AMERICAN FAMILY PHYSICIAN

Prevention and Treatment of Drowning

TIMOTHY F. MOTT, KELLY M. LATIMER

ABSTRACT

Nearly 4,000 drowning deaths occur annually in the United States, with drowning representing the most common injury-related cause of death in children one to four years of age. Drowning is a process that runs the spectrum from brief entry of liquid into the airways with subsequent clearance and only minor temporary injury, to the prolonged presence of fluid in the lungs leading to lung dysfunction, hypoxia, neurologic and cardiac abnormalities, and death. The World Health Organization has defined drowning as "the process of experiencing respiratory impairment from submersion/immersion in liquid." Terms such as near, wet, dry, passive, active, secondary, and silent drowning should no longer be used because they are confusing and hinder proper categorization and management. The American Heart Association's Revised Utstein Drowning Form and treatment guidelines are important in guiding care, disposition, and prognosis. Prompt resuscitation at the scene after a shorter duration of submersion is associated with better outcomes. Because cardiac arrhythmias due to drowning are almost exclusively caused by hypoxia, the resuscitation order prioritizes airway and breathing before compressions. Prevention remains the best treatment. Education, swimming and water safety lessons, and proper pool fencing are the interventions with the highest level of current evidence, especially in children two to four years of age. Alcohol use during water activities dramatically increases the risk of drowning; therefore, abstinence is recommended for all participants and supervisors.

Keywords: Drowning, WHO, respiratory impairment, floatable swimming aids

Drowning kills nearly 4,000 persons in the United States and more than 300,000 persons worldwide every year.[1] For U.S. children between one and four years of age, drowning has surpassed motor vehicle crashes as the most common injury-related cause of death at 2.6 per 100,000 persons annually.[2] Despite this significant health burden, public health initiatives have lagged because of lack of standardization in definitions and reporting.

DEFINITION

Before the first World Congress on Drowning (WCOD) in 2002, public health surveillance, research, and policy on drowning were impeded by a lack of clear terminology.[3] Highlighting this problem, a systematic review of the literature from 1966 to 2002 found at least 33 different definitions for drowning incidents.[4] The WCOD was organized largely to remedy this issue. The WCOD developed consensus guidelines using the Utstein principles—a term coined from a series of meetings held at Utstein Abbey in Stavanger, Norway, to clarify the nomenclature associated with out-of-hospital cardiac arrests.[4] The guidelines applied the same principles to clarify definitions, terminology, and data sets used in the epidemiology and treatment of drowning.[5] Following extensive discussion and debate, the World Health Organization agreed on the following definition: "Drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid."[3]

Terms such as near, wet, dry, passive, active, secondary, and silent drowning should not be used because they can be confusing and ultimately hinder classification or management.[3] The Utstein approach simplified the classification of drowning outcomes to only three domains: death, morbidity, and no morbidity.[3]

EPIDEMIOLOGY

Despite declines in the death and hospitalization rates from drowning over the past decade, it remains the top injury-related concern in children.[2,6,7] Approximately 5,800 persons are treated in U.S. emergency departments each year for submersion or drowning injuries, with one-half of those patients requiring hospital admission.[6,8,9]

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Permanent neurologic sequelae, such as persistent vegetative state or spastic quadriplegia, occur in 5% to 10% of childhood drowning cases.[10]

The typical location of drowning varies depending on age. Children younger than four years are more likely to drown in a swimming pool, whereas adults are more likely to drown in a natural body of water (Figure 1).[6] A systematic review found drowning to be the most common cause of recreational aquatic activity death in persons 15 years or older; 30% to 70% of drowning fatality victims had alcohol in their bloodstream.[11] Even small amounts of alcohol increase the risk of drowning, and this risk increases with the amount of alcohol consumed.[10-13]

PATHOPHYSIOLOGY AND CLINICAL PRESENTATION

Understanding the drowning process bolsters accurate diagnosis, treatment, and prognosis. Initially, fluid enters the oropharynx and is cleared, if possible. If clearing is not possible, conscious breath holding ensues. Eventually, the internal drive to inspire becomes insurmountable, and fluid enters the airways, stimulating cough or laryngospasm. If the drowning process continues, a number of events may occur, such as fluid and electrolyte shifts, alveolar dysfunction, and hypoxia.[14,15] These may trigger further deterioration with pulmonary edema, decreased lung compliance, and bronchospasm.[14,15] Cardiac deterioration develops after seconds to minutes of hypoxia, typically progressing from tachycardia to bradycardia, pulseless electrical activity, and asystole.[15-17]

EVALUATION AND TREATMENT

The Utstein approach to the evaluation of drowning victims not only standardizes reporting and data collection but also provides guidance for the history, physical examination, and appropriate management (eFigure A).

History

Details of the drowning event guide treatment and determine prognosis. Younger patients tend to have better outcomes.[18] Submersion for six minutes or longer is associated with a significantly poorer prognosis. When considering open water drowning victims with good outcomes (i.e., did not die or experience severe neurologic sequelae), 88% were submerged less than six minutes vs. 7.4% of victims with six to 10 minutes of submersion.[18] In-water resuscitation, where several rescue breaths are given by trained lifesaving personnel while still in the water, is associated with shorter duration of anoxia and a higher rate of survival.[19] Lack of adequate training, openwater conditions, distance to shore, water depth, equipment availability (e.g., flotation devices), and a person's features (e.g., injury, obesity) may limit the feasibility of in-water resuscitation.[19]

Cold water submersion was previously considered neuroprotective because of decreased metabolic demands of hypothermia and the diving reflex. Case reports described young victims with prolonged submersion in very cold water who survived neurologically intact.[20,21] However, it has been determined that water temperature has no correlation with overall outcome.[18] Contrary to popular belief, fresh vs. saltwater aspiration makes no difference in the degree of lung injury.[15]

Unless the victim has experienced a diving or boating accident or has fallen from a height, cervical spine immobilization is unnecessary because only 0.5% of drowning victims have a cervical spine injury.[22]

Physical Examination and Initial Treatment

A drowning classification system has been established to classify victims at the rescue scene based on the clinical parameters of respirations, pulse, pulmonary auscultation, and blood pressure[14,17] (Figure 2[17]).

Attention to airway, breathing, and compressions (ABC) in that order (compared with the modern advanced cardiac life support guidelines' compressions, airway, and breathing [CAB]) is paramount because any cardiac arrhythmias are almost exclusively secondary to hypoxia.[23] A patient who is not breathing or has a Glasgow Coma Scale score less than 8 should be intubated and given ventilatory support.[14] Conscious drowning victims with rales in some or all pulmonary lung fields require supplementary oxygen and evaluation in the emergency department.[14,17] A victim who is still on the scene, has no other medical complications, and demonstrates clear lung fields (with or without a cough) does not automatically require further medical attention.[14,17] This represents more than 94% of lifeguard rescues.[14,17]

Vomiting occurs in 30% to 85% of drowning victims because of swallowing large amounts of water and positive pressure ventilation during resuscitation.[19,24] Aspiration of gastric contents portends worse lung injury.

Diagnostic Evaluation

Although certain diagnostic evaluations start at the scene and may progress to an emergency department,

Revised Utstein Drowning Data Form

Patient ID:

Gender: ☐ M ☐ F ☐ U

Age:_____

or date of birth:_____/_____/_____
DD/MM/YY

Date of event:_____/_____/_____
DD/MM/YY

Times:

Call received:_____

EMS resus:_____

Precipitating event known?

☐ Yes ☐ No

If yes: ☐ Intoxication ☐ Trauma

Pre-existing medical:

List:_____

Drugs: _____

Other: _____

Location of drowning:

☐ Bucket ☐ Toilet
☐ Bathtub ☐ Lake
☐ Ocean ☐ Pool
☐ River/flowing water ☐ Other

Event witnessed?

☐ Yes ☐ No

If yes, time of event:_____

Witnessed/monitored by:_____

☐ Layperson ☐ Healthcare personnel

At scene:

Loss of consciousness: ☐ Yes ☐ No

CPR before EMS: ☐ Yes ☐ No

☐ By layperson ☐ Healthcare personnel

Techniques used:

☐ Rescue breathing ☐ Chest compression

EMS assessment/management:

Spont breathing: ☐ Yes ☐ No ☐ U

Signs of circulation: ☐ Yes ☐ No ☐ U

Airway interventions: ☐ Yes ☐ No ☐ U

Initial neuro state: GCS: E____V____M____

or: ☐ A ☐ V ☐ P ☐ U

or: ☐ A ☐ B ☐ C

ED assessment/management:

Spont breathing: ☐ Yes ☐ No ☐ U

Palpable pulse: ☐ Yes ☐ No ☐ U

Tracheal tube/ventilation: ☐ Yes ☐ No ☐ U

Initial: temp____BP____RR____SpO_2____FiO_2

Initial neuro state: GCS: E____V____M____

Or: ☐ A ☐ V ☐ P ☐ U

Or: ☐ A ☐ B ☐ C

Outcome:

ROSC:

Any: ☐ Yes ☐ No ☐ U

> 20 min: ☐ Yes ☐ No ☐ U

DNAR order: ☐ Yes ☐ No ☐ U

Date of event:_____/_____/_____
DD/MM/YY

Survived to:

ICU/ED: ☐ Yes ☐ No ☐ U

Hospital admission: ☐ Yes ☐ No ☐ U

Hospital discharge: ☐ Yes ☐ No ☐ U

If discharged alive: ☐ CPC ☐ U

Conn Drowning Coma Scale: A = Alert; B = Blunted; C = Comatose. GCS: E = Eye opening; V = Verbal response; M = Motor response.
AVPU scale: A = Alert or awake; V = Response to voice; P = Response to pain only; U = Unarousable

eFigure A. Revised Utstein drowning data form.

BP = Blood pressure; CPC = Cerebral performance category; CPR = Cardiopulmonary resuscitation; DNAR = Do not attempt resuscitation; ED = Emergency department; EMS = Emergency medical services; FiO_2 = Fraction of inspired oxygen; GCS = Glasgow Coma Scale; ICU = Intensive care unit; ROSC = Return of spontaneous circulation; RR = Respiratory rate; SpO_2 = Arterial oxygen saturation; U = Unknown.

the overall breadth of diagnostic workup is limited and primarily focuses on respiratory function. If hypothermia is a concern, infrared thermometric devices should not be used to determine core temperature because they register falsely lower body temperatures in victims whose heads have been submerged.[25] On arrival to the emergency department, clinical impression should guide laboratory studies. Serum electrolyte, hemoglobin, and hematocrit levels are typically in normal ranges and measurement is not beneficial.[17,26]

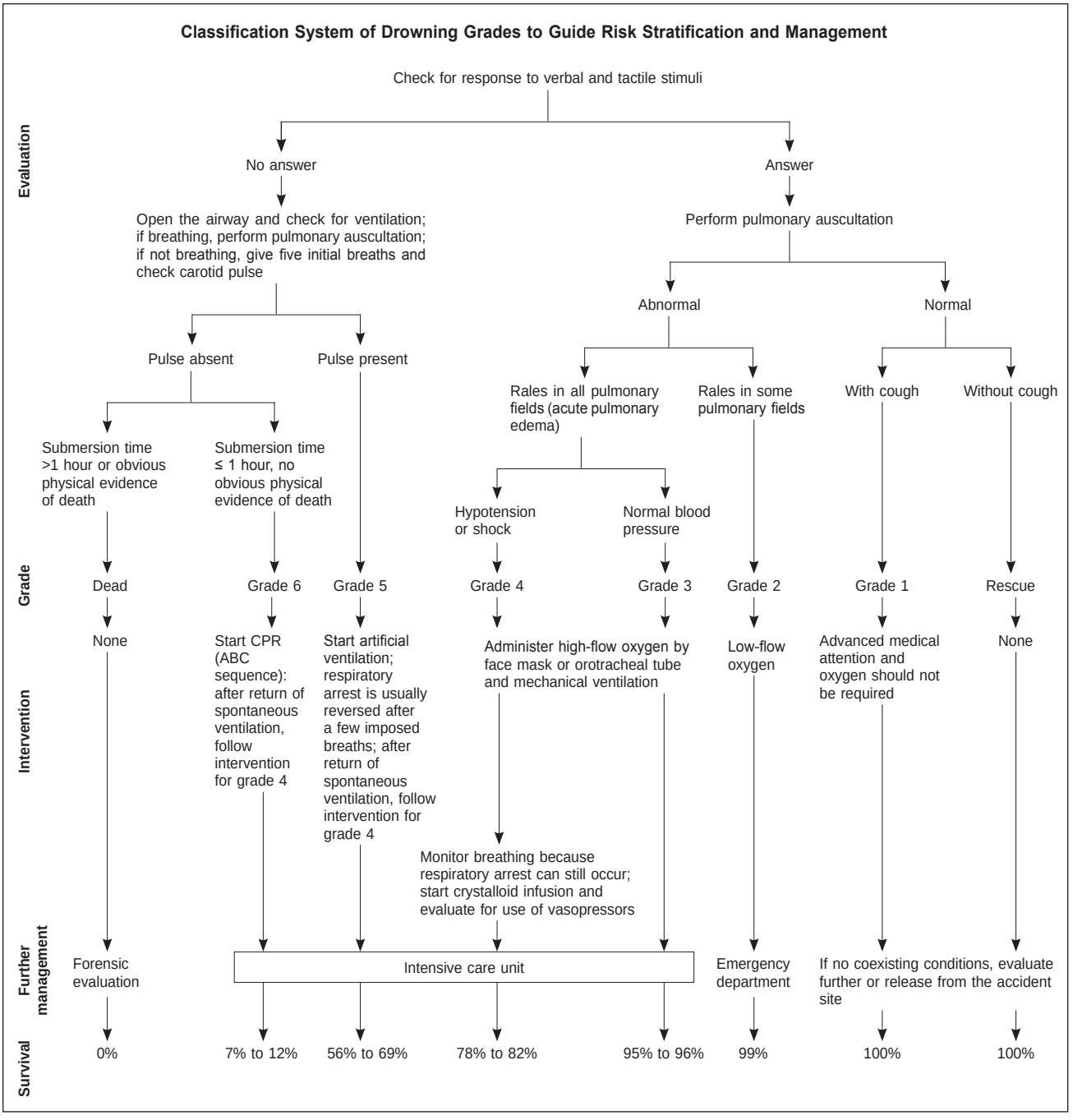

Figure 2. Classification system of drowning grades to guide risk stratification and management.

ABC = Airway, breathing, and compressions; CPR = Cardiopulmonary resuscitation.

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An initial chest radiograph may be unremarkable even if significant lung injury has occurred, or, conversely, pneumonia may be overdiagnosed because of water in the lungs.[27,28] Drowning victims with suspected head or neck trauma should undergo computed tomography of the head and cervical spine.[22] For drowning victims in cardiac arrest, a nonshockable rhythm (asystole or pulseless electrical activity) is more common than in nondrowning cardiac arrest victims.[16]

PREVENTION

Drowning is rarely caused by a single factor; therefore, prevention strategies should not be pursued in isolation.[12] Prevention methods target

Table 1. Drowning Prevention Methods

Method	Comments
Physical	
Pools	
Fencing	Odds ratio for drowning in a fenced vs. an unfenced pool = 0.27 (95% confidence interval, 0.16 to 0.47)[29]
	Four-sided fencing completely surrounding pool (not attached to house on one side)
	Gates should open away from the pool, be self-closing and self-latching, with the latching mechanism at least 58 inches above the ground
	Fence composition should not be climbable (e.g., not chain link)
	Fence should be at least 4 feet high with no more than 4 inches between vertical aspects and no more than 4 inches between the bottom of the fence and the ground
Drain covers, safety vacuum release systems, multiple drains to displace pressure	Prevents entrapment and entanglement of hair or body parts; other filter techniques that provide pressure venting should be implemented
Rescue equipment	U.S. Coast Guard–approved water rescue equipment (such as a reaching pole or shepherd's crook and life buoys) should be readily available poolside, in addition to a working telephone
Pool alarms (multiple types, such as floating, subsurface, and wristband alarms)	No evidence that alarms are of benefit; may provide a false sense of security; not a substitute for adequate supervision or adequate pool fencing
Personal flotation devices	According to a 2008 report from the U.S. Coast Guard, 91% of drowning victims (464 of 510) were not wearing personal flotation devices[31]
	There is little evidence on effectiveness, but use likely decreases morbidity and mortality; proper use is based on the individual and the setting
	See U.S. Coast Guard guidelines at http://www.uscg.mil/hq/cg5/cg5214/pfdselection.asp
Floatable swimming aids	Not approved as personal flotation devices; do not replace adequate supervision Air-containing types can deflate
Bath stands	Drownings associated with bath stand use were caused by product defect in < 10% of cases[33]
	May give caregivers the false perception that the infant needs less attention; cannot substitute for adequate direct supervision
Behavioral	
Avoid alcohol use	30% to 70% of adults who die from drowning have positive blood alcohol levels[11]
	Discourage the use of alcohol or other drugs for all boaters and participants in water recreation
	Adults supervising children should not be using alcohol or drugs
CPR	Immediate on-the-scene care is important for survival
	All adults and caregivers should be trained in CPR and understand the rationale for using the ABC order of resuscitation (not the CAB order)
Supervision	
Lifeguards	Encourage use of water recreation areas staffed by lifeguards with certification in CPR
Adults/caregivers	Knowledge of CPR should be mandatory for supervising children
	Direct supervision should be employed with any age swimmer; adult "water watchers" should avoid distracting activities
	Touch supervision must take place with nonswimmers; adult should be in the pool and within arm's reach of nonswimmer at all times

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Table 1. Drowning Prevention Methods

Method	Comments
Avoid rip currents	Learn characteristics of rip currents (e.g., reverse bubbles moving away from beach, broken waves between sandbars)
	Encourage use of beaches with lifeguards and heed warnings of posted surf conditions
	To escape, do not battle current; swim perpendicular to current (parallel to shore) until cleared from rip current and then swim at an angle, away from the current and toward the shore
	For safety tips about rip currents, see http://www.ripcurrents.noaa.gov/
Open bodies of water and other natural swim areas	
Approach water with an unknown depth and/or hazards with caution	Even in clear water, depths may be uncertain, so entering feet first the first time is advised
Assess for currents	Swift currents can trap persons underneath rocks, trees, or other debris, and can overwhelm even strong swimmers
Standing water	
Monitor water-containing objects	Buckets, inflatable pools, and natural standing water should never be left unattended; buckets and inflatable pools should be emptied when not in use
	Restrict toddlers' access to bathrooms and toilets with childproof latching systems
Education	
Swimming and water safety lessons	Possibly effective in children two to four years of age
	American Academy of Pediatrics supports swimming lessons for children four years and older
Medical	
Monitor children with seizure disorders	Children with seizure disorders should always have direct supervision when swimming or bathing
	Showering is preferable to bathing when supervision cannot take place because of privacy concerns
Monitor children with autism spectrum disorder and cardiac channelopathies (long QT syndrome and catecholaminergic polymorphic ventricular tachycardia)	There is slight evidence that children with these disorders have increased rates of drowning and thus may require increased supervision
Community/government	
Office-based interventions	Can be implemented by physicians and support staff
	Identify families with access to residential pools for targeted drowning prevention counseling
	Ensure adequate counseling and support services for drowning victims
Legislation to prevent drowning	Safe pool fencing
	Proper staffing of pools or public swimming areas with CPR-certified lifeguards
	Strict boating laws regarding alcohol consumption
Drowning awareness campaigns; educational materials	CPR training
	Swimming lessons
	Drowning prevention techniques

ABC = Airway, breathing, and compressions; CAB = Compressions, airway, and breathing; CPR = Cardiopulmonary resuscitation.

Information from references 10 through 13, 17, and 29 through 33.

the aforementioned epidemiologic concerns and can be divided into physical, behavioral, medical, and community/government areas of interest (Table 1[10-13,17,29-33]). Although rigorous studies with high-level evidence are lacking, there is some evidence supporting educational programs, swimming and water safety lessons, and pool fencing in the prevention of drowning, especially in children two to four years of age.[12,13,29] Residential pool safety measures are highlighted by the American Academy of Family Physicians in its clinical policy statement at http://www.aafp.org/about/policies/all/residential-pool.html. With adequate supervision, swimming instruction, and public education measures, it is estimated that 85% of drownings can be prevented.[30]

Note: For complete article visit: www.aafp.org/afp.

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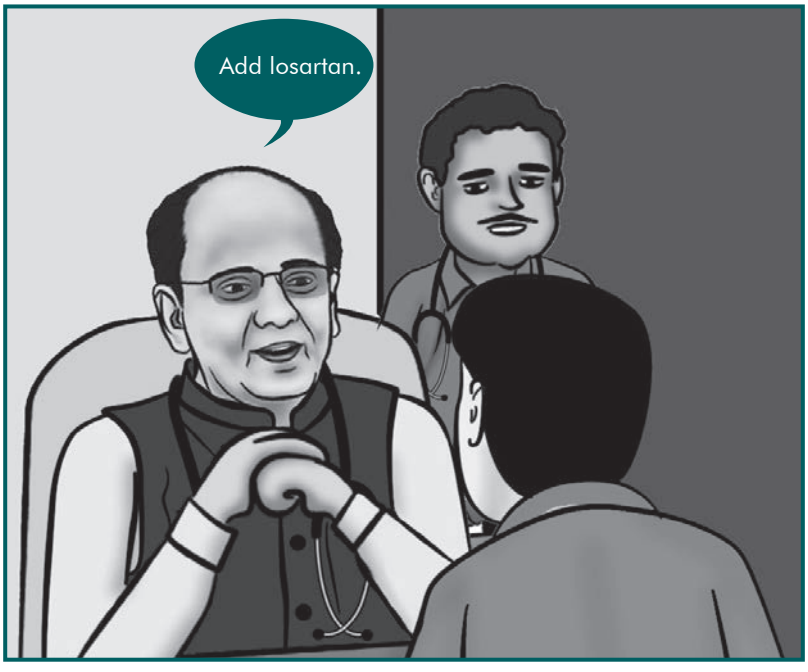
Make sure

DURING MEDICAL PRACTICE

SITUATION: A hypertensive patient with long-standing type 2 diabetes on a calcium channel blocker was found to have moderately increased albuminuria (between 30 and 300 mg/day).



LESSON: In the RENAAL (Reduction of Endpoints in NIDDM with the Angiotensin II Antagonist Losartan) study in patients with type 2 diabetes already receiving conventional antihypertensive therapy, the use of the ARB losartan significantly decreased the risk of end-stage renal disease. Losartan also significantly decreased the degree of proteinuria.

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