CME CREDIT

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'Dry drowning' and other myths

ABSTRACT

Drowning is a common and often preventable cause of death, especially in children. The mass media often propagate misinformation about "dry" and "secondary" drowning, diverting attention from appropriate efforts to prevent drowning and rescue and treat those who do drown.

KEY POINTS

Drowning is a process of aspiration leading to hypoxia and eventually cardiac arrest. However, it is not synonymous with death: it can be interrupted.

Patients who have been rescued from drowning and who have minimal symptoms generally get better within 4 to 8 hours of the event.

Rescued victims should be warned that, although a rare condition, if they develop cough, breathlessness, or any other worrisome symptom within 8 hours of being in the water, they should seek medical attention immediately.

In June 2017, a 4-year-old boy died 1 week after being knocked over and briefly submerged while playing in knee-deep water. This story was widely reported as a case of a rare occurrence called "dry" or "secondary" drowning, depending on the source.[1] The media accounts went viral, spreading fear in parents and others learning about these alleged conditions from the news and social media.

Many alleged cases of dry drowning are reported every year, but each has been found to have a recognized medical source that has a legitimate medically recognized diagnosis (which dry and secondary drowning are not).

Drowning is one of the most common causes of death in children, and so we ought to make sure that the information we share about it is accurate, as it is vital to effective prevention, rescue, and treatment.

Unfortunately, medical providers, medical journals, and the mass media continue to disseminate misinformation on drowning.[2] These reports often prevail over updated information and hinder accurate understanding of the drowning problem and its solutions.

Every death is tragic, especially the death of a child, and our heartfelt sympathies go out to the family in this alleged drowning case, as well as to all families suffering the loss of a loved one to drowning. However, in the 2017 case, the cause of death was found on autopsy to be myocarditis not related in any way to drowning. As often happens in such situations, this clarification did not receive any media attention, despite the wide reporting and penetration of the original, erroneous story.

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We hope our review will reduce misunderstanding among the public and healthcare providers, contribute to improved data collection, and help to promote interventions aimed at prevention, rescue, and mitigation of drowning incidents.

WHAT IS DROWNING?

A consensus committee of the World Health Organization defined drowning as "the process of experiencing respiratory impairment from submersion/immersion in liquid."[3] The process begins when the victim's airway goes below the surface of the liquid (submersion) or when water splashes over the face (immersion). If the victim is rescued at any time, the process is interrupted, and this is termed a nonfatal drowning. If the victim dies at any time, this is a fatal drowning. Any water-distress incident without evidence of respiratory impairment (ie, without aspiration) should be considered a water rescue and not a drowning.

Rarely do minimally symptomatic cases progress to death, just as most cases of chest pain do not progress to cardiac arrest.[4] Nonetheless, rescued drowning victims can deteriorate, which is why we encourage people to seek medical care immediately upon warning signs, as we do with chest pain. For drowning, such warning signs are any water distress followed by difficulty breathing, excessive coughing, foam in the mouth, or abnormal behavior.

In rare cases, hypothermia provides a protective mechanism that allows victims to survive prolonged submersion

A SERIOUS PUBLIC HEALTH ISSUE

Drowning is a serious and neglected public health issue, claiming the lives of 372,000 people a year worldwide.[5] It is a leading cause of death in children ages 1 to 14. The toll continues largely unabated, and in low- and middle-income nations it does not attract the levels of funding that go to other forms of injury prevention, such as road safety.

Nonfatal drowning—with symptoms ranging from mild cough to severe pulmonary edema, and complications ranging from none to severe neurologic impairment—is far more common than fatal drowning.[6] For every fatal drowning, there are at least 5 nonfatal drowning incidents in which medical care is needed, and 200 rescues are performed.[7–10]

In the United States, drowning accounts for almost 13,000 emergency department visits per year and about 3,500 deaths.[7,8]

In Brazil, with two-thirds the population of the United States, drowning accounts for far fewer hospital visits but about twice as many deaths. In Rio de Janeiro, where a highly effective and specialized prehospital service is provided at 3 drowning resuscitation centers staffed by medical doctors, an analysis of the 46,060 cases of rescue in 10 years from 1991 to 2000 showed that medical assistance was needed in only 930 cases (2%).[10] The preventive and rescue actions of parents, bystanders, lifeguards, and prehospital rescue services significantly reduce the number of drowning deaths, but these groups do not consistently gather data on nonfatal drowning that can be included in a comprehensive database.

DROWNING IS A PROCESS

When a person in the water can no longer keep the airway clear, water that enters the mouth is voluntarily spit out or swallowed. Within a few seconds to minutes, the person can no longer clear the airways and water is aspirated, stimulating the cough reflex. Laryngospasm, another myth concerning drowning, is presumed to protect the airways but does not, as it is rare, occurring in less than 2% of cases.[11,12]

If the person is not rescued, aspiration of water continues, and hypoxemia leads to loss of consciousness and apnea within seconds to a few minutes, followed by cardiac arrest. As a consequence, hypoxemic cardiac arrest generally occurs after a period of tachycardia followed by bradycardia and pulseless electrical activity, usually leading to asystole.[13,14]

The entire drowning process, from water distress to cardiac arrest, usually takes a few minutes, but in rare situations, such as rapid hypothermia, it can go on for up to an hour.[15] Most drowning patients have an otherwise healthy heart, and the apnea and hypoxemia precede the cardiac arrest by only a few seconds to minutes; thus, cardiac arrest is caused by the hypoxemic insult and not by ventricular dysrhythmias.[6,16]

Drowning can be interrupted at any point between distress and death. If the person is rescued early, the clinical picture is determined by the reactivity of the airway and the

amount of water that has been aspirated, but not by the type of water (salt or fresh).

Another myth is that drowning in salt water is different from drowning in fresh water. Both salt water and fresh water cause similar surfactant destruction and washout and disrupt the alveolar-capillary membrane. Disruption of the alveolar-capillary membrane increases its permeability and exacerbates shifting of fluid, plasma, and electrolytes into the alveoli.[13] The clinical picture of the damage is one of regional or generalized pulmonary edema, which interferes with gas exchange in the lungs.[6,13,17]

Animal studies by Modell et al showed that aspiration of just 2.2 mL of water per kilogram of body weight is sufficient to cause severe disturbances in oxygen exchange,[17] reflected in a rise in arterial pH and a drop in partial pressure of oxygen. The situation must be similar in humans. In a 70-kg person, this is only about 154 mL of water—about two-thirds of a cup.

The combined effects of fluid in the lungs, the loss of surfactant, and the increase in capillary-alveolar permeability can result in decreased lung compliance, increased right-to-left shunting in the lungs, atelectasis, alveolitis, hypoxemia, and cerebral hypoxia.[13]

If the victim needs cardiopulmonary resuscitation, the possibility of neurologic damage is similar to that in other cardiac arrest situations, but exceptions exist. For example, in rare cases, hypothermia provides a protective mechanism that allows victims to survive prolonged submersion.[4,15]

The duration of submersion is the best predictor of death.[18] Underwater, people are not taking in oxygen, and cerebral hypoxia causes both morbidity and death. For this reason, reversing cerebral hypoxia with effective ventilation, oxygen, and chest compression is the priority of treatment.

MYTHS AND SLOPPY TERMINOLOGY

"Near drowning," "dry drowning," "wet drowning," "delayed drowning," and "secondary drowning" are not medically accepted diagnoses,[3,4,19] and many organizations and lifesaving institutions around the world discourage the use of these terms.[19,20] Unfortunately, these terms still slip past the editors of medical journals and are thus perpetuated. The terms are most pervasive in the nonmedical media, where drowning seems to be synonymous with death.[3,19,21] We urge all authors and stakeholders to abandon these terms in favor of understanding and communicating drowning as a process that can vary in severity and have a fatal or nonfatal outcome.

Near-drowning

Historically, drowning meant death, while near-drowning meant the victim survived, at least initially (usually for at least 24 hours).

Before 2002, there were 13 different published definitions of near-drowning.[21,22] This variability has caused a great deal of confusion when trying to describe and monitor drowning.

A person can drown and survive, just as a person can have cardiac arrest and survive.[4,21] Just as there is no recognized condition of "near-cardiac arrest," there is also no condition of near-drowning. Using near-drowning as a medical diagnosis hides the true burden of drowning and consequently amplifies difficulties in developing effective prevention, rescue, and treatment programs.

Dry drowning

The duration of submersion is the best predictor of death

Dry drowning has never been an accepted medical term, although it has been used to describe different parts of the drowning process. While many authors use it as a synonym for secondary drowning (described below), in the past it was usually used in cases in which no water was found in the lungs at autopsy in persons who were found dead in the water.[2–4,21] This occurred in about 10% to 15% of cases and was also called drowning "without water aspiration."

Perhaps some victims suffer sudden cardiac death. It happens on land—why not in the water? Modell et al stated, "In the absence of the common finding of significant pulmonary edema in the victim's respiratory system, to conclude his or her death was caused by 'drowning without aspiration' is unwise."[23]

Laryngospasm is another proposed explanation. It could play a role in the fewer than 2% of cases in which no other cause of death is found on clinical examination or autopsy,[11,12,19,23] but it does not occur in most cases of drowning, or it is brief and is terminated by

From reference 25, with permission.

Figure 1. Drowning chain of survival.

the respiratory movements that allow the air in the lung to escape and water to be inhaled.

The problem with the term dry drowning is the harm caused by misdiagnosing cases of sudden death as drowning, when an alternative cause is present. Most importantly, the management is the same if small amounts of water are present or not; therefore, no clinical distinction is made between wet and dry drowning.

Secondary drowning

Secondary drowning, sometimes called delayed drowning, is another term that is not medically accepted. The historical use of this term reflects the reality that some patients may worsen due to pulmonary edema after aspirating small amounts of water.

People do not unexpectedly die of drowning days or weeks later with no preceding symptoms

Drowning starts with aspiration, and few or only mild symptoms may be present as soon as the person is removed from the water. Either the small amount of water in the lungs is absorbed and causes no complications or, rarely, the patient's condition becomes progressively worse over the next few hours as the alveoli become inflamed and the alveolar-capillary membrane is disrupted. But people do not unexpectedly die of drowning days or weeks later with no preceding symptoms. The lungs and heart do not "fill up with water," and water does not need to be pumped out of the lungs.

There has never been a case published in the medical literature of a patient who underwent clinical evaluation, was initially without symptoms, and later deteriorated and died more than 8 hours after the incident.[6,10,21] People who have drowned and have minimal symptoms get better (usually) or worse (rarely) within 4 to 8 hours. In a study of more than 41,000 lifeguard rescues, only 0.5% of symptomatic patients died.[6]

Drowning secondary to injury or sudden illness

Any injury, trauma, or sudden illness that can cause loss of consciousness or mental or physical weakness can lead to drowning. Physicians need to recognize these situations to treat them appropriately. Drowning that is secondary to other primary insults can be classified as[24]:

- Drowning caused by injury or trauma (eg, a surfing, boating, or a hang-gliding accident)
- Drowning caused by a sudden illness such as cardiac disease (eg, myocardial ischemia, arrhythmias, prolonged QT syndrome, hypertrophic cardiomyopathy) or neurologic disease (eg, epilepsy, stroke)
- Diving disease (eg, decompression sickness, pulmonary overpressurization syndrome, compression barotrauma, narcosis ["rapture of the deep"], shallow water blackout, immersion pulmonary edema).

Bystanders, first responders, and health professionals need to be aware of the complete sequence of actions required when dealing with water distress or drowning (**Figure 1**).[25]

PREVENTION IS BEST

Drowning is a leading and preventable cause of death worldwide and for people of all ages. The danger is real, not esoteric or rare, and healthcare providers should use any opportunity to discuss with patients, parents, and the media the most important tool for treating drowning: primary prevention.

For example, small children should be continuously and uninterruptedly supervised within arm's reach while in the water, even if a lifeguard is present. Other preventive measures are lifejackets, fences completely enclosing pools or ponds, and swimming and water safety lessons. Drowning often occurs in a deceptively pleasant environment that may not seem dangerous.

RECOGNIZE DISTRESS

When preventive measures fail, responders (usually a health professional is involved) need to be able to perform the necessary steps to interrupt the drowning process.

The first challenge is to recognize when someone in the water is at risk of drowning and needs to be rescued.[25] Early self-rescue or rescue by others may stop the drowning process and prevent most cases of initial and subsequent water aspiration, respiratory distress, and medical complications.

DON'T BECOME A VICTIM

Rescuers must take care not to become victims themselves. Panicked swimmers can thrash about and injure the rescuer or clutch at anything they encounter, dragging the rescuer under. And the rescuer can succumb to the same hazards that got the victim into trouble, such as strong currents, deep water, or underwater hazards.

Certified lifeguards are trained to get victims out of the water safely. The American Red Cross slogan "Reach or throw, don't go" means "Reach out with a pole or other object or throw something that floats; don't get in the water yourself."

WHAT TO TELL THE PUBLIC

While some journalists acknowledge that the terms dry drowning and secondary drowning are medically discredited, they still use them in their reports. The novelty of this story—and its appeal to media outlets—is precisely the unfamiliarity of these terms to the general public and the perceived mysterious, looming threat.

We often hear that these terms are more familiar to the public, which is likely true. More concerning, some physicians continue to use them (and older definitions of drowning that equate it with death) in media interviews, clinical care, and publications. The paradox is that we, the medical community, invented these terms, not patients or the media.

As clinicians and researchers, we should drive popular culture definitions, not the other way around. Rather than dismiss these terms as "semantics" or "technicalities," we should take the opportunity to highlight the dangers of drowning and the importance of prevention,

TABLE 1

When drowning victims need further medical help

Send to the hospital if victim has any of the following:

- Loss of consciousness
- Altered mental state
- Required positive pressure ventilation
- Requires supplemental oxygen
- Required cardiopulmonary resuscitation
- Low oxygen saturation
- Abnormal lung auscultation
- Hypotension
- Continued chest pain or dyspnea
- Suspected traumatic injury
- An underlying medical condition is expected or exacerbated:
  - Cardiac ischemia
  - Seizure disorder
  - Stroke
  - Respiratory disease
  - Intoxication

Consider releasing victims who have all of the following after 10–15 minutes of close observation:

- On basic assessment
  - No cough
  - Normal respiratory effort and rate
  - Normal skin color and perfusion
  - Normal mentation
  - No shivering
- On advanced evaluation (prehospital care)
  - Normal oxygen saturation
  - Normal pulse rate and blood pressure
  - Normal lung sounds

Small children should be continuously supervised within arm's reach while in the water

and to promote simpler language that is easier for us and our patients to understand.[19,21]

Healthcare providers should understand and share modern drowning science and best practices, which will reduce fear, improve resource utilization, and prevent potentially deadly consequences due to misunderstanding or misinterpretation of incorrect terminology.

WHEN PATIENTS SHOULD SEEK CARE

Anyone who experiences cough, breathlessness, or other worrisome symptoms such as abnormal mentation within 8 hours of a drowning incident (using the modern definition above) should seek medical advice immediately.

We tell people to seek care if symptoms seem any worse than the experience of a drink "going down the wrong pipe" at the dinner table.[21] But symptoms can be minimal. Careful attention should be given to mild symptoms that get progressively worse during that time. These cases can rarely progress to acute respiratory distress syndrome.

Table 1 explores who needs further medical help after being rescued from the water.[26]

In most of these cases, it is most appropriate to call an ambulance, but care may involve seeing a doctor depending on the severity of the symptoms.[6,21] Usually, drowning patients are observed for 4 to 8 hours in an emergency department and are discharged if normal. Symptoms that are more significant include persistent cough, foam at the mouth or nose, confusion, or abnormal behavior, and these require further medical evaluation.

Patients should also seek medical care even if they are 100% normal upon exiting the water but develop worrisome symptoms more than 8 hours later, and providers should consider diagnoses other than primary drowning. Spontaneous pneumothorax, chemical pneumonitis, bacterial or viral pneumonia, head injury, asthma, chest trauma, and acute respiratory distress syndrome have been mislabeled as delayed, dry, or secondary drowning.[3,4,19,21]

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