CLINICAL VIGNETTE

Drowning

Irawan Susanto, M.D., and Joanne Bando, M.D.

Case History

A 53-year-old man was pulled from the ocean by a lifeguard. He was pulseless and apneic. CPR with assisted ventilation was initiated. He was then brought to the Emergency Department (ED), where he was unresponsive on arrival. CPR was continued with return of spontaneous circulation (ROSC). He was intubated, and orogastric tube was placed with bloody output.

On physical examination, his temperature was 35.9. There was no evidence of head trauma. He moved all extremities spontaneously but had upper extremity posturing with intermittent agitation. He was tachycardic and tachypneic without accessory respiratory muscle use. Exam was remarkable for diffuse basilar crackles, no murmurs, and unremarkable abdomen. Laboratory data included white blood cell count of 12 x 10^3 , potassium 3.1, bicarbonate 10, lactate 50, mild transaminitis, and normal troponin. Blood alcohol level was 453 mg/dL, and he had cannabinoids in his urine toxicology screen. Computed tomography of the brain and cervical spine showed no acute finding or fractures. His chest radiograph had basal infiltrates. His electrocardiogram tracing demonstrated sinus rhythm without Osborn waves.

He was admitted to the Intensive Care Unit (ICU) and kept hypothermic for the first 24 hours with head elevation and hyperventilation. He was empirically treated for aspiration pneumonia with Piperacillin-Tazobactam. His laboratory derangements normalized. His neurologic status improved to where he was able to follow commands on hospital day 3, and he was extubated. History obtained after extubation revealed depression with many recent life-changing events. Psychiatric evaluation concluded that he was impulsive while intoxicated, but otherwise not actively suicidal. He was referred to an inpatient substance abuse program for rehabilitation.

Discussion and Teaching Points

The 2010 American Heart Association (AHA) guideline recommends using the term drowning to describe the process that results in primary respiratory impairment from submersion or immersion in a liquid medium (Utstein definition).[1,2] The AHA discourages the use of other terms such as near drowning, non-fatal drowning, secondary drowning, or wet drowning.

Drowning results in 500,000 deaths worldwide annually. In the United States, there is a bimodal distribution with peak incidence at ages 1-5 and 15-25. The incidence is higher in African Americans, amongst those with low socioeconomic status, and in the summer months with more water activities. Risk factors for drowning include overestimation of swimming ability, risk-taking behavior, alcohol and drug use (involved in 50% of adult drowning deaths), inadequate supervision of children, hypothermia, exhaustion, arrhythmia, trauma, stroke, myocardial infarction, seizure, and hyperventilation (which reduces hypercapneic ventilatory drive.)

The pathophysiology of drowning starts with panic followed by breath-holding. Hypoxemia ensues from multiple causes, including aspiration of water or reflex laryngospasm. Entry of water into the lungs washes away surfactant resulting in atelectasis, shunt and ventilation perfusion mismatches. Prolonged hypoxemia leads to cerebral hypoxemia and brain edema, and prolonged immersion in cold water results in hypothermia. Arrhythmias are frequently seen, including tachycardia, bradycardia, atrial, and ventricular fibrillation. Hypoxemia results in metabolic and respiratory acidosis.

Massive volume aspiration into the lungs may result in death. Salt water aspiration causes massive pulmonary edema and hypertonic serum. Fresh water aspiration results in volume overload and electrolyte dilution by the hypotonic water absorbed into the circulation. In addition, water temperature and the presence of water contaminants at the site of drowning also affect the resulting pulmonary pathology. Favorable prognostic factors in drowning include: if the event is witnessed, short duration of submersion, early resuscitation, and rapid transportation to a medical facility.[3] Duration of submersion is one of the best predictors for neurologic outcome. The probability of death or severe neurologic sequelae is associated with submersion time: 10% with up to 5 minutes, 56% with 6-10 minutes, 88% with 11-25 minutes, and 100% with over 25 minutes.

The pre-hospital management of drowning patient is unique compared to standard resuscitation. In drowning victims, resuscitation follows the airway, breathing, and circulation (ABC) algorithm, as opposed to the emphasis on circulation in the non-drowning resuscitation of an unresponsive patient.[1] The AHA 2010 guidelines recommend two initial rescue breaths followed by pulse search. Prompt rescue breathing

increases the probability of survival. There is no need to attempt to remove any water aspirated, unless a foreign body obstruction is suspected. Abdominal thrusts and Heimlich maneuver are not recommended. When a pulse is not felt after the two rescue breaths, CPR is initiated according to standard basic life support (BLS) guidelines, excluding drowning victims who have been submerged for over 60 minutes without obvious physical evidence of death (rigor mortis, body decomposition, or livor mortis).[4] CPR should continue until signs of life appear, rescuers are exhausted, or an advanced life support (ACLS) team takes over. Once the drowning victim is out of the water, standard advanced life support (ACLS) is performed. ACLS is to continue until the victim has been rewarmed and asystole has persisted for over 20 minutes. The incidence of cervical spine injury in drowning is very low (0.009%); therefore, cervical spine immobilization is not routinely recommended to allow more efficient and timely rescue breaths, unless there is suspicion for trauma such is in diving-related drowning.[1]

ED management of the drowning patient includes establishment of airway, oxygen support, positive airway pressure as needed, rewarming, and baseline laboratory and imaging evaluation. Most drowning deaths occur within 7 hours of presentation; therefore, all drowning victims must be observed in the ED for at least 8 hours or admitted to the hospital even when the patients are neurologically intact without cardiopulmonary dysfunction.

The management of hyperthermia in drowning is controversial. While hypothermia provides neuroprotection, standard ACLS resuscitation usually does not work in severely hypothermic patients. Current guidelines recommend rewarming patients to 32-24°C until ROSC, then maintaining that level of mild hypothermia for neuroprotection for an additional 12-24 hours if there are no contraindications.[1,4]

There is a characteristic electrocardiographic finding in severe hypothermia called the J wave or Osborn wave (Figure 1), in which there is a deflection with a dome or hump at the R-ST junction (J point). It is usually not seen when the temperature is over 32°C. Hypothermia increased the epicardial potassium current relative to the current in the endocardium during ventricular repolarization. This transmural voltage gradient is reflected on the surface electrocardiogram as a prominent J, or Osborn, wave.[5] The differential diagnosis of prominent Osborn waves includes early repolarization, hypercalcemia, and Brugada syndrome.

The inpatient management of drowning patient includes neurological, respiratory, and cardiovascular stabilization. If there is concern for cerebral edema, head of bed elevation with or without hyperventilation should be initiated. Seizure prophylaxis can be given and euglycemia should be maintained. Ventilatory support is given as needed. Empiric antibiotics may be given for possible infectious aspiration. Common organisms include waterborne agents such as Aeromonas, Pseudomonas, and Proteus. Corticosteroids are not routinely recommended. Treatment for hypotension and volume assessment with replenishment may be necessary due to cold diuresis with hypothermia. Echocardiogram may be useful to assess cardiac function.

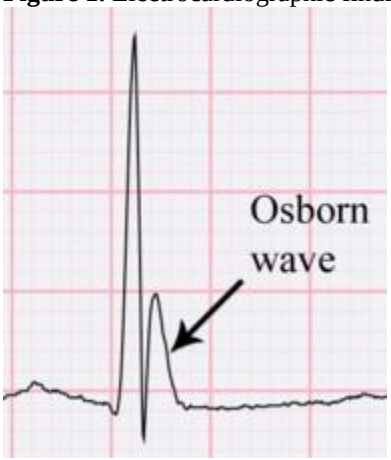
Negative neurologic prognosticators include duration of submersion over 5 minutes, time to effective BLS > 10 minutes, resuscitation duration > 25 minutes, age > 14 years, Glasgow coma scale < 5, absence of brainstem reflexes, persistent apnea needing CPR in ED, and arterial pH < 7.1 on presentation.

Summary

This case exemplifies many salient points of the presentation and management of a drowning victim. Alcohol is a major risk factor in adult drowning. Pre-hospital resuscitation starts with two initial rescue breaths. Cervical collar placement is usually not indicated unless there is a strong suspicion for trauma, as it may interfere with effective and speedy delivery of resuscitation. The absence of a pulse after rescue breaths necessitates initiation of standard BLS and, if available, ACLS. In the hypothermic drowning victim, rewarming to ROSC may be needed. In the persistently comatose patient, continued mild hypothermia after ROSC for 24 hours may be useful for neuroprotection. There is no difference in the management of salt and freshwater drowning. In a comatose patient, empiric management of cerebral edema is appropriate. Duration of submersion is a strong predictor for neurologic prognostication.

Figures

Figure 1. Electrocardiographic finding – Osborn wave.



REFERENCES

1. **Vanden Hoek TL, Morrison LJ, Shuster M, Donnino M, Sinz E, Lavonas EJ, Jeejeebhoy FM, Gabrielli A**. Part 12: cardiac arrest in special situations: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010 Nov 2;122(18 Suppl 3):S829-61. doi: 10.1161/CIRCULATIONAHA.110.971069. Review. Erratum in: Circulation. 2011 Feb 15;123(6):e239. *Circulation*. 2011 Oct 11;124(15):e405. PubMed PMID: 20956228.
2. **Idris AH, Berg RA, Bierens J, Bossaert L, Branche CM, Gabrielli A, Graves SA, Handley AJ, Hoelle R, Morley PT, Papa L, Pepe PE, Quan L, Szpilman D, Wigginton JG, Modell JH; American Heart**

Association. Recommended guidelines for uniform reporting of data from drowning: the "Utstein style". *Circulation*. 2003 Nov 18;108(20):2565-74. Review. PubMed PMID: 14623794.

3. **Krantz MJ, Lowery CM**. Images in clinical medicine. Giant Osborn waves in hypothermia. N Engl J Med. 2005 Jan 13;352(2):184. PubMed PMID: 15647581.
4. **Youn CS, Choi SP, Yim HW, Park KN**. Out-of-hospital cardiac arrest due to drowning: An Utstein Style report of 10 years of experience from St. Mary's Hospital. *Resuscitation*. 2009 Jul;80(7):778-83. doi:10.1016/j.resuscitation.2009.04.007. Epub 2009 May 13. PubMed PMID: 19443097.
5. **Szpilman D, Bierens JJ, Handley AJ, Orlowski JP**. Drowning. *N Engl J Med.* 2012 May 31;366(22):2102-10. doi: 10.1056/NEJMra1013317. Review. PubMed PMID: 22646632.

Submitted June 2, 2015