collection of drowning data, thus contributing to a better understanding of the process to effectively prevent, react, and mitigate it, and to facilitate the prioritization of cost/benefit ratios related to public health, financial aspects, political scope, and social impacts[6] (Fig 1).

Pathophysiology

Whatever the reason a person is in the water, drowning carries a higher possibility of death if the individual is not rescued or unable to cope with the situation.[6] The initial triggers for drowning are diverse and very complex.[9] It may simply be an inability to stay afloat (eg, young children may sink with minimal struggle[13]) or to exit the water (eg, river channel). These triggers vary with age, circumstance, water temperature (cold water may precipitate cardiac arrhythmias [autonomic conflict]), water competency, and some events temporally associated with being in the water (eg, traumatic injury, illness such as myocardial infarction or seizure).[14,15] These may all result in a physical inability or loss of consciousness. Many of these variables are still not fully understood. In the majority of drowning events, the victim fails to keep his or her airway above the surface, and water that enters the mouth is voluntarily spat out or swallowed. When water is aspirated into the airways, coughing occurs as an initial reflex response. Some morphologic forensic studies indicate that penetration of liquid into the lungs occurs in almost all drowning deaths. Dry lungs can be found only in bodies disposed of into water following death on land.[16] In < 2% of cases,[16,17] laryngospasm may be

TABLE 1] Categorization Framework for Nonfatal Drowning[12]

Severity of respiratory impairment after the drowning process stopped[a]		
(1) Mild	(2) Moderate	(3) Severe
• Breathing • Involuntary distressed coughing[b] AND • Fully alert	• Difficulty breathing AND • Disoriented but conscious	• Not breathing AND • Unconscious
Morbidity category (based on any decline from previous functional capacity[c]) at the time of measurement[d]		
(A) No morbidity	(B) Some morbidity	(C) Severe morbidity
• No decline	• Some decline	• Severe decline

[a]There must be evidence of respiratory impairment to be classified as a nonfatal drowning.
[b]The following descriptors serve to better characterize the meaning of "involuntary distressed coughing": coughing up liquid/moving liquid out of the airway; in water, in distress and coughing; sustained coughing.
[c]The phrase "previous functional capacity" includes the person's cognitive, motor, and psychological capacity.
[d]The morbidity category at the time when nonfatal drowning information is gathered. For the purposes of this categorization framework, morbidity is defined as a decline from the individual's functional capacity prior to the drowning.

present, but the onset of hypoxia will terminate this rapidly. If the person is not rescued, aspiration of water continues, and hypoxemia leads to loss of consciousness and apnea in seconds to minutes.[8,18] As a consequence, hypoxic cardiac arrest generally occurs following a period of bradycardia and pulseless electrical activity and not ventricular fibrillation or tachycardia.[19,20]

Following rescue, the clinical picture is determined by the personal reactivity of the airways and the amount of water that has been aspirated with the corresponding hypoxia. Water in the alveoli causes surfactant destruction and washout, initiating an acute lung injury. Salt and fresh water aspirations cause similar pathology. In either situation, the effect of the osmotic gradient on

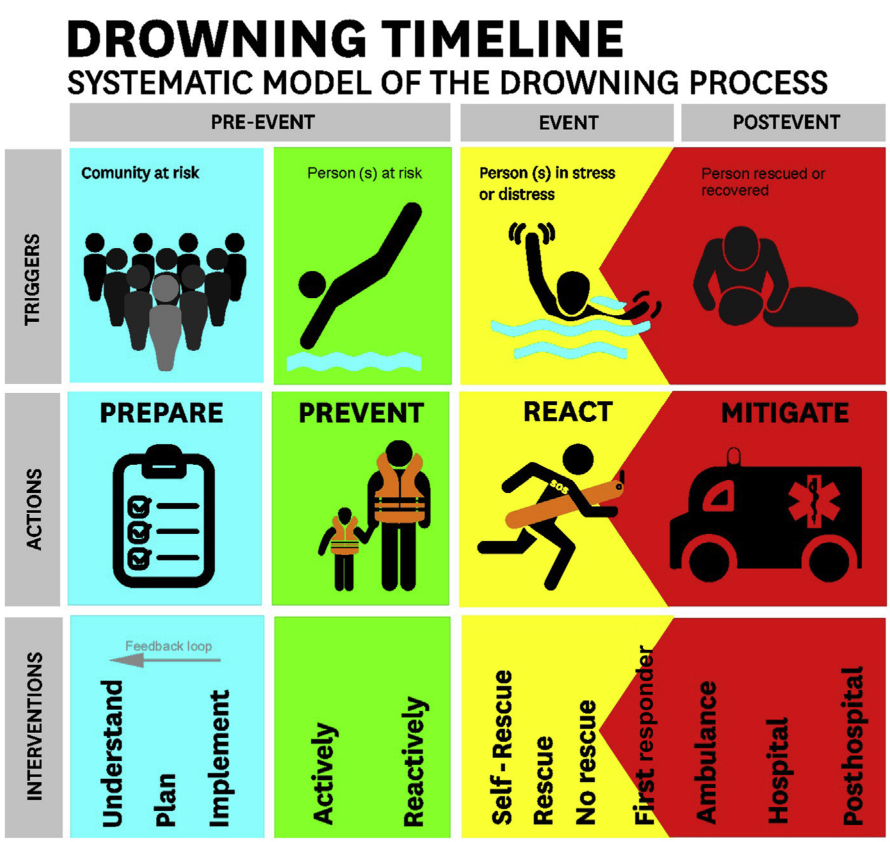

Figure 1 – *Drowning timeline.*[6] *Authors acknowledge SEMES (Sociedad Espanola de Medicine de Urgencias e Emergencias) for the design.*

Figure 2 – *Drowning chain of survival. Reprinted with permission from Szpilman et al.*[9]

the alveolar-capillary membrane can disrupt its integrity, increase its permeability, and exacerbate fluid, plasma, and electrolyte shifts.[19] The clinical picture is of regional or generalized pulmonary edema that alters the exchange of oxygen and CO_2 in different proportions.[18,19,21] In animal research,[21] the aspiration of 2.2 mL of water per kilogram of body weight leads to a severe disturbance on exchange of oxygen, decreasing the PaO_2 to approximately 60 mm Hg within 3 min. In humans, it seems that as little as 1 to 3 mL/kg of water aspiration produces profound alterations in pulmonary gas exchange and decreases pulmonary compliance by 10% to 40%. The combined effects of fluid in the lungs, loss of surfactant, and increased capillary-alveolar permeability can result in decreased lung compliance, increased right-to-left shunting in the lungs, atelectasis, and alveolitis, a noncardiogenic pulmonary edema.[19]

Prehospital Care: Drowning Chain of Survival

The drowning chain of survival[9] (Fig 2) refers to a series of interventions that, when put into action by lay or professional people, reduces the mortality associated with drowning.

Series of Interventions

1. Prevent drowning. The most effective way to reduce the number of drowning deaths is prevention. It has been estimated that $>$ 90% of all drownings are preventable.[5,22,23]
2. Recognize distress and call for help. Recognizing a person in distress and sending for help is a key element that ensures early activation of professional rescue and medical services.[9]
3. Provide flotation. Flotation should be provided to the victim to try and stop the process of drowning by reducing the submersion risk.[9] It is critical that personnel take precautions not to become another victim by attempting inappropriate or dangerous rescue responses.[7,8] If not interrupted, the drowning process leads to unconsciousness and apnea, rapidly followed by cardiac arrest. During this short window of opportunity, immediate in-water ventilation may provide benefit if safe to do so. It can increase the discharge from hospital without sequelae by more than threefold, but it is only possible if the rescuer is highly trained. Victims with only respiratory arrest usually respond after a few rescue breaths. If there is no response, the victim should be assumed to be in cardiac arrest and be rescued as quickly as possible to a location where full CPR can be initiated because in-water chest compressions are futile.[24] Considering the low spinal injury incidence (0.009%-0.5%), an attempt to immobilize the spine should only be made if there is strong indication of injury and certainly not in cases in which the victim appears lifeless.[25-30]
4. Remove from water/rescue only if safe to do so. Rescue involves three phases: approach, contact, and stabilization. Removal from the water is essential to terminate the drowning process and allows assessment and clinical management of the victim.[24] Entering the water is a personal decision and should take into consideration the rescuer's experience. Extrication of the water is preferably in a near horizontal position but with the head maintained above body level and airway open.[31]
5. Provide care as needed/basic and advanced life support. Cardiopulmonary or isolated respiratory arrest in drowning comprises $<$ 0.5% of all rescues.[22] Early basic life support contributes to a good outcome and should be initiated as soon as possible.[4] Once on land, the victim should be placed supine, with trunk and head at the same level, and checked for responsiveness and normal breathing. If unconscious but breathing, the recovery position should be used.[24,31] If not breathing, ventilation is essential.[4,18,25] Hypoxia is the primary cause of cardiac arrest in drowning and requires rapid alleviation.[8,18,25,32] Thus, the airway-breathing-circulation[33] sequence is used, including

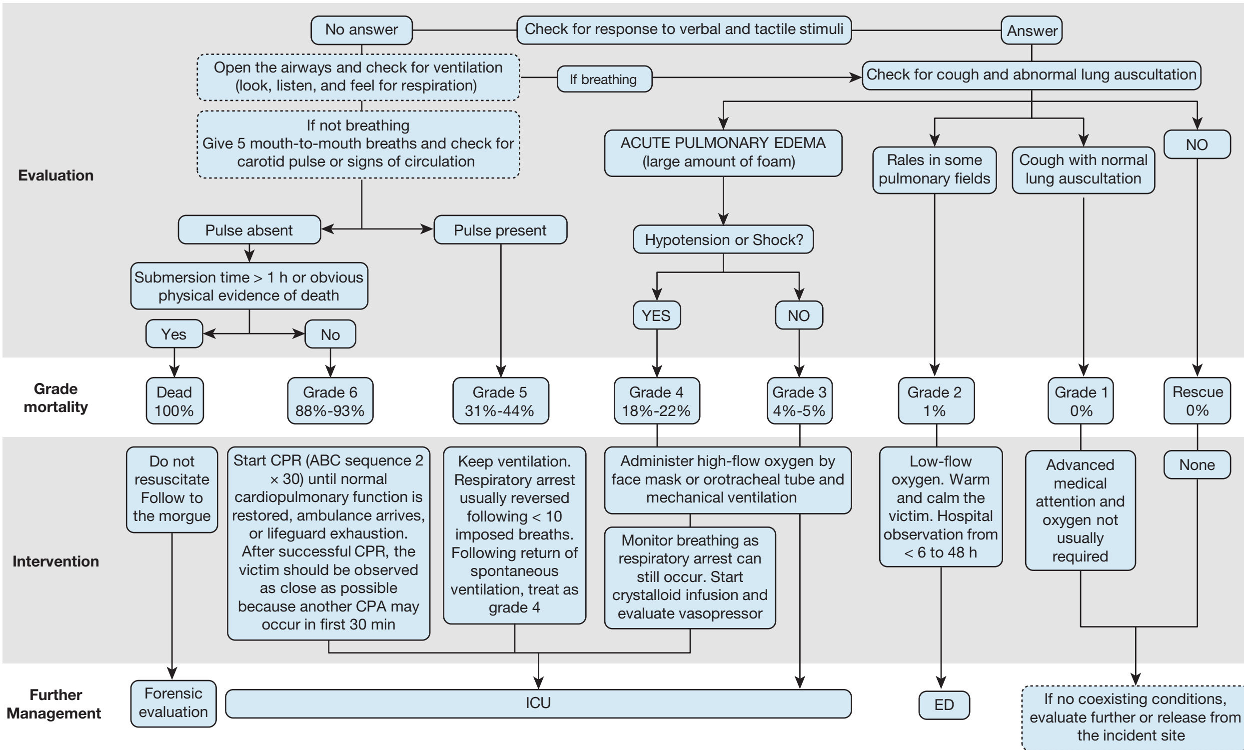

Figure 3 – *Drowning severity classification and flowchart strategy decision based on evaluation of 87,339 rescues.*[4,18] *Recovery position is the lateral decubitus position. CPA = cardiopulmonary arrest.*

five initial ventilations followed by 30 chest compressions. The initial five ventilations aim to overcome the high lung resistance, due to fluid and foam occluding the airways, allowing oxygen to reach the alveolars.[25,34] Following this sequence, a ratio of two ventilations to 30 compressions is used until there are: signs of life; rescuer exhaustion; or advanced life support (ALS) becomes available.[25,32] This is in preference to circulation-airway-breathing or compression-only CPR sequences; however, any attempt at resuscitation is preferential to none. It is common for swallowed water and stomach contents to be regurgitated into the airway, with subsequent risk of aspiration.[18,24,35] Active efforts to expel water from the airway (abdominal thrusts or placing the victim head down) should be avoided as they delay initiation of ventilations, increase the risk of vomiting by more than fivefold, and thereby lead to significant increase in mortality.[24,31] If vomiting occurs, the victim should be immediately turned onto the lateral position, vomitus removed by a finger sweep or suction, and resuscitation continued. The effectiveness of automated external defibrillators for cardiac arrest in drowning is low as the presenting rhythm is usually pulseless electrical activity or asystole. The incidence of ventricular fibrillation or ventricular tachycardia is low (4.5%-6%). A shockable rhythm is, however, a positive predictor of survival[8,35-37] and more likely if there is a history of coronary artery disease, epinephrine use, or in the presence of severe hypothermia.[20]

ALS is given according to drowning severity classification[4,18] stratified into six grades (Fig 3) recommending the best practice treatment and the likelihood of death.

At grade 6 (cardiopulmonary arrest), advanced CPR should be initiated at the scene by using bag-valve-mask ventilation with high-flow oxygen until a definitive airway can be achieved (oro-tracheal tube). The use of supraglottic airway devices is controversial. The pulmonary airway pressure usually exceeds the safety threshold to maintain pharyngeal seals with pressures of 25 to 28 cm H_2O,[34,38] allowing a high potential to leak, causing new aspirations of stomach contents (water included). Once intubated, most victims can be oxygenated and ventilated effectively despite the presence of pulmonary edema in the tracheal tube. Orotracheal tube suctioning can disturb oxygenation and lung recruitment. This should be balanced against the need to

TABLE 2] Drowning: When to Initiate CPR and When to Discontinue[4,5,8,11,18-20,23,24,39-41]

Question	Recommendation
In whom to begin?	• Give ventilatory support for respiratory distress/arrest to avoid cardiac arrest • Start CPR in all patients submerged < 60 min who do not present obvious physical evidence of death (rigor mortis, body decomposition, or dependent lividity)
When to discontinue?	• Basic life support should continue unless signs of life re-appear, rescuer exhaustion, or advanced life support is available • Advanced life support should be ongoing until patient has been rewarmed (if hypothermic) and asystole persist for > 20 min

ventilate and oxygenate. Peripheral venous access is a good alternative route for drug administration in the prehospital setting. Intraosseous access is the alternative route, if available. Endotracheal administration of drugs is not recommended in drowning.[32] Cumulative doses of epinephrine 1 mg IV (or 0.01 mg/kg) can be considered if the routine dosage fails to achieve success after the initial 5 min of CPR. Once resuscitation attempts are successful, an orogastric tube can be placed to reduce gastric distention and prevent further aspiration. Recommendations for when to start and stop resuscitation are described in Table 2.[4,5,8,11,18-20,23,24,39-41]

Grade 5 (isolated respiratory arrest) is usually reversed by initial basic life support with oxygenation and ventilation before ALS is commenced. If there is spontaneous ventilation but oxygenation is compromised (acute pulmonary edema [grades 3 and 4]), the objective is to achieve a prehospital peripheral saturation > 92% by administering oxygen by face mask at a rate of 15 L/min of oxygen. Early oral tracheal intubation and mechanical ventilation are indicated as soon as possible, because of respiratory fatigue, despite adequate oxygenation by face mask.

Although all grade 4 cases need oral tracheal intubation, a few grade 3 drowning cases will tolerate noninvasive ventilatory support[18,39,42,43] provided their conscious level allows. Patients should be anesthetized to tolerate intubation and artificial mechanical ventilation. ED attendance is recommended for all grade 2 to 6 patients. Most grade 2 victims require low-flow oxygen and will normalize their clinical situation within 6 to 48 h and can be discharged home.[18]

Hospital Care

The decision to admit to an ICU or hospital bed vs observation in the ED or discharge home should consider the severity of the patient's drowning as well as any comorbid or premorbid conditions. A thorough medical assessment should be performed, including chest radiography and/or lung ultrasound, arterial blood gas measurement, and blood tests.[44,45] The latter should include tests of renal function, liver function, electrolytes, hemoglobin, and any appropriate toxicology given the association with suicide and alcohol excess. Grade 3 to 6 patients should be admitted to an ICU for close observation and therapy. Grade 2 patients can be observed in the ED, but grade 1 and rescue cases with no symptoms or associated illness or trauma can be released home.[18,44]

Respiratory System

Patients classified as grade 3 to 6 usually have ALS and mechanical ventilation, with acceptable oxygenation, initiated in the prehospital phase. If not, the receiving clinician should initiate it. Positive end-expiratory pressure (PEEP) should be added initially at a level of 5 cm H_2O and then increased by increments of 2 to 3 cm H_2O if needed and possible. The PEEP should be used until the desired intrapulmonary shunt (QS:QT) of ≤ 20% or Pa_{O_2}:F_{IO_2} of ≥ 250 is achieved.[19] At grade 4, if hypotension is not corrected by oxygen, a rapid crystalloid infusion should be used prior to trying to reduce PEEP. Once the desired oxygenation is achieved, that level of PEEP should be maintained unchanged for at least 48 h prior to attempts at weaning.[46] This is the minimum time required for adequate surfactant regeneration. Premature ventilatory weaning may cause the return of pulmonary edema, with the need for re-intubation and an anticipation of prolonged hospital stays and further morbidity.[4] A clinical picture very similar to ARDS but with a prompt recovery and no lung sequelae is common following significant drowning episodes (grades 3-6). A protective lung ventilation strategy (eg, low tidal volumes [6 mL/kg ideal body weight]) similar to ARDS should be used. Permissive hypercapnia should be avoided, however, to prevent further neurologic insult in those with significant hypoxic-ischemic brain injury (usually grade 6).[4] CPAP, pressure support ventilation mode, and/or noninvasive

TABLE 3] Recommended Care for Victim Who Remains Comatose or Unresponsive Following Successful CPR or Who Deteriorates Neurologically[39,50]

• Raise the head of the bed by 30 degrees (if there is no hypotension)
• Maintain adequate mechanical ventilation by using drugs to low patient fighting the ventilator
• Ensure appropriate respiratory toilet (keeping positive airway pressure) without provoking hypoxia
• Treat for seizure activity
• Avoid sudden metabolic corrections
• Prevent interventions that increase intracranial pressure, including urinary retention, pain, hypotension, hypercapnia, hypoxemia
• Hyperthermia should be avoided and normoglycemia maintained

ventilation are appropriate weaning strategies if pulmonary and psychological status allows.[42,43]

Pools, rivers, and beaches generally have insufficient bacteria colonization to promote pneumonia in the immediate postdrowning period.[47] Pneumonia is often misdiagnosed initially because of the early radiographic appearance of water in the lungs, with few patients actually requiring antibiotic therapy (12%). If the victim requires mechanical ventilation, the incidence of pneumonia (ventilator associated) increases to 34% to 52% in the third or fourth day of hospitalization when pulmonary edema is resolving.[48] Vigilance for pulmonary complications as well as other infectious complications is important. Prophylactic antibiotics tend to only select out more resistant and aggressive organisms.[49] The first signs of pulmonary infection are at 48 to 72 h and are gauged by prolonged fever, sustained leukocytosis, persistent or new pulmonary infiltrates, and leukocyte response in the tracheal aspirates.

A broad-spectrum antibiotic therapy to cover gram-positive and gram-negative bacteria should be used immediately if the drowning occurred in water with high pathogen load (UFC $> 10^{20}$). In ventilator-associated pneumonia, the predominant microorganisms of the ICU or available cultures should be considered. In resistant infections, consideration should be given to alternate pathogens (eg, fungal, algae, protozoa). Fiber optic bronchoscopy may be useful for evaluation of infection by obtaining quantitative cultures, determining the extent and severity of airway injury, and for the rare occasions in which therapeutic clearing of sand, gravel, or other solids is indicated. Corticosteroids should not be used except for bronchospasm. The clinician must be aware of and constantly vigilant for volutrauma and barotrauma during mechanical ventilation.[47]

Focused bedside ultrasound can be used to diagnose and monitor the respiratory and circulatory system in real time, specifically the rapid diagnosis of pneumothoraces and distribution of lung edema.[45] Ultrasound assessment of cardiac function can guide fluid therapy, indication for inotropes or vasopressors, monitor the response to therapy, and exclude concurrent pathologies.

Circulatory System

Cardiac dysfunction with low cardiac output is a usual occurrence immediately following severe cases of drowning.[19] Low cardiac output is associated with high pulmonary capillary occlusion pressure (hypoxic vasoconstriction), high central venous pressure, and pulmonary vascular resistance that can persist for days. This may add a cardiogenic component to the drowning, primary non-cardiogenic pulmonary edema. The reduced cardiac output can be corrected with oxygenation, crystalloid infusion, and restoration of normal body temperature. Vasopressor infusion should be reserved for refractory hypotension. Echocardiography to assess cardiac function can guide the clinician in titrating inotropes, vasopressors, or both if volume crystalloid replacement is inadequate.[4]

In patients who are hemodynamically unstable or have severe pulmonary dysfunction, pulmonary artery catheterization may be considered to provide useful information. There is no evidence to support the use of any specific fluid therapy for salt and freshwater drowning,[19] the use of diuretics, or water restriction. Metabolic acidosis occurs in 70% of patients arriving at the hospital following a drowning episode.[18]

Neurologic System

Most late deaths and long-term sequelae of drowning are neurologic in origin (anoxic-ischemic cerebral insult) and are almost exclusive in grade 6, as pulmonary injury is usual reversible.[4,47] Although the highest priority of CPR is restoration of spontaneous circulation, every effort in the early stages should be directed at resuscitating the brain and preventing further neurologic damage. These steps include providing adequate oxygenation ($SaO_2 > 92\%$) and cerebral perfusion (mean arterial pressure, around 100 mm Hg). Any

TABLE 4] Probability of Neurologically Intact Survival to Hospital Discharge, Based on Duration of Submersion[8,11,18-20,23,24,39-41]

Duration of Submersion	Death or Severe Neurologic Impairment
0 to < 5 min	10%
5 to < 10 min	56%
10 to < 25 min	88%
> 25 min	99.9%

In these data, 5 more minutes of submersion in the 5 to < 10 min group increases mortality almost 6 times compared with that in the 0 to < 5 min group.

victim who remains comatose or unresponsive following successful CPR or deteriorates neurologically should undergo careful and frequent neurologic function assessment and care by using the measures given in Table 3.[39,50]

Drowning victims with spontaneous circulation who remain comatose should have targeted temperature management to improve outcomes following cerebral hypoxia-ischemia.[51-53] Maintaining a core temperature of 32°C to 34°C for at least 24 h postarrest is associated with improved neurologic outcomes.[51-54] Although there is insufficient evidence to support a specific target Pa_{CO_2} or oxygen saturation, hypoxemia should be avoided. Studies have failed to show improved outcome using intracranial pressure monitoring,[56] therapies to control intracranial hypertension, or maintenance of artificially high cerebral perfusion pressure.[55,56]

New therapeutic interventions for drowning victims such as artificial surfactant[57-59] or nitric oxide[60] are still experimental, with a few successful case reports. Extracorporeal membrane oxygenation may be considered when the patient is profoundly hypothermic or conventional respiratory assistance is insufficient to maintain oxygenation. Such an approach assumes that this option is available and feasible.[61-64]

Unusual Complications

In the most severe cases (grade 6), the hypoxic and/or hypo-perfusion associated with drowning can trigger the systemic inflammatory response syndrome. This can manifest as isolated cardiac, renal, or hepatic dysfunction through to sepsis and multi-organ dysfunction syndrome. Rarely, drowning victims with normal chest radiography develop fulminant pulmonary edema up to 12 h following the incident. Whether this late-onset pulmonary edema is delayed ARDS, a neurogenic pulmonary edema secondary to hypoxia, or just an airway hyperreactive to water aspiration is still unclear.[4,11,18,65]

Cold Water Drowning

Submersion in cold water and sudden release of breath hold can induce cardiac arrhythmias, particular in those with long QT syndrome, by simultaneously activating the antagonistic responses of the autonomic nervous system (autonomic conflict), including the sympathetic "cold shock response" producing a tachycardia and bradycardia mediated by the parasympathetic "diving response." These responses may, in vulnerable individuals, account for sudden death in cold water.[36,56-67] Hypothermia reduces the electrical and metabolic activity of the brain; cerebral oxygen consumption reduces by approximately 5% per each degree Celsius reduction in temperature within the range of 37°C to 20°C,[68] thus prolonging the interval until cellular anoxia, adenosine triphosphate depletion, and cell death signaling. If cooling occurs prior to submersion (ie, hypoxia), it provides a form of cerebral protection that explains cases with good neurologic outcome despite prolonged submersion for up to 90 min.[25,40] In these cases, the water temperature was 6°C or lower. Extracorporeal membrane oxygenation has been used in the resuscitation of these victims with good neurologic outcomes, despite an initially poor prognosis.[4,32,40,61,62] Previously hypothermic victims re-warmed to near-normal core temperature, who remain asystolic with significantly elevated serum potassium levels, despite resuscitation, is a key indicator of futility.[25,69,70]

Outcome and Scoring Systems

Ninety-five percent of drowning cases grades 1 to 5 return home without sequelae.[18] In grade 6, prognostic variables are important while counseling family members and in deciding which treatment strategies are appropriate.[8] Victims who remain comatose or deteriorate neurologically should undergo intensive assessment and care.[39] Several studies have established that outcome is almost solely determined by a single factor: duration of submersion (Table 4).[8,11,18-20,23,24,39-41]

This emphasizes the need for accurate documentation of the prehospital presentation and incident details. Following

successful CPR, assessment of neurologic severity will allow comparison of different therapeutic approaches.[71]

TABLE 5] Drowning Clinical Prognostic Score for the Immediate Period Postsuccessful CPR, Based on Glasgow Coma Score[8]

Neurologic Prognostic Score Postsuccessful CPR on Drowning	
A: First Hour	B: Following 5 to 8 h
Alert = 10	Alert = 9.5
Confused = 9	Confused = 8
Torpor = 7	Torpor = 6
Coma with normal brainstem = 5	Coma with normal brainstem = 3
Coma with abnormal brainstem = 2	Coma with abnormal brainstem = 1
A + B: Recovery Without Sequelae	
Excellent (≥ 13)	≥ 95%
Very good (10-12)	75% to 85%
Good (8)	40% to 60%
Regular (5)	10% to 30%
Poor (3)	≤ 5%

Data suggest that patients who remain decorticate, decerebrate, or flaccid in the 2 to 6 h following the drowning incident (when no drugs are implicated) are brain dead or will survive with moderate to severe neurologic impairment.[5] Patients who are improving but remain unresponsive have a 50% likelihood of a good outcome (Table 5).[8]

Conclusions

As one of the most common causes of unintentional injury-related morbidity and mortality worldwide, drowning remains a significant public health issue and an extremely complex process in which there is no simple or single solution. However, the true impact of drowning on public health is unknown due to a lack of high-quality epidemiologic data in the field. The most effective intervention to reduce drowning deaths is prevention. When prevention fails, further reduction in morbidity and mortality is only achieved by effective rescue and early clinical interventions when indicated. In many areas of medicine, it is obvious that prevention is better than cure, but how do you motivate and educate those populations that are at the highest risk? Does it require the emotive scenario of a child's death or severe neurologic insult as a result of a drowning event for people to act? The drowning process may involve a complex interplay between acute injury or disease and an inability to maintain the airway clear of the water's surface. The simple life skills of water awareness and the ability to float face up will prevent many of the complications of this potentially fatal process.

There is a deficit of high-quality scientific evidence at all stages of the patient's journey following a drowning event, particularly in the hospital setting. These events result in a multisystem disorder to a greater or lesser extent depending on the duration of the hypoxic insult. Following a successful rescue, the key therapy is oxygen and facilitation of its delivery to the tissues of the body.

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