

A decorative border featuring vibrant red and orange flowers, green leaves, and several birds in flight, framing the central text.

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A conceptual image showing a hand reaching down from the sky towards a hand reaching up from the ocean. The background is a clear blue sky and a vast, calm blue ocean. The text 'Drowning and Submersion Injury' is overlaid in white serif font across the lower half of the image.

Drowning and Submersion Injury

Slide 7

E1

En.ΤΓ•ΓΨ/•Ψ/•Ψ :

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.

- ✓ The World Congress of Drowning definition of drowning is The term *drowning* does not imply the final outcome death or survival; the outcome should be denoted as *fatal* or *nonfatal* drowning.
- ✓ The injury following a drowning event is *hypoxia*.

Epidemiology

- ✓ Compared with other types of injuries, drowning has one of the highest case fatality rates and is 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.

risk of drowning

- ✓ The risk of drowning and the circumstances leading to it vary by age .
- ✓ Drowning risk also relates to other host factors, including
- ✓ Environmental risk factors include:
 - exposure to water and varying supervision.

Underlying Conditions

- ✓ **Epilepsy** (19 fold increase)
- ✓ **Cardiac etiologies:** arrhythmias, myocarditis, and prolonged QT syndromes, have been found in some children who die suddenly in the water, particularly in those with a family history of syncope, cardiac arrest, prior drowning, or QT prolongation.
- ✓ **intentional injury**
- ✓ **Child abuse**
- ✓ **Suicide**
- ✓ **Alcohol Use** (>70% adolescence & adult)

Pathophysiology

- ✓ Drowning victims drown silently and do not signal distress or call for help. (In humans, aspiration of small amounts (1-3 mL/kg) can lead to marked **hypoxemia and a 10-40% reduction lung compliance.**)
- ✓ Vocalization is precluded by efforts to achieve maximal lung volume to keep the head above the water or by aspiration leading to **laryngospasm**.
- ✓ Young children can struggle for only 10-20 sec and adolescents for 30-60 sec before final submersion.

Anoxic-Ischemic Injury

✓ During drowning, small amounts of water enter the hypopharynx, **triggering laryngospasm**. There is a **progressive decrease** in arterial blood oxyhemoglobin saturation (**SaO₂**) and the final soon **loses consciousness from hypoxia**.

Profound hypoxia and medullary depression lead to terminal apnea.

Anoxic-Ischemic Injury

- ✓ **Cardiovascular response** leads to progressively decreasing cardiac output and oxygen delivery to other organs. By 3-4 min, myocardial hypoxia leads to abrupt circulatory failure.

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

- ✓ The extent of the **global hypoxic-ischemic injury** determines the final outcome and becomes more evident over subsequent hours.

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**. Severe cerebral edema can elevate intracranial pressure (ICP), contributing to further ischemia; **intracranial hypertension** is an ominous **sign of profound CNS damage**.

Anoxic-Ischemic Injury

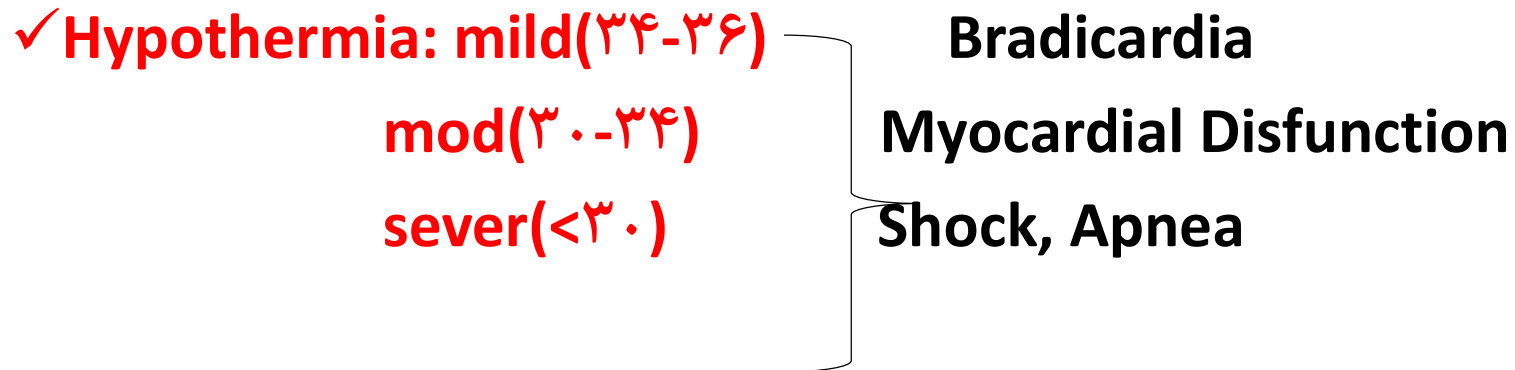
- ✓ **ARDS (acute respiratory distress syndrome):** In the lung, damage to the pulmonary vascular endothelium.
- ✓ **Myocardial dysfunction:** arterial hypotension, decreased cardiac output, arrhythmias.
- ✓ **Acute kidney injury:** ATN , Cortical necrosis , Renal Failure
- ✓ **Vascular endothelial injury:** intravascular coagulation, hemolysis, thrombocytopenia, DIC.
- ✓ **Gastrointestinal damage:** bloody diarrhea with mucosal sloughing.
- ✓ **Serum levels of hepatic transaminases and pancreatic enzymes increase**
- ✓ **Bacteremia and Sepsis**

Pulmonary Injury

- ✓ Water readily moved into the pulmonary circulation with positive pressure ventilation. More importantly, it can **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.**

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

Cold Water Injury



✓ <28 : **sever Bradicardia , 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 nonhypothermic victims.

Management

✓ Duration of submersion, speed of the rescue, effectiveness of resuscitative

efforts, and clinical course determine the outcome in submersion victims.

- 1) 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. These victims should be transported from the scene to the ED for further evaluation and observation
- 2) 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 **ABC** (airway, breathing, circulation) of **emergency resuscitation**.
- ✓ **CPR of drowning victims must include providing ventilation.**
- ✓ Subsequent ED and PICU care often involve advanced life support (ALS) strategies and management of multiorgan dysfunction with discussion about end-of-life care.

Initial Evaluation and Resuscitation

- ✓ **The goal** is to **reverse the anoxia** from submersion and **limit secondary hypoxic injury after submersion**. **Every minute** that passes without the reestablishment of adequate breathing and circulation dramatically decreases the possibility of a good outcome.
- ✓ Common themes in **children who have good recovery** are a **short duration of event** and **initiation of CPR as soon as possible**, before arrival of emergency medical services.

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

Initial Evaluation and Resuscitation

- ✓ The airway should be clear of vomitus and foreign material, which may cause obstruction or aspiration. 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.
- ✓ *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**.

Initial Evaluation and Resuscitation

- ✓ If the victim has ineffective respiration or apnea, ventilatory support must be initiated immediately. **Mouth-to-mouth or mouth-to-nose breathing** by trained bystanders often restores spontaneous ventilation.
- ✓ As soon as it is available, supplemental oxygen should be administered to all victims. Positive pressure **bag-mask ventilation with 100%** inspired oxygen should be instituted in patients with respiratory insufficiency.
- ✓ If apnea, cyanosis, hypoventilation, or labored respiration persists, 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.
- ✓ Slow capillary refill, cool extremities, and altered mental status are potential indicators of **shock**.

Initial Evaluation and Resuscitation

- ✓ **Core temperature must be evaluated** , specially in children, because moderate to severe hypothermia can depress myocardial function and cause arrhythmias.
- ✓ **Wet clothing should be removed** to prevent ongoing heat losses, although in the hemodynamically stable patient, rewarming should be initiated in the controlled environment of the receiving ED or PICU.
- ✓ **Unstable patients** (i.e., arrhythmias) should be warmed to **34°C (93.2°F)**, taking care not to overheat.

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 for intravascular volume administration of drowning victims)**
- ✓ 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 (IV dose is 0.1 mg/kg using the 1:10,000 [0.1 mg/mL] solution given every 3-5 min, as needed). Epinephrine can be given intratracheally (endotracheal tube dose is 0.1-0.2 mg/kg of 1:10,000 [1 mg/mL] solution) if no IV access is available.

Hospital-Based Evaluation and Treatment

- ✓ At a minimum, **serial monitoring of vital signs** (respiratory rate, heart rate, blood pressure, and temperature) and oxygenation by pulse oximetry, **repeated pulmonary examination**, and **neurologic assessment** should be performed in all drowning victims.
- ✓ 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.

Hospital-Based Evaluation and Treatment

- **Cardiorespiratory Management:**

- ✓ The provision of **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.
- ✓ **Overzealous fluid administration**, however, especially in the presence of poor myocardial function, can worsen pulmonary edema.

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.
- ✓ Comatose drowning patients are at risk for intracranial hypertension. There is little evidence that **ICP monitoring and therapy.**

Hospital-Based Evaluation and Treatment

- **Neurologic Management:**

- ✓ **Seizures** after hypoxic brain injury are common, although detection is often difficult in the ICU because these patients are frequently sedated, thus masking clinical signs.
- ✓ Continuous electroencephalographic **(EEG) monitoring** in critically ill patients to detect seizures or as an adjunct in the clinical evaluation of brain death.
- ✓ Seizures should be treated if possible to **stabilize cerebral oxygen** use, although benefits are inconclusive: **Fosphenytoin or phenytoin, Benzodiazepines, barbiturates, and other anticonvulsants.**

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.

- ✓ **Hyperglycemia is associated with a poor outcome** in critically ill pediatric drowning victims. **Glucose control in patients after drowning** should be focused on avoiding hypoglycemia, hyperglycemia, and wide or rapid fluctuations in serum glucose, to prevent further harm.

- ✓ Diuretics, fluid restriction, and dialysis are occasionally needed to treat fluid overload or electrolyte disturbances; renal function usually normalizes in survivors.

- ✓

Hospital-Based Evaluation and Treatment

- ✓ **Rhabdomyolysis** after drowning has been reported.
- ✓ **Profuse bloody diarrhea** and mucosal sloughing usually portend a grim prognosis; conservative management includes **bowel rest, nasogastric suction, and gastric pH neutralization.**
- ✓ Enteral tube feeding or parenteral nutrition is occasionally indicated in children who do not recover quickly.
- ✓ 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.** Generally, **prophylactic antibiotics are not recommended.**

otcoms

✓ Bad Prognosis:

١. Deep Coma

٢. Apnea

٣. Absence of Pupil Reflex

٤. Hyperglysemia

٥. Drowning Duration > ١٠ min

٦. No response to CPR > ٢٥ min

best criteria



Electrical Burns



Electrical Burns

➤ There are 3 types of electrical burns:

1. Extension cord (minor):

- ✓ **Minor electrical burns** usually occur as a result of biting on an extension cord. These injuries produce **localized burns to the mouth**, which usually involve the portions of the **upper and lower lips** that come in contact with the extension cord.
- ✓ These are **nonconductive injuries** (do not extend beyond the site of injury)
- ✓ **Hospital admission is not necessary**, and **care is focused on the area of the injury visible in the mouth.**
- ✓ Ensuring it is **low voltage** and **does not cause entry or exit wounds or cardiac issues.**
- ✓ **Treatment with topical antibiotic creams** is sufficient until the patient is seen in a burn unit **outpatient department or by a plastic surgeon.**

Electrical Burns

✓ **High-tension electrical wire burn:** A more serious category of electrical burn

- ✓ These injuries result from **high voltage (> 1,000 V)**.
- ✓ Mortality rate of **3-15%** for children.
- ✓ Survivors have a **high rate of morbidity**, including major limb amputations.
- ✓ The majority of entrance wounds involve the upper extremity, with small exit wounds in the lower extremity.
- ✓ Multiple exit wounds in some patients attest to the possibility of several electrical pathways in the body, placing virtually any structure in the body at risk **Damage to the abdominal viscera, Thoracic structures, and the nervous system** (confusion, coma, paralysis).

Electrical Burns

- ✓ **Cardiac abnormalities** :ventricular fibrillation or cardiac arrest, are common
 - patients with high-tension electrical injury need an initial electrocardiogram and cardiac monitoring until they are stable and have been fully assessed.
 - **Higher-risk patients** have abnormal electrocardiographic findings and a history of loss of consciousness.
- ✓ **Renal damage**: Deep muscle necrosis and subsequent Myoglobinuria : Patients need forced alkaline diuresis to minimize renal damage.
- ✓ **compartment syndrome**: Aggressive removal of all dead and devitalized tissue, even with the risk of functional loss.

Electrical Burns



۳. Lightning burns:

- ✓ Occur when a **high-voltage** current directly strikes a person (most dangerous) or when the current strikes the ground or an adjacent Object.
- ✓ Lightning burns depend on the **current path, the type of clothing worn, the presence of metal, and cutaneous moisture.**
- ✓ Entry, exit, and path lesions are possible; the prognosis is **poorest for lesions of the head or legs.**
- ✓ **Internal organ injury** along the path is common and **does not relate to the severity of the cutaneous burn.**

Electrical Burns

✓ **Linear burns, usually 1st or 2nd degree**, are in the locations where **sweat** is present.

✓ **Feathering, or an arborescent pattern**, is characteristic of lightning injury.



✓ Lightning may **ignite clothing** or **produce serious cutaneous burns from heated metal** in the clothing.

✓ Internal complications of lightning burns include **cardiac arrest** caused by **asystole, transient hypertension, premature ventricular contractions, ventricular fibrillation**, and **myocardial ischemia**.

Electrical Burns

- ✓ **Most severe cardiac complications resolve** if the patient is supported with **CPR**.
- ✓ **CNS complications** include **cerebral edema** , **hemorrhage**, **seizures**, **mood changes**, **depression**, and **paralysis of the lower extremities**.
- ✓ **Rhabdomyolysis** and myoglobinuria (with possible renal failure) also occur.
- ✓ **Ocular manifestations** include **vitreous hemorrhage**, **iridocyclitis**, **retinal tearing**, or **retinal detachment**.