



A photograph of a body of water with a hand reaching out from the surface and another hand reaching out from above the surface, creating a visual metaphor for drowning and submersion.

Drowning and Submersion Injury

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En.TT•ΓΨ/•F/•I :

DROWNING AND SUBMERSION INJURY

- ✓ Drowning is one of the leading **causes of childhood morbidity and mortality in the world.**
- ✓ **Prevention** is the most important step to reducing the impact of drowning injury.
- ✓ followed by early initiation of cardiopulmonary resuscitation **(CPR) at the scene.**

TERMINOLOGY

✓ **Terms should not be used**

- Near-drowning
- Secondary drowning
- Wet drowning
- Dry drowning

TERMINOLOGY

- ✓ **Drowning:** The process of experiencing respiratory impairment from submersion or immersion in liquid.
- ✓ **Fatal drowning :** A drowning event with a fatal outcome.
- ✓ **Rescue :** person submerged but at no time develops respiratory symptoms or impairment.

TERMINOLOGY

✓ **Non-fatal drowning** : A drowning event in which the process of respiratory impairment is stopped before death, and the victim survives.

١. **Mild impairment: Breathing, involuntary coughing and fully alert**
٢. **Moderate impairment : Difficulty breathing or disoriented but conscious**
٣. **Severe impairment: Not breathing or unconscious**

EPIDEMIOLOGY

Compared with other types of injuries, drowning has :

- ✓ **one of the highest case fatality rates**
- ✓ **in the top-10 causes of death related to unintentional injuries for all pediatric age groups.**
- ✓ From 2010 to 2015, the highest drowning death rates were seen in children age 1-4 yr and 15-19 yr.

EPIDEMIOLOGY IN US

✓ The highest incidence of drowning occurs:

✓ Approximately 1 percent of child drownings
Appear related to **child abuse or neglect**.

- Males
- African-Americans
- children 1-5 yo
- swimming pools, bathtubs, or around other liquid
- persons with low socioeconomic status
- residents of Southern states

✓ Drowning is much more common during the **summer months**.

DROWNING IN IRAN

✓ The **Third** cause of death is **unintentional injuries** in iran.

✓ **Isfahan:**

کودکان زیر ۵ سال قربانیان اصلی
در سال های ۹۴ و ۹۵ در رتبه چهارم کشوری
در سال های ۹۶ تا ۹۹ در رتبه پنجم کشوری
در سال های ۱۴۰۰ و ۱۴۰۱ جزو پنج استان اول در آمار غرق شدگی نبوده
اما در سه ماه نخست ۱۴۰۲، رتبه سوم کشور را در این زمینه داشته است.
که به ترتیب در شهرستان های نجف آباد، اصفهان و فلاورجان اتفاق افتاده است.
بیشتر حوادث غرق شدگی در استخرهای کشاورزی با ۳۶ درصد، رودخانه ۲۳ درصد،
استخر ۱۸ درصد و کانال های آب ۹ درصد بوده است.

RISK OF DROWNING

- ✓ **Host factors:** Male gender
Alcohol use
Underlying disease
Swimming lessons



- Epileps(19 fold increase)
- Cardiac etiologies
- intentional injury
- Child abuse
- Suicide
- Alcohol Use(>7.%)
- Develop Disorder

- ✓ **Environmental factors:**

exposure to water and Inadequate adult supervision.

PATHOPHYSIOLOGY

✓ Drowning victims drown **silently** and Vocalization is precluded .

- Reflex inspiratory efforts
- Coughing by water contacts
- Aspiration of water

Laryngospasm

within minutes

Hypoxia

- ✓ loss of consciousness, followed by apnea
- ✓ bradycardia and pulseless electrical activity
- ✓ Cardiac arrest
- ✓ Affects every organ system

PATHOPHYSIOLOGY

- ✓ Fluid composition can affect clinical sequelae:
- **Cold water** submersion can cause ventricular dysrhythmia
- **Salt water** drowning that results in cardiac arrest
- **Water with high pathogen load** (eg, sewage) increases risk for infection and sepsis

Clinical management is not significantly different in saltwater and freshwater aspirations.

ANOXIC-ISCHEMIC INJURY

- ✓ Hypoxemia in turn affects every organ system, with the major component of morbidity and mortality from Cerebral hypoxia.

Profound hypoxia and medullary depression lead to terminal apnea.

ANOXIC-ISCHEMIC INJURY

✓ Cardiovascular response:

- By 3-4 min, myocardial hypoxia leads to abrupt circulatory failure, progressively decreasing cardiac output and oxygen delivery to organs.
- Ineffective cardiac contractions with electrical activity may occur briefly, without effective perfusion. (pulseless electrical activity)

With early initiation of CPR, spontaneous circulation may initially be successfully restored.

ANOXIC-ISCHEMIC INJURY

✓ CNS injury:

- is the most common cause of mortality and long-term morbidity.
- Although the duration of anoxia before irreversible CNS injury begins is uncertain, it is probably on the order of 3-5 min.

Submersions <5 min are associated with a favorable prognosis, whereas those >25 min are generally fatal.

➤ **Cerebral edema:**

Several hours after cardiopulmonary arrest, cerebral edema may occur, although the mechanism is not entirely clear.

ANOXIC-ISCHEMIC INJURY

- ✓ **ARDS:** pulmonary vascular endothelium damage
- ✓ **Myocardial dysfunction:** Hypotension, decreased cardiac output, arrhythmias.
- ✓ **Acute kidney injury:** ATN , Metabolic or respiratory acidosis, Renal Failure
- ✓ **Vascular endothelial injury:** hemolysis, thrombocytopenia, DIC.
- ✓ **Gastrointestinal damage:** bloody diarrhea with mucosal sloughing.
- ✓ **Serum levels of hepatic transaminases and pancreatic enzymes increase**
- ✓ **Bacteremia and Sepsis**

PULMONARY INJURY

- In humans, aspiration of small amounts (1-3 mL/kg) can lead to marked hypoxemia and a 10-40% **reduction in lung compliance**.
- Wash out surfactant and cause alveolar instability, **ventilation-perfusion mismatch**, and **intrapulmonary shunting**.
- Gastric contents, pathogenic organisms, toxic chemicals, and other foreign matter can injure the lung or cause airway **obstruction**.

COLD WATER INJURY

➤ Hypothermia:

Mild($34-36$)

Mod($30-34$)

Sever(<30)



Bradycardia
Myocardial
Disfunction
Shock
Apnea

➤ <28 : sever Bradycardia , VF , Asystol , Deep Coma

65% of hypothermic patients (body temperature $<35^{\circ}\text{C}$ [95°F]) died, compared with a 27% observed mortality rate in non-hypothermic victims.

MANAGEMENT

✓ Duration of submersion, speed of the rescue, effectiveness of resuscitative efforts, and clinical course determine the outcome in submersion victims.

- ۱) The **first group** consists of children who require minimal resuscitation at the scene and quickly regain spontaneous respiration and consciousness. They have good outcomes and minimal complications.
- ۲) The **second group** comprises children in cardiac arrest who require aggressive or prolonged resuscitation and have a high risk of multiple-organ system complications, major neurologic morbidity, or death.

MANAGEMENT

- ✓ Initial management of drowning victims requires coordinated and experienced **prehospital care** following the **ABCs** (airway, breathing, circulation) of emergency resuscitation.
- ✓ CPR of drowning victims must include providing **ventilation**.

Initial resuscitation must focus on rapidly restoring oxygenation, ventilation and adequate circulation.

INITIAL EVALUATION AND RESUSCITATION

✓ **Airway** : should be clear

➤ In cases of suspected airway foreign body, **chest compressions** or **back blows** are preferable maneuvers.



Abdominal thrusts should not be used for fluid removal.
abdominal thrusts may increase the risk of regurgitation
and aspiration.

INITIAL EVALUATION AND RESUSCITATION

✓ **Breathing:** ventilatory support must be initiated immediately.



➤ **Mouth-to-mouth or mouth-to-nose breathing** restores spontaneous ventilation.

➤ As soon as it is available , **bag-mask ventilation with 100%** should be administered to all victims.

➤ If apnea, cyanosis, hypoventilation, trained personnel, depressed mental status or hemodynamic instability should perform **endotracheal intubation** as soon as possible.

INITIAL EVALUATION AND RESUSCITATION

- ✓ **Heart rate and rhythm, blood pressure ,temperature, and end-organ perfusion** require urgent assessment.
- ✓ **CPR** should be instituted immediately in **pulseless, bradycardic, or severely hypotensive victims.**
- ✓ Continuous monitoring of the electrocardiogram **(ECG)** allows appropriate diagnosis and treatment of arrhythmias with AED.

INITIAL EVALUATION AND RESUSCITATION

- ✓ **CPR** is determined **as soon as possible** without compromising the safety of the rescuer or delaying the removal of the victim from the water.
- ✓ **Chest compressions should not be attempted in open water**, but can be attempted on a boat if conditions allow and rescuers are trained and focus on performing high-quality compressions.

INITIAL EVALUATION AND RESUSCITATION

- ✓ *The cervical spine should be protected in anyone with potential traumatic neck injury.* In such cases, the neck should be maintained in a **neutral position** and protected with a **well-fitting cervical collar**.
- ✓ Slow capillary refill, cool extremities, and altered mental status are potential indicators of **shock**.

INITIAL EVALUATION AND RESUSCITATION

- ✓ **Core temperature must be evaluated:** moderate to severe hypothermia can depress myocardial function and cause arrhythmias.
- ✓ **Wet clothing should be removed,** although in the **hemodynamically stable patient,** rewarming should be initiated in the **ED or PICU.**
- ✓ **Unstable patients** should be warmed to **34°C(33-36),** taking care not to overheat.

Not normothermia may be the goal

INITIAL EVALUATION AND RESUSCITATION

- ✓ We suggest **continuing resuscitative efforts** until the patient's core temperature reaches **32 to 35°C (93 to 95°F)** and **asystole has been present for at least 20 minutes**.
- ✓ In a drowning patient with return of spontaneous circulation **after cardiac arrest**, we maintain a core temperature **between 33 and 36°C** for at least **24 hours**.

INITIAL EVALUATION AND RESUSCITATION

- ✓ Intravenous (IV) fluids and vasoactive medications are required to improve circulation and perfusion.

Hypotonic or glucose-containing solutions should not be used.

- ✓ **Intraosseous catheter** placement is a potentially lifesaving in critically ill children.
- ✓ **Epinephrine** is usually the initial drug of choice in victims with bradycardic cardiopulmonary arrest and Shock.

HOSPITAL-BASED EVALUATION AND TREATMENT

- ✓ should be performed in all drowning victims:
- **Serial monitoring of vital signs** (RR-PR-BP-Temp)
- **Oxygenation by pulse oximetry**
- **Pulmonary examination**
- **Cardiac examination**
- **Neurologic assessment**

HOSPITAL-BASED EVALUATION AND TREATMENT

✓ Initial testing:

- Bedside glucose measurement
- Chest radiograph (CXR)
- Electrocardiogram (ECG)
- Serum electrolytes and creatinine, liver function tests, blood counts, and prothrombin time
- Serum ethanol concentration in adolescent and adult patients
- Troponin if ECG changes or signs of cardiovascular toxicity (eg, hypotension, dysrhythmia)
- Reliable pulse oximetry saturation or arterial blood gas
- Brain CT if persistent altered mental status
- Focused imaging based on concern for injury

Almost half of asymptomatic or minimally symptomatic alert children (GCS:>13) discharge after 6-8 hr of observation if appropriate follow-up can be ensured.

Normal mentation

Normal age-adjusted vital signs

Normal O₂ saturation and initial CXR

Normal pulmonary auscultation

No new or worsening respiratory symptoms

Supplemental oxygen requirement does not develop

HOSPITAL-BASED EVALUATION AND TREATMENT

✓ **Cardiorespiratory Management:**

- **Adequate oxygenation and ventilation** is a prerequisite to improving myocardial function.
- **Fluid resuscitation and inotropic agents** are often necessary to improve heart function and restore tissue perfusion.
- **Overload fluid avoiding** , especially in the presence of poor myocardial function, can worsen pulmonary edema.

HOSPITAL-BASED EVALUATION AND TREATMENT

✓ **patient with a persistently altered mental status**

may have suffered hypoxic-ischemic neurologic injury and/or have non-convulsive status epilepticus.

✓ **The goal of hospital management** : prevent secondary neurologic injury due to:

★ ischemia

★ cerebral edema

★ hypoxemia

★ acidosis

★ fluid and electrolyte imbalances

★ seizure activity.

HOSPITAL-BASED EVALUATION AND TREATMENT

✓ Neurologic Management:

- The most critical and effective neurologic intensive care measures after drowning are **rapid restoration and maintenance of adequate oxygenation, ventilation, and perfusion.**
- **Core body temperature and glucose** management may also be important modulators of neurologic injury after hypoxia-ischemia.

HOSPITAL-BASED EVALUATION AND TREATMENT

✓ Comatose drowning patients:

- At risk for intracranial hypertension. There is little evidence that **ICP monitoring and therapy**.
- **Avoid** hypoxemia, hypercarbia, hypotension, pain, urinary retention, or agitation, as these can raise intracranial pressure and/or worsen cerebral oxygenation.
- The **head of the bed** should be **elevated to 30 degrees** if potential spinal cord injuries have been excluded, and the patient is not hypotensive.

HOSPITAL-BASED EVALUATION AND TREATMENT

- For patients in imminent danger of cerebral herniation should be instituted as soon as possible to temporarily reduce intracranial pressure.
- **Prolonged hyperventilation should be avoided** because it causes cerebral vasoconstriction, decreases cerebral blood flow, and worsens cerebral ischemia.
- **Adequate sedation should be provided** which can increase intracranial pressure.
- **neuromuscular blocking agents should be avoided** because they can interfere with neurologic assessment.

HOSPITAL-BASED EVALUATION AND TREATMENT

- **Seizures** after hypoxic brain injury **are common**, although detection is often difficult in the ICU because these patients are frequently sedated.
- should have an **EEG** to exclude **status epilepticus** ,Even if there is no myoclonic activity and mental status remains poor (**R/O brain death**).
- Seizures should be aggressively controlled:
stabilize cerebral oxygen and **use Fosphenytoin or phenytoin, other anticonvulsants.**

Non-sedating anticonvulsants (eg,phenytoin) are preferred because they do not complicate neurologic assessment.

HOSPITAL-BASED EVALUATION AND TREATMENT

- **Avoid hyperthermia** since it increases cerebral metabolic demand.
- **Maintain euglycemia** as both hypoglycemia and hyperglycemia may be harmful to the brain.
- **Diuretics** can be used to avoid **hypervolemia** and to **treat elevated intracranial pressure**, but equal care should be taken to avoid volume depletion, which can lower cardiac output and cerebral perfusion.

Delayed cerebral edema may develop 24 hours after the initial hypoxic-ischemic injury and carries a poor prognosis.

HOSPITAL-BASED EVALUATION AND TREATMENT

- **Other Evaluations:**

- ✓ **Spinal precautions** should be maintained in victims with altered mental status and suspected traumatic injury.
- ✓ **Significant anemia** suggests trauma and internal hemorrhage.
- ✓ **Profuse bloody diarrhea** and mucosal sloughing usually portend a bad prognosis; conservative management : **bowel rest, nasogastric suction , and PPI.**
- ✓ **Rhabdomyolysis** after drowning has been reported.

HOSPITAL-BASED EVALUATION AND TREATMENT

- ✓ Almost half of drowning victims have a fever during the 1st 48 hr after submersion. Hyperthermia is usually not caused by infection and resolves without antibiotics in approximately 80% of patients.

Prophylactic antibiotics are not recommended

- ✓ Antibiotics should be reserved for cases

Clinical pulmonary infection

submerged in grossly contaminated water

Aeromonas, Pseudomonas, and Proteus

HOSPITAL-BASED EVALUATION AND TREATMENT

- ✓ **Glucocorticoids:** There is no good evidence to support the routine use of glucocorticoids for acute lung injury in drowning victims.
- ✓ **Surfactant:** Although there are case reports of surfactant treatment with good outcomes, **No trials have been performed** in non-fatal drowning victims, **No high-quality evidence that pulmonary function improves** with surfactant therapy.

HOSPITAL-BASED EVALUATION AND TREATMENT

- **Psychiatric and psychosocial sequelae** in the family of a pediatric drowning victim are common. Grief, guilt, and anger are typical among family members , including siblings. Divorce rates increase within a few years of the injury, and parents often report difficulties with employment or substance abuse.

THANK YOU

