Drowning occurs due to respiratory impairment from submersion or immersion in a liquid medium. Aspiration of water leads to hypoxemia which affects all organ systems, resulting in respiratory insufficiency and ARDS, cardiac arrhythmias, and neuronal damage. The management of drowning focuses initially on ventilation support followed by cardiopulmonary resuscitation. Prevention is key as drowning is most often preventable.

Introduction

Definition

- Respiratory impairment caused by submersion or immersion in a liquid medium
  - Submersion: airway is below the surface of a liquid
  - Immersion: airway is above the surface of a liquid
- Non-fatal drowning:
  - Survival, at least temporarily, after suffocation (or loss of consciousness) by submersion in a liquid medium
Epidemiology

- Important cause of childhood fatalities worldwide

Risk factors

- Inadequate adult supervision
- Inability to swim (or overestimation of swimming endurance)
- High-risk behaviors (especially in ages 15–25)
- Use of alcohol and other drugs
- Hypothermia
- Concomitant trauma, stroke, or myocardial infarction
- Seizure disorder

Pathophysiology

- Begins with panic, breath-holding, air hunger, and abnormal breathing patterns
  - Causes reflex inspiratory efforts by means of
    - Aspiration or laryngospasm
  - Leads to hypoxemia when water enters the lower respiratory tract
  - Hypoxemia affects every organ system
    - Cerebral hypoxia is a major cause of morbidity and mortality.
- All types of drowning (fatal and nonfatal) result in
  - Decreased lung compliance
  - Ventilation-perfusion mismatch
  - Intrapulmonary shunting
    - These changes play a major role in developing hypoxemia.
  - Volume aspirated (in mL/kg of body weight) determines the degree of respiratory compromise.

Video Gallery

Drowning: Epidemiology, Pathology & Diagnosis by Julianna Jung, MD, FACEP

Clinical Manifestations

Clinical manifestations of drowning are due to the effects of hypoxemia.

- **Vital signs:**
  - Hypotension
  - Hypothermia
  - Hypoxemia

- **Respiratory changes:**
  - Water aspiration causes surfactant washout from the alveoli leading to
    - Pulmonary edema
    - Respiratory insufficiency
    - ARDS
May experience shortness of breath, crackles, and wheezing
Even if the patient is initially stabilized, ARDS can develop insidiously over the next 72 hours.

- **Cardiovascular changes:**
  - Arrhythmias often occur secondary to hypothermia and hypoxemia.
    - Tachycardia followed by sinus bradycardia
    - May progress to atrial fibrillation

- **Neurologic changes:**
  - Neuronal damage from hypoxia and ischemia causes
    - Cerebral edema
    - Elevated intracranial pressure
    - Hypoxic encephalopathy
    - Seizures

- **Acid-base and electrolytes changes:**
  - Metabolic and/or respiratory acidosis
  - Renal failure may occur due to acute tubular necrosis
    - Caused by hypoxemia, shock, hemoglobinuria, or myoglobinuria

**Management**

Safely remove patient from water and begin immediate resuscitation with primary and secondary survey.

- **Check for breathing:**
  - Normal breathing → supplement with oxygen (Goal: SpO₂ > 90%)
  - If no effective breathing → **begin rescue breathing** (Note: This is the priority! Begin rescue breathing immediately and then check for pulse to determine if CPR is needed.)

- **Check for pulse:**
  - No pulse → begin immediate CPR
  - If pulse is found but breathing is not normal → continue rescue breathing/oxygen supplementation

- **Intubate if**
  - Patient is apneic or in respiratory distress
  - Patient is unable to protect their airways
  - Inability to maintain PaO₂ > 60 mmHg or SpO₂ > 90% **despite** the use or high-flow oxygen or noninvasive ventilation

- **If hypothermic** (core temperature <33°C)
  - Remove wet clothing
  - Begin rewarming

Once the patient has arrived at a medical facility, perform

- Initial trauma evaluation
- Frequent vital signs and clinical reassessment
- Continuous oxygen supplementation and end-tidal CO₂ monitoring
- Continuous telemetry
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Outcome and Prevention

Outcome

The following are associated with poor prognosis.

- Submersion duration > 5 minutes
- Initiation of basic life support > 10 minutes
- Resuscitation duration > 25 minutes
- Age > 14 years
- GCS < 5
- Arterial blood pH < 7.1 on presentation

Prevention

Education on water safety is the best prevention.

- Gating access to swimming pools
- Providing adult supervision
- Not swimming alone
- Use of personal flotation devices
- Avoidance of alcohol and drugs while swimming

Clinical Relevance

**ARDS:**
Acute respiratory distress syndrome (ARDS) is a severe inflammatory reaction of the lung that is characterized by the presence of pulmonary infiltrates due to alveolar fluid accumulation (without evidence suggestive of a cardiogenic etiology). The main finding of ARDS is respiratory failure. Chest X-ray usually shows diffuse bilateral lung infiltrates described as (“butterfly opacity”). Management depends mainly on treating the underlying etiology and maintaining adequate oxygenation, which may require intubation and mechanical ventilation.

**Pulmonary edema:**
Pulmonary edema is a condition caused by excess fluid in the lungs. It is a consequence of a disease process rather than a primary pathology. It is classified into cardiogenic and noncardiogenic based on the cause of the edema. Pulmonary edema is visible on chest X-ray.

**ABC assessment:**
Dealing with patients in emergency situations is always challenging. Failure to provide appropriate medical care in a timely manner might result in catastrophes. The ABC assessment and its variations are initial mnemonics to remember the essential steps to perform at first patient encounter. ABC stands for airway, breathing, and circulation. Since its development, changes have been made to the mnemonic. In 2010, the AHA recommended CAB (chest compressions, airway, and breathing) for cardiac arrest situations.
References


Dipak Chandy, MD Gerald L Weinhouse, MD (2020); Drowning (submersion injuries); https://www.uptodate.com/contents/drowning-submersion-injuries?search=drowning&source=search_result&selectedTitle=1~80&usage_type=default&display_rank=1

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