

## Drowning: Pulmonary changes

Drowning is a complex physiologic process complicated further by confusion surrounding its definition and misinformation in the lay press. The current WHO definition is:

*“Drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid; outcomes are classified as death, morbidity and no morbidity.”*

The sequence of events can vary substantially, however the drowning process typically starts with voluntary breath holding. This progresses to involuntary laryngospasm due to the presence of liquid in the pharynx. During this process water may be swallowed. There can be considerable respiratory effort performed by the patient against the closed glottis during this time period which could result in post-obstructive pulmonary edema, however results of this are typically overshadowed by the changes resulting from aspiration. During the laryngospasm period, the patient becomes hypercarbic, acidotic, and hypoxemic and the laryngospasm eventually breaks due to the hypoxia. Potentially large quantities of liquid are then aspirated into the lungs and hypercarbia and hypoxia continue to worsen as gas exchange is impossible with the alveoli being fluid filled.

Specific effects on the lungs following drowning can include:

- Surfactant dysfunction
- Osmotic shifts across alveoli
- Pulmonary edema
- Atelectasis
- V/Q mismatch and shunting
- Pulmonary hypertension
- Decreased compliance

Although there may be some small laboratory and theoretical differences between fresh vs. salt water aspiration, this is not felt to be clinically important and has similar end points. For example: fresh water aspiration disrupts normal surfactant function resulting in alveolar collapse and volume overload from the hypotonic freshwater causes pulmonary edema, with salt water surfactant is largely intact but the hypertonicity draws more fluid into the lungs causing pulmonary edema. It should be noted that fresh water aspiration is associated with a greater incidence of pneumonia due to all the nasty bugs that can live there.

Note: The first steps to resuscitate a drowning victim in the field are rescue breaths, while still in the water if practical and moving the victim out of the water would result in a delay in resuscitation. This is because the primary problem is typically respiratory.

Further reading: A Joseph Layon, Jerome H. Modell, David S. Warner, Mark A. Warner; Drowning: Update 2009. *Anesthesiology* 2009; 110:1390–1401