Drowning

A Cry for Help

IN this issue of Anesthesiology, Layon and Modell review current evidenced-based management of drowning victims who reach medical care. Modern resuscitation research of the drowning victim now spans decades. This review article expertly and comprehensively evaluates information resulting from that investigation; perhaps as important as that which is said, is that which is not said.

Throughout the 1960s and 1970s, Dr. Model and his colleagues provided groundbreaking research describing principally pulmonary and blood electrolyte responses to drowning and the effects of the liquid medium on these responses (e.g., fresh water vs. salt water). That era can now be considered as the golden age of drowning research. Preclinical models were developed and exploited. Clinical case series and experimental interventions were reported that harnessed simultaneous advances in critical care. However, the work did not progress to the level of randomized intervention trials, and the science did not keep pace with that of brain resuscitation research. This is particularly crucial because asphyxial brain injury is often the terminal event or persistent debilitating factor in those resuscitated from cardiac arrest caused by drowning. A review of the PubMed database reveals negligible current effort to better define drowning pathophysiology or clinical management of its victims. Indeed, the majority of papers cited by Layon and Modell were published before 1990.

Is this subject of concern to anesthesiologists? Drowning victims are typically treated first at the site of rescue, later in the emergency department, and unless death or hospital discharge ensues, are transferred to medical intensive care units. Although trauma may accompany drowning, this infrequently results in a call for perioperative management. Yet, anesthesiologists pride themselves on their expertise in resuscitation medicine and this offers great opportunity to participate in revitalization of the endeavor to improve management of drowning victims.

Drowning is a major public health problem. In the United States, it is a leading cause of accidental death through the first 5 decades of life, with peak incidences occurring during early childhood and adolescence. Estimates vary but suggest that at least 150,000 to 800,000 people die worldwide from accidental drowning each year, with untold numbers sustaining permanent neurocognitive deficits. Despite the prevalence of this disorder, novel information applicable to medical management has been scant over the past 2 decades.

This is held in contrast to major advances in both cardiopulmonary and cerebral resuscitation. Most notably, it has been proved that induced mild/moderate hypothermia initiated after restoration of spontaneous circulation for out-of-hospital ventricular fibrillation cardiac arrest reduces both mortality and neurologic morbidity. This success was predicated on extensive preclinical research. Preclinical models of ischemic and anoxic cerebral injury have dramatically improved, particularly those that allow analysis of long-term outcome. Understanding the immediate and delayed cellular responses to ischemia has radically altered how we think about the response of brain to energy deprivation and reperfusion injury. Knowledge of ischemia and reperfusion injury is highly relevant to drowning and can allow a platform for rational investigation of novel intervention. Yet, little research is performed, and modern, validated, and clinically relevant preclinical models are not available to examine these complex pathologic conditions in the specific context of drowning. It cannot be assumed that simple major cerebral vessel occlusion in laboratory animals will mimic interactions among tissue energy deprivation, temperature shifts, electrolyte abnormalities, and pulmonary injury often associated with immersion in various fluids.

Similarly, there is need for clinical research. The earlier the intervention takes place, the larger the effect on a positive outcome. What interventions, achievable in the field, can be implemented to improve functional outcome? Is hyperoxia adverse? Should efforts be made to sustain hypothermia? At either preclinical or clinical levels, both are known to substantively alter outcome from cardiac arrest, but no work has focused on drowning. Within the hospital, little data define the role of intracranial pressure management or electrophysiologic monitoring, cerebral microdialysis, neurochemical markers, tissue oxygen management, pharmacologic intervention, glucose control, rewarming strategies (cold drowning), temperature management, or influence of respiratory care on brain outcome specific to drowning.

This Editorial View accompanies the following article: Layon AJ, Modell JH. Drowning: Update 2009. Anesthesiology 2009;110:1390–401

Accepted for publication February 27, 2009. The authors are not supported by, nor maintain any financial interest in, any commercial activity that may be associated with the topic of this article.


patients. These are all factors for which anesthesiologists offer major expertise.

There are more reasons for the anesthesiologist to become interested in the issue of drowning. Case reports have shown that, during drowning, combinations of the extremes in hypoxemia and hypothermia have led to survival, where the individual pathologic processes initiated by either alone would have been lethal. It may be enlightening to understand why survival may occur after submersion times of more than 1 h, resuscitation times of more than 2 h, extremes in temperature (13.7°C) in the absence of cardiopulmonary bypass, and profound derangements in acid-base status. A better observation, registration, and understanding of these accidental events and mechanisms associated with survival may identify new paradigms in treatment of hypoxic and hypothermic insults.

Another issue that needs urgent attention, and where anesthesiologists can show leadership, has to do with the trend that compression-only cardiopulmonary resuscitation is likely to become the standard for layperson Basic Life Support in witnessed sudden cardiac arrest. Before cardiopulmonary resuscitation without ventilation can be proposed in drowning victims, important questions need to be answered. What happens to a marginally active globally hypoxic and/or hypothermic myocardium, as in the case of drowning, when compression-only cardiopulmonary resuscitation is applied? Considering that hypoxia-induced bradycardia leading to eventual arrest is likely in most drowning victims, the response to ventilation may be quite different from that of focal myocardial ischemia.**

Drowning is a major public health issue calling for worldwide attention. While the US drowning rate is decreasing, drowning is the most common cause of child mortality in seven Asian nations. Drowning rates in lower and middle income countries are six times higher than in high-income nations, but less adaptive populations in high-income nations also have high drowning rates. There is no effort to resuscitate in most drowning events in much of the world. Anesthesiologists can show the social commitment of their specialty by developing and teaching the most appropriate resuscitation techniques. It is also important to answer questions such as should the Sellick maneuver be applied during Basic Life Support when mouth-to-mouth ventilation is impeded due to low lung compliance, which drowning victims benefit from oxygen therapy, what is the value of prehospital pulse oximetry, which victims need to be admitted to hospital, when is discharge indicated, and what are the early predictors of permanent neurologic damage. There are no standardized scoring systems with reasonable accuracy to provide a prognosis after drowning. The most efficacious rewarming methods and optimum rewarming speed in hypothermic drowning victims still need to be determined. Answers to these questions will be helpful in the case of an individual victim but will have enormous impact when, due to floods or boat accidents, large numbers of drowning victims have to be treated, resources are scarce, and triage is needed. The 2002 World Congress on Drowning identified over 200 research needs in the prevention, rescue, and treatment of drowning.

Conduct of randomized clinical trials is necessary to better define intervention efficacy. A multicenter clinical trial involving major medical centers may be the final arbiter of post-drowning care, but many victims are first delivered to local hospitals when interventions are likely to have the greatest impact on outcome, so these first contact hospitals must also be included in randomized management protocols. Databases have been proposed to better define outcome responses to various interventions. Detailed recommendations regarding the kind of data that should be collected have been published and tested. However, to our knowledge, no databases other than mortality and incident reports collected by the Centers for Disease Control are actively collecting information that could transform practice. Coordinated data collection at the local, state, and federal level will be needed to positively affect outcomes from drowning.

Drowning is a prevalent disease that will require sophisticated resuscitation science to substantively advance patient care. There is need for basic scientists, clinicians at major centers, local medical doctors, and emergency personnel to support this effort. What can anesthesiology contribute? Resuscitation is yeoman’s work in our specialty, and indeed anesthesiologists such as Dr. Modell were at the forefront of drowning research in its golden age. Anesthesiology meetings are replete with innovations in resuscitation science. Interactions between anesthesiologists/intensivists and emergency physicians will be necessary to generate and implement clinically important advances. In many countries, these entities are comprised within the same specialty. The challenge is to begin a new age of drowning research, incorporating the vast amount of new knowledge obtained in diseases familiar to us (e.g., anoxia, cardiac arrest, ischemia) that can be evaluated in the context of and uniquely applied to care of the drowning victim. Drowning victims are often from the most vulnerable population with the greatest chance of full recovery and opportunity to contribute to society, but we must move forward now with new research initiatives so we can save patients with brains and hearts too good to die.***

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References