



DROWNING

— IN —
FORENSIC MEDICINE

UNDERSTANDING THE SILENT STRUGGLE

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DEFENITION OF DROWNING

The process of experiencing respiratory impairment from submersion or immersion of a liquid.

It is a form of violent asphyxial death.

Complete submersion not necessary, submersion of nose and mouth is enough.

Immersion

The **body is surrounded or partially covered by liquid**, but the **airway (nose and mouth) may remain above the water surface**.

The person is in water, but can still breathe.

Examples:

- A person falls into a pool but keeps their head above water.
- A swimmer floating in water.

For drowning:

Immersion alone does **not cause drowning** unless it leads to airway obstruction.

Submersion

Occurs when the **nose and mouth become covered by liquid**, preventing normal breathing.

The airway is under water → respiratory impairment occurs.

Examples:

- A person's face is underwater.
- A person cannot lift their head above water.

For drowning:

Complete body submersion is **not required**....covering the **nose and mouth is enough** to cause drowning.



Global Epidemiology Of Drowning

Drowning is a **major global public health problem** and one of the **leading causes of injury-related deaths** worldwide.



236,000
deaths every year

Approximately 236,000 people die from drowning every year according to the **WHO**.



>90%

of drowning deaths occur in **low- and middle-income countries**.

Due to increased exposure to unsafe water and limited prevention measures.



<5 YEARS

Children under 5 years are among the **highest-risk groups**.

HIGH-RISK ENVIRONMENTS FOR YOUNG CHILDREN

Especially in areas with access to:



Swimming pools



Beaches



Unprotected water sources



HIGHER RISK IN MALES

Males have a higher risk of drowning due to:

- Greater exposure to water activities
- Risk-taking behaviors

KEY GLOBAL FACTS



Drowning is among the **top 3** causes of unintentional injury death for all age groups globally.



It kills more **children aged 1–4 years** than any other cause except congenital disorders.



Drowning is **preventable** through proven interventions: supervision, barriers, swimming skills, life jackets, and safe environments.



Every drowning is a **family tragedy** and a societal loss.



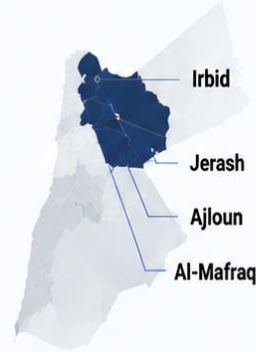
DROWNING IS PREVENTABLE. TOGETHER, WE CAN SAVE LIVES.

+962 Epidemiology Of Drowning



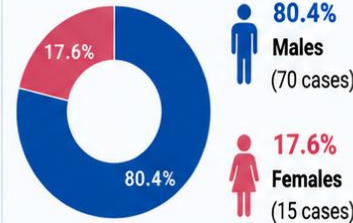
STUDY OVERVIEW

- Conducted at the Forensic Medicine Teaching Centre, Irbid, covering Northern Jordan (Irbid, Jerash, Ajloun, Al-Mafraq).
- Reviewed **2,808** autopsy reports and identified **85** fatal drowning cases (2015–2019).



DEMOGRAPHIC FINDINGS

Gender



Age Distribution

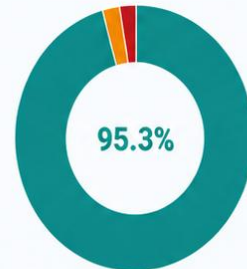
High-risk group:
2–27 years
(88.2%)



Highest frequency
occurred at
2 years of age.



MANNER OF DEATH

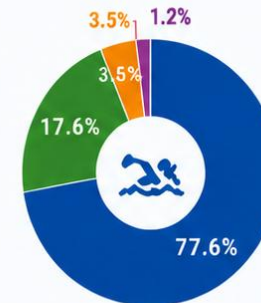


- Accidental drowning
81 cases (95.3%)
- Suicide
2 cases (2.4%)
- Homicide
2 cases (2.4%)



GEOGRAPHIC DISTRIBUTION

Irbid	77.6%	(66 cases)
Al-Mafraq	17.6%	(15 cases)
Ajloun	3.5%	(3 cases)
Jerash	1.2%	(1 case)



Drowning in Northern Jordan predominantly affects young males during summer months, with accidental drowning being the overwhelming manner of death.

JO Case Example: Dead Sea Flash Flood Disaster Jordan (2018)

The Incident

On 25 October 2018, a school trip near the Dead Sea region was struck by sudden heavy rainfall that caused flash floods (severe torrents) in the valleys leading toward the Dead Sea.

A group of students and teachers from a school in Amman were caught in the floodwaters during an outdoor trip.

The rapidly moving water swept people away, resulting in multiple drowning deaths and injuries.

Forensic Importance of the Case

Mechanism of Death

Flash flood drowning

Manner of Death:

Accidental

Mechanism:

Heavy rainfall



Sudden flood formation



Victims swept away by strong currents



Airway submersion



Respiratory impairment



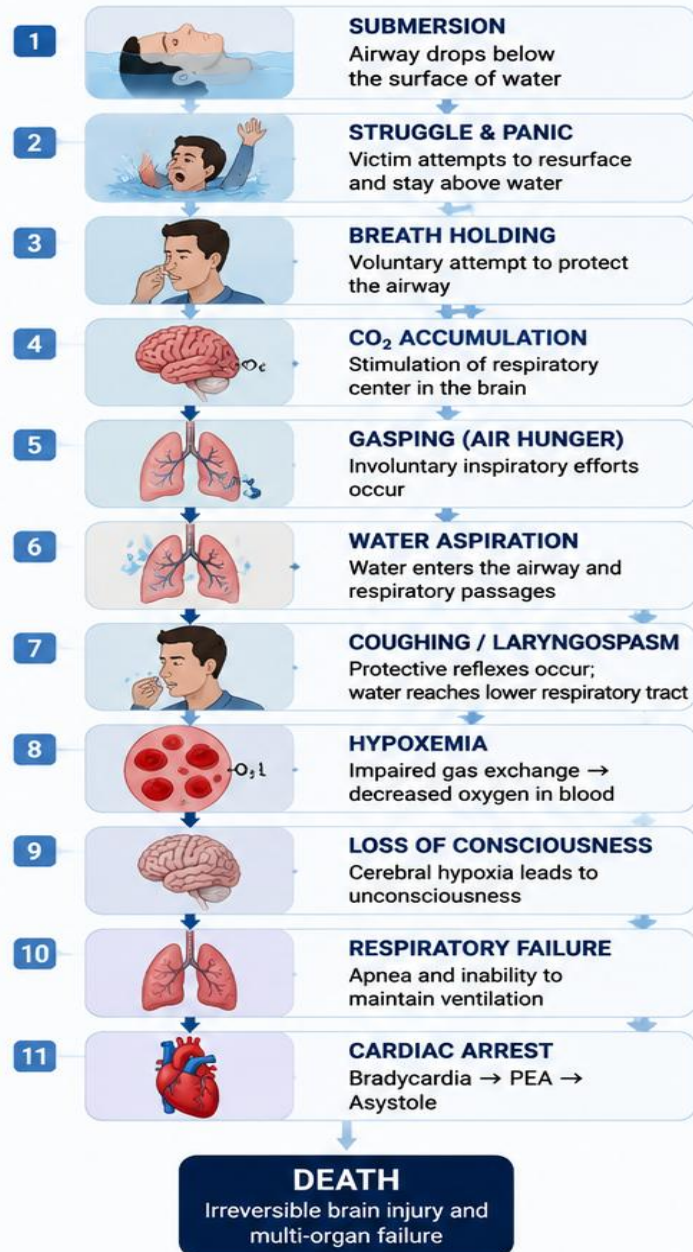
Hypoxia



Drowning

MECHANISM OF DROWNING

From Submersion to Death



PHASES OF DROWNING

1. BREATH-HOLDING PHASE

- Begins after submersion
- Victim voluntarily holds breath
- CO₂ accumulates
- Respiratory center stimulated
- Involuntary breathing efforts begin



2. ASPIRATION & RESPIRATORY DISTRESS

- Gaspings due to severe air hunger
- Water enters the airway
- Cough reflex triggered
- Swallowing of water may occur
- Progressive hypoxia develops



3. UNCONSCIOUSNESS & DEATH

- Loss of consciousness
- Respiratory movements stop
- Cardiac dysfunction:
 - Bradycardia
 - Pulseless electrical activity (PEA)
 - Cardiac arrest
- Irreversible brain injury and death

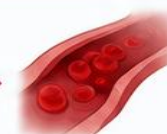


PHYSIOLOGICAL CHANGES DURING DROWNING



RESPIRATORY EFFECTS

- Airway obstruction
- Surfactant dysfunction
- Alveolar damage
- Pulmonary edema
- Impaired gas exchange



OXYGENATION CHANGES

- Hypoxemia
- Hypercapnia
- Metabolic acidosis
- Decreased oxygen delivery to tissues



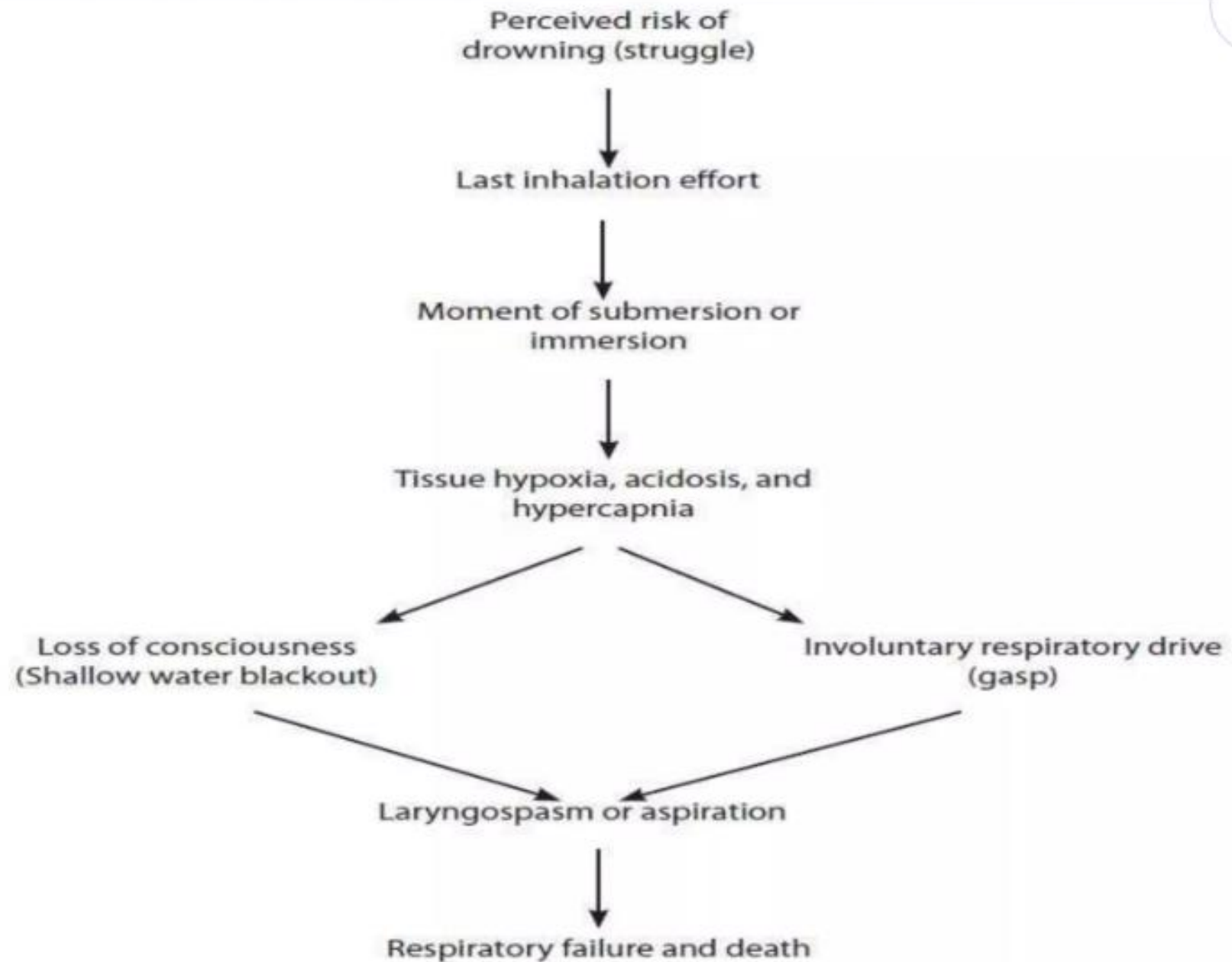
BRAIN EFFECTS

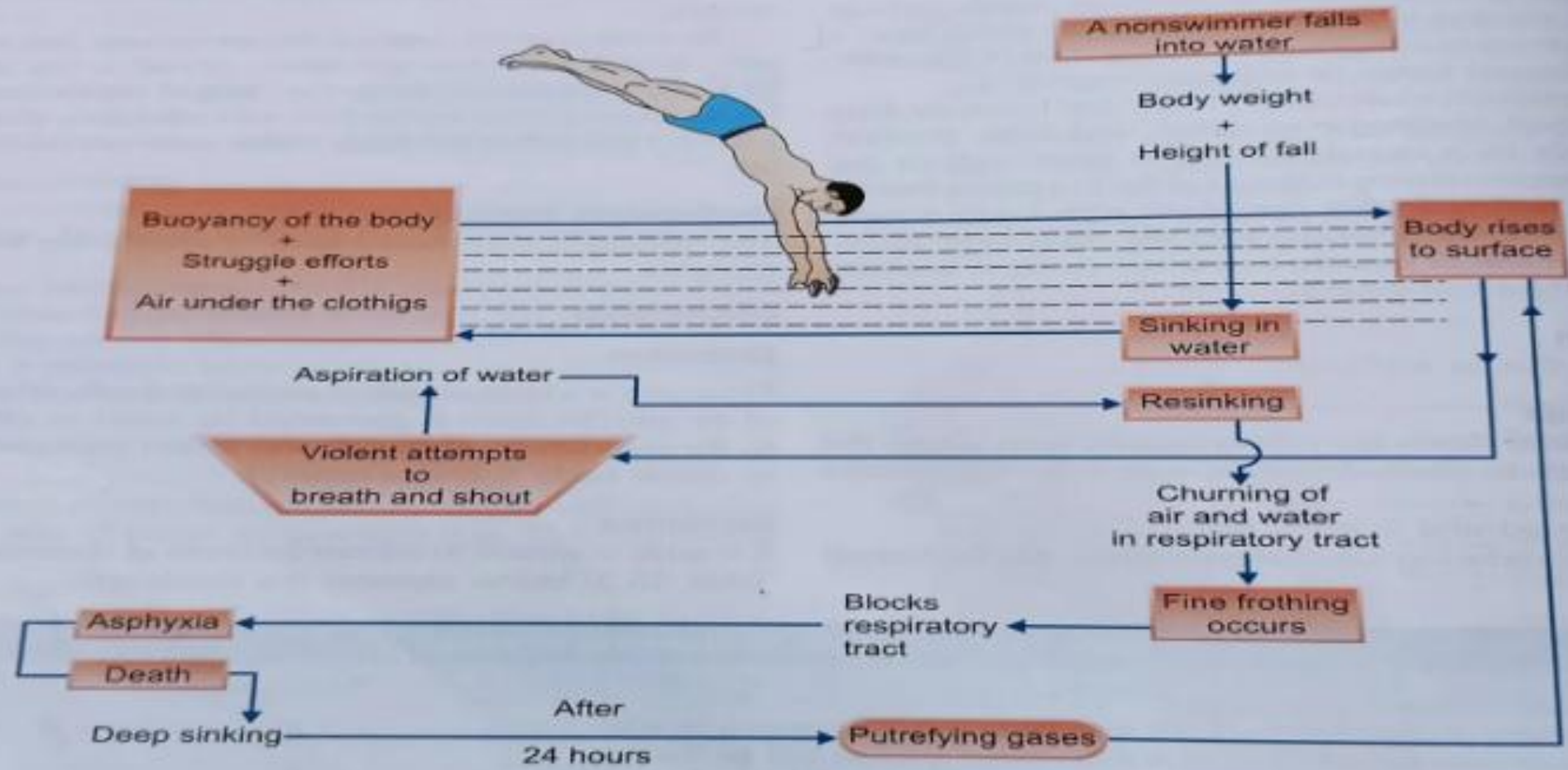
- Highly sensitive to hypoxia
- Loss of consciousness
- Neurological injury
- Permanent disability



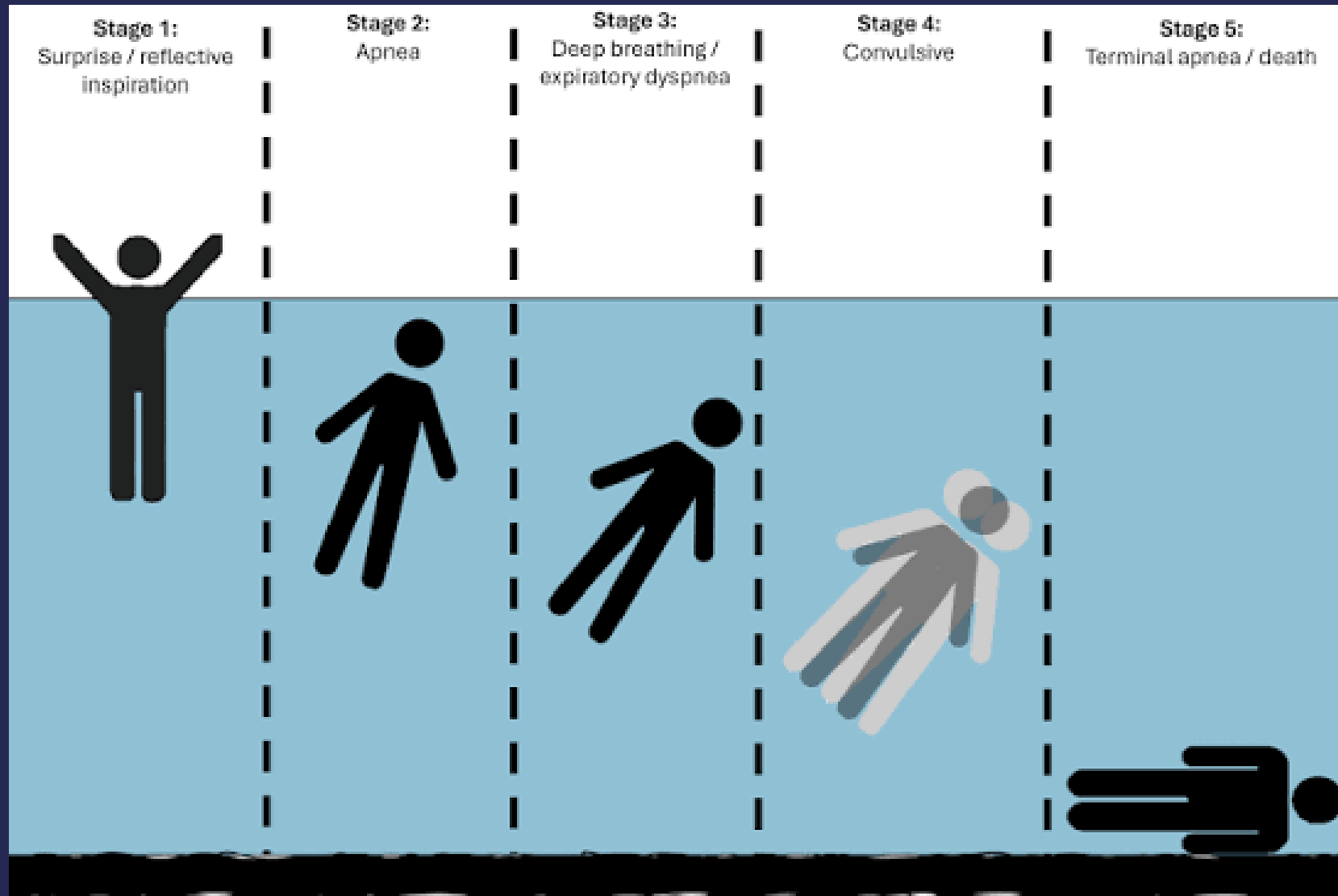
CARDIOVASCULAR EFFECTS

- Initial tachycardia
- Followed by bradycardia
- PEA → Asystole
- Cardiac arrest





Stages of Drowning



Stage 1: Surprise / Reflexive Inspiration

Initial response after unexpected immersion

- Sudden contact with water causes a **surprise reaction**.
- The victim may take a sudden involuntary breath.
- If the airway is below water, water may enter the respiratory tract.
- Panic and fear activate a struggle response.

Main event:

Reflex inspiration + initial water exposure



Stage 2: Apnea (Breath-Holding Phase)

Voluntary attempt to protect the airway

- The victim consciously holds their breath.
- Oxygen levels begin to decrease.
- Carbon dioxide (CO₂) accumulates in the blood.
- Rising CO₂ stimulates the respiratory center in the brain.

Main event:

Breath holding → CO₂ accumulation → urge to breathe



Stage 3: Deep Breathing / Expiratory Dyspnea

Involuntary respiratory efforts begin

- Increasing CO₂ causes intense **air hunger**.
- The victim performs involuntary inspiratory attempts.
- Water enters the airway and lungs.
- Cough reflex and airway irritation occur.

Main event:

Gasping + water aspiration + progressive hypoxia



Stage 4: Convulsive Stage

Severe oxygen deprivation

- Brain hypoxia develops due to reduced oxygen supply.
- Loss of consciousness occurs.
- Convulsive movements may appear.
- Respiratory movements become ineffective.

Main event:

Cerebral hypoxia → unconsciousness → respiratory failure



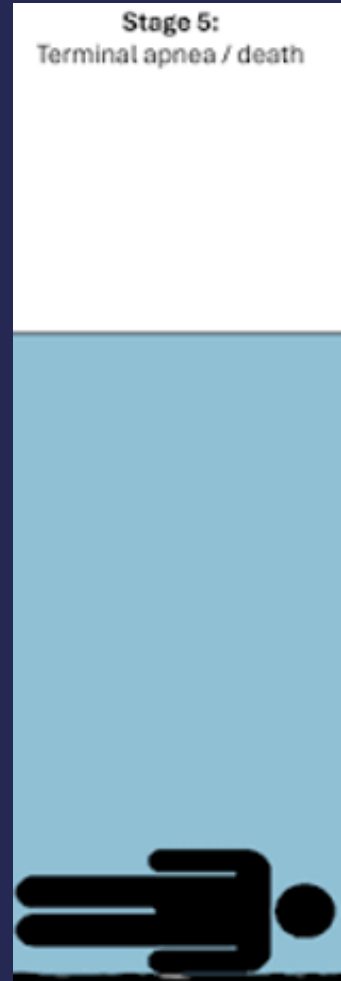
Stage 5: Terminal Apnea / Death

Final stage of drowning

- Respiratory movements stop.
- Severe hypoxia affects the heart.
- Cardiac rhythm deteriorates:
 - Bradycardia
 - Pulseless electrical activity (PEA)
 - Cardiac arrest
- Irreversible brain injury and death occur.

Main event:

Respiratory arrest → cardiac arrest → death





RISK FACTORS OF DROWNING

Factors that increase the likelihood of drowning and water-related deaths



MALE GENDER

- Males are 2–4 times more likely to drown than females.
- Higher risk-taking behavior and more exposure to water activities.



YOUNG AGE AND CHILDREN

- Children under 5 years are at highest risk.
- Lack of judgment and awareness.
- More curious and impulsive behavior.



SUMMER MONTHS

- More time spent in and around water.
- Higher temperatures increase recreational water activities.
- Crowded beaches and pools increase risk.



LACK OF SWIMMING ABILITY

- Inability to swim greatly increases the risk.
- Panic and inability to stay afloat.



LACK OF BARRIERS

- No fences or gates around pools or open water.
- Easy access for children increases risk.



LACK OF CLOSE SUPERVISION

- Children should be supervised at all times.
- Drowning can occur quickly and silently.



LOCATION

- High-risk locations include rivers, lakes, quarries, canals, and open seas.
- Unfamiliar or unsafe water environments increase risk.



FAILURE TO WEAR A LIFE JACKET

- Not wearing a life jacket while boating or swimming in open water is a major risk factor.



ALCOHOL USE

- Alcohol impairs judgment, coordination, and balance.
- Increases risk-taking behavior.
- Major contributor to drowning in adults.



SEIZURE DISORDERS

- People with seizure disorders are at higher risk of drowning.
- Seizures can occur unexpectedly in water.
- Proper management and supervision are essential.

CAUSES OF DEATH IN DROWNING

MAIN CAUSES OF DEATH



ASPHYXIA

Most common cause



VENTRICULAR FIBRILLATION

In freshwater drowning



MYOCARDIAL ANOXIA

Due to lack of oxygen reaching the heart



LARYNGEAL SPASM

Sudden spasm of the larynx preventing air entry



VAGAL INHIBITION

Due to impact with water (especially cold water)



EXHAUSTION

Due to prolonged struggle in water



HEAD INJURIES

Concussion and head injury due to impact or fall

SECONDARY CAUSES

- Septic pneumonia
- Sudden bursting of aneurysm

APOPLEXY

- Subarachnoid hemorrhage from the rupture of berry aneurysm or cerebral hemorrhage by the rupture of cerebral vessels from sudden rush of blood to the brain due to excitement or sudden fall from height into cold water.

TODDLERS



- Lapse of supervision
- Afternoon/early evening – meal time
- 84% with responsible supervising adults
- Only 18% of cases actually witnessed

RECREATIONAL BOATING



- 90% of deaths due to drowning
- Vast majority are not wearing life jackets
- 1,200/yr
- Small, open boats
- 20% of deaths
- Too few or no floatation devices!

DIVING



700–800/yr
1st dive in unfamiliar water
40–50% alcohol related

ALCOHOL



- 25–50% of teen and adult deaths associated with water recreation
- Alcohol influences balance, coordination, and judgment, and its effects are heightened by sun exposure and heat

OTHER CAUSES



- Spas, hot tubs
 - Entrapment in drains, covers
- Buckets drowning
 - Males > females
 - Warm months > cold
 - Consider child abuse



MEDICAL CONDITIONS



- Epilepsy:
 - 1.5–4.6% had pre-existing seizure disorder
 - >5 years old, drown in bathtub, not supervised
- Long QT syndrome:
 - Swimming may be a trigger for arrest in patients with LQTS
 - Drowning may be first presentation
 - Specific gene KVLQT1 mutation associated with swimming trigger & submersion

Factors Affecting the Severity of Drowning

- **1. Amount of Aspirated Water**

- The **quantity of water entering the lungs** is the most important factor.

- Aspiration of **1–3 mL/kg of fluid** can impair pulmonary surfactant function.

- Leads to:

- Alveolar dysfunction
 - Respiratory impairment
 - Hypoxemia

2. Water Temperature

-Cold water may cause:

- Ventricular dysrhythmias
- Hypothermia
- Cardiac instability

-Rarely, rapid cooling may provide temporary brain protection by reducing metabolism.

3. Water Tonicity (Composition)

-Freshwater (hypotonic):

- Dilutes surfactant
- May cause alveolar collapse

-Saltwater (hypertonic):

- Draws fluid into alveoli
- Causes pulmonary edema

4. Water Contamination

- Contaminated water increases the risk of:
 - Pulmonary infection
 - Pneumonia
 - Sepsis

5. Duration of Submersion

- Longer submersion time increases:
 - Oxygen deprivation
 - Brain injury
 - Risk of death

CLASSIFICATION OF DROWNING

TYPICAL DROWNING

Occurs due to submersion of the body in a liquid medium.



FRESH WATER DROWNING

Drowning that occurs in lakes, rivers, ponds, wells, streams, etc.



SALT WATER DROWNING

Drowning that occurs in seas, oceans, and salt water bodies.

ATYPICAL DROWNING

Occurs under unusual circumstances or in a non-typical manner.



DRY DROWNING

Laryngospasm occurs after aspiration of water, preventing water from reaching the lungs.



IMMERSION SYNDROME

Sudden collapse and death immediately after immersion in cold water due to gasping reflex.



NEAR DROWNING

Survivable drowning event in which the victim experiences respiratory impairment but is resuscitated.



SHALLOW WATER DROWNING

Drowning that occurs in a small amount of water, often leading to head injury or cervical spine injury.

FRESHWATER DROWNING

Freshwater drowning occurs when freshwater enters the alveoli during submersion. Freshwater is a **HYPOTONIC** solution compared with blood plasma.

FRESHWATER IS HYPOTONIC

FRESHWATER
(Hypotonic)



BLOOD PLASMA
(Isotonic)



VS

Freshwater has a lower concentration of electrolytes (less salt) than blood plasma, so water moves from the alveoli into the blood.

PATHOPHYSIOLOGY / MECHANISM

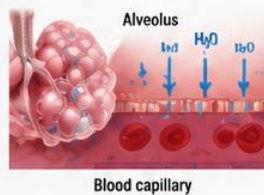
1 ASPIRATION OF FRESHWATER

During submersion, freshwater enters the airways and reaches the alveoli.



2 OSMOTIC MOVEMENT OF WATER

Because freshwater is hypotonic, it passes through the alveolar-capillary membrane into the circulation by osmotic forces.



3 BLOOD CHANGES

- Hemodilution (dilution of blood)
- Hemolysis (rupture of RBCs)



4 ELECTROLYTE DISTURBANCE

Release of intracellular potassium → **Hyperkalemia** ($\uparrow K^+$)



5 CARDIAC EFFECTS

Hyperkalemia and hypoxia lead to cardiac arrhythmias.



6 VENTRICULAR FIBRILLATION AND DEATH



PULMONARY EFFECTS

Freshwater:
Hypotonic water dilutes surfactant



Alveolar collapse



Pulmonary edema



Intrapulmonary shunt and V/Q mismatch



Hypoxia



Respiratory failure
→ Cardiac arrest
→ Death



FATAL PERIOD



Approximately 4–5 minutes

(Time from submersion to expected death if untreated)

FORENSIC IMPORTANCE / AUTOPSY FINDINGS

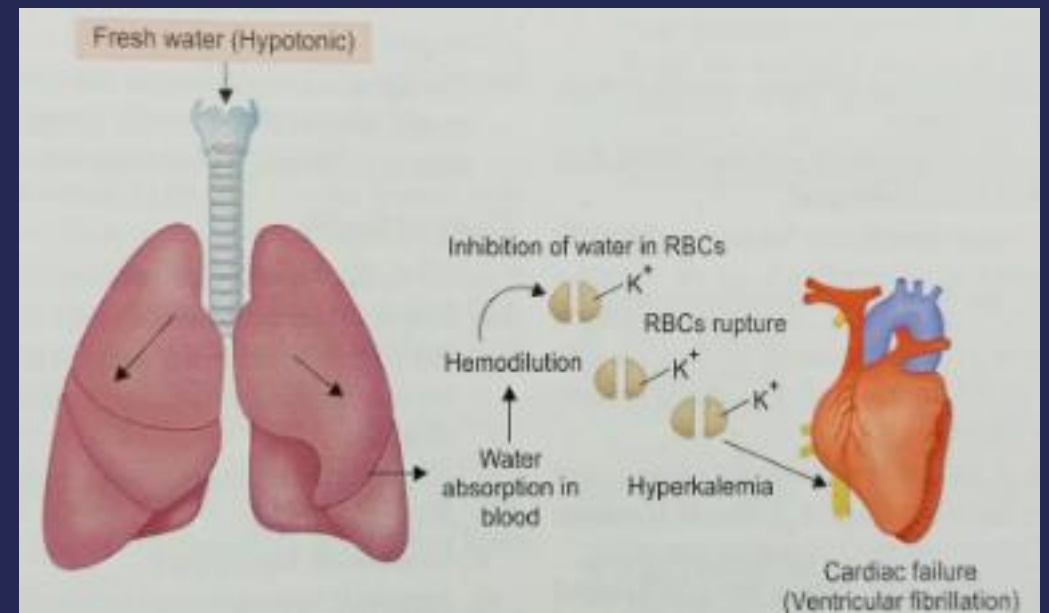
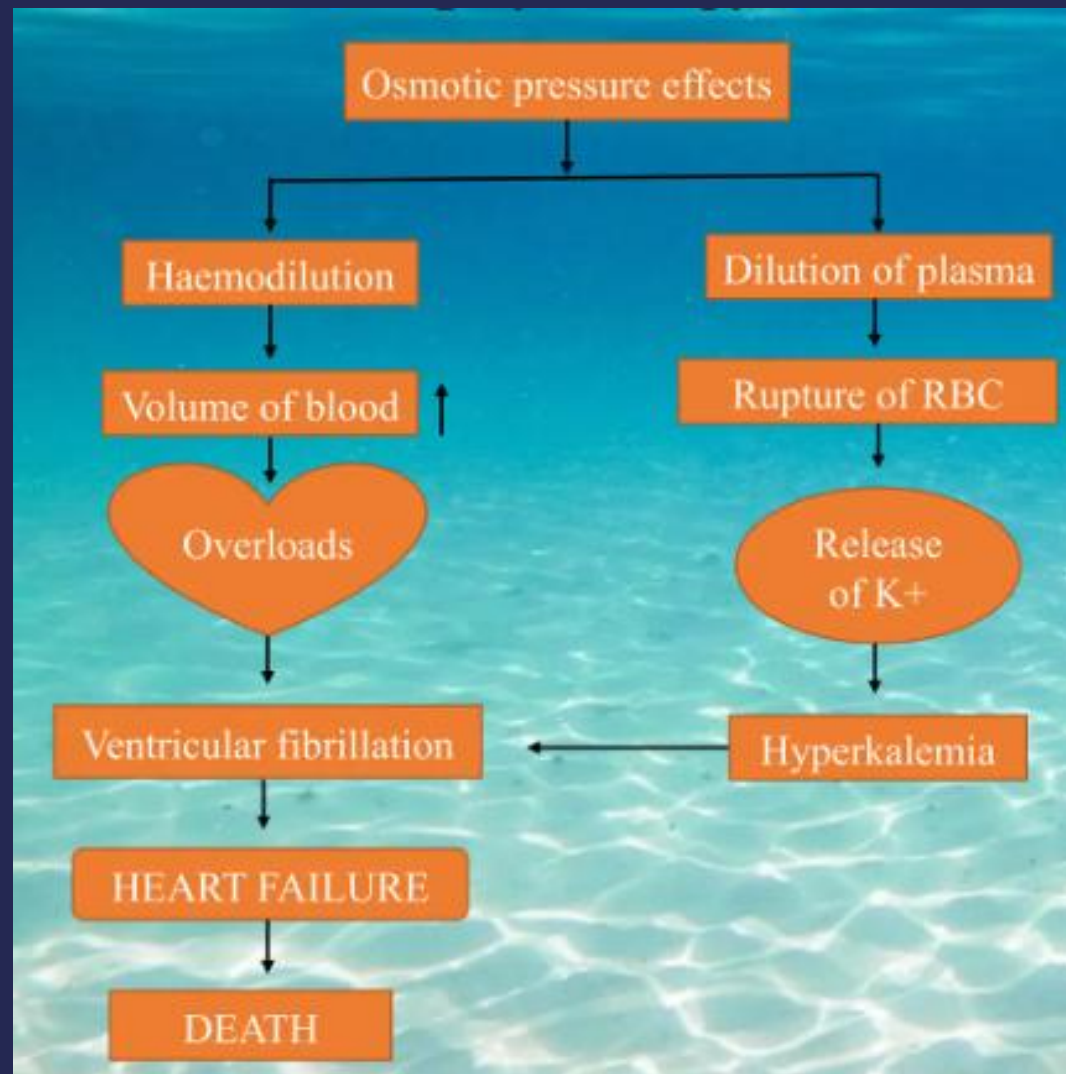


- Lungs are heavy, congested, and waterlogged.
- Abundant fine, frothy fluid in the airways and over the cut surface.
- Pulmonary edema.
- Stomach and paranasal sinuses may contain water, diatoms, sand or debris.
- Classical signs of drowning may be present.

KEY POINTS

- Freshwater is hypotonic → water moves into the blood by osmotic forces.
- Causes hemodilution, hemolysis, hyperkalemia.
- Leads to cardiac arrhythmias, ventricular fibrillation and death.
- Main cause of death is hypoxia and respiratory failure.





SALTWATER (SEA WATER) DROWNING

Saltwater drowning: aspiration of **hypertonic** salt water results in the withdrawal of water from the pulmonary circulation into the alveolar spaces as a result of osmotic forces, leading to **pulmonary edema** and death.



SALTWATER IS HYPERTONIC



SEA WATER
(Hypertonic)



BLOOD PLASMA
(Isotonic)

VS

Sea water has a higher concentration of electrolytes (more salt) than blood plasma, so it pulls water from the blood into the alveoli.

PATHOPHYSIOLOGY / MECHANISM

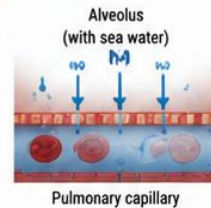
1 ASPIRATION OF SALTWATER

During submersion, salt water enters the airways and reaches the alveoli.



2 OSMOTIC EFFECT (HYPERTONIC SOLUTION)

Because sea water is hypertonic, it draws water from the pulmonary circulation into the alveolar spaces.



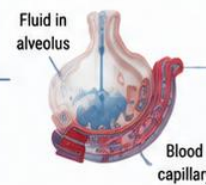
3 PULMONARY EDEMA DEVELOPS

Fluid accumulates in the alveoli causing pulmonary edema and alveolar flooding.



4 IMPAIRED GAS EXCHANGE

Fluid in the alveoli prevents effective oxygen exchange → intrapulmonary shunt and V/Q mismatch.



5 HYPOXIA

Severe hypoxemia occurs.



Decreased oxygen
in the blood

6 RESPIRATORY FAILURE AND DEATH

Progressive hypoxia leads to respiratory failure, cardiac arrest, and death.



DEATH

SUMMARY OF MECHANISM



FATAL PERIOD



**Approximately
8–12 minutes**

(Time from submersion to expected death if untreated)

FORENSIC IMPORTANCE / AUTOPSY FINDINGS

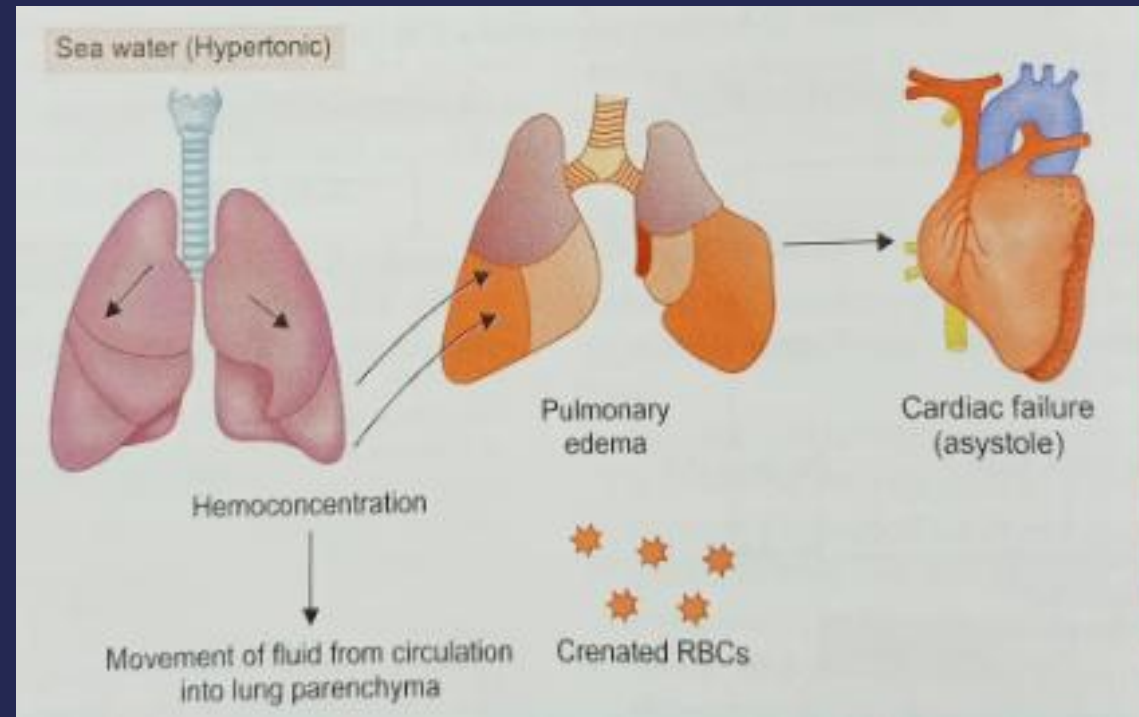
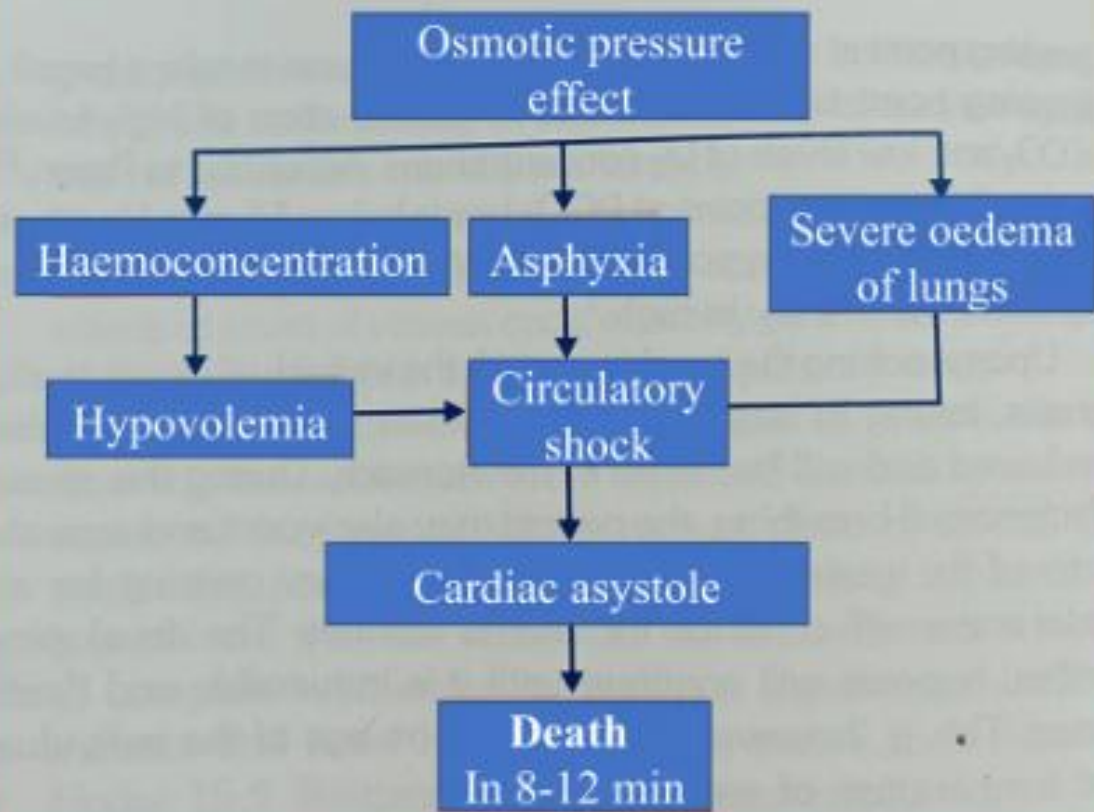
- Lungs are heavy, voluminous, and edematous.
- Abundant fine, frothy, pinkish fluid in the airways and over the cut surface.
- Pulmonary edema.
- Stomach and paranasal sinuses may contain water, diatoms, sand or debris.
- Classical signs of drowning may be present.



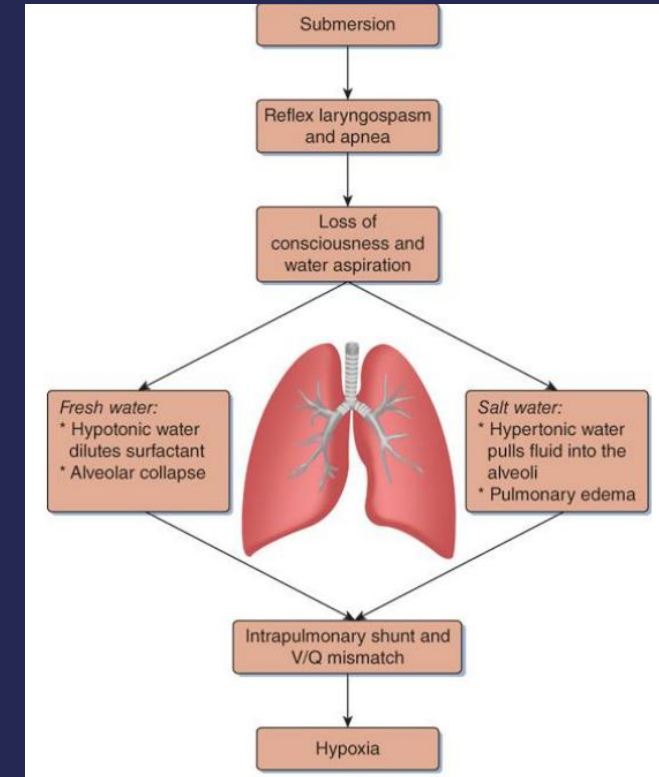
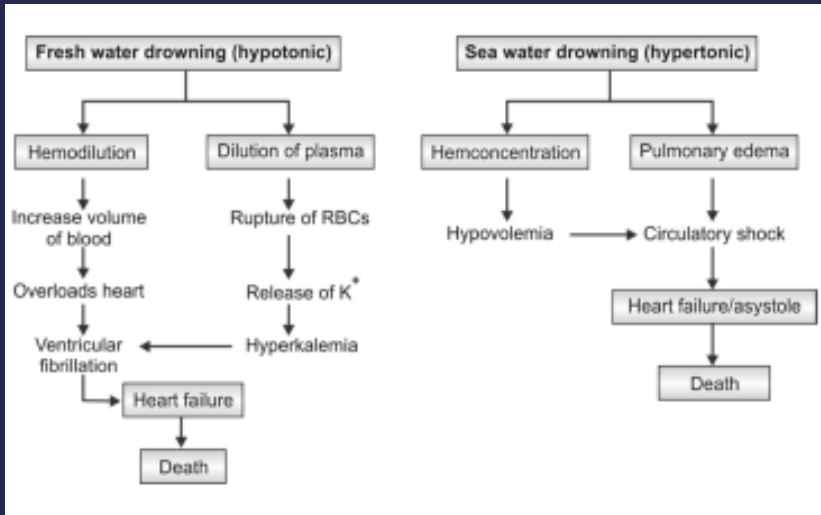
KEY POINTS

- Sea water is hypertonic → pulls water into the alveoli.
- Causes pulmonary edema and severe hypoxemia.
- Main cause of death is hypoxia and respiratory failure.

IMPORTANT: The depth of water is not important; submersion of the airway is sufficient to cause drowning.



Freshwater VS Seawater



Trait	Fresh water drowning	Sea water drowning
Size and weight	Ballooned but light	Ballooned but heavy
Colour	Pale pink	Purplish or bluish
Consistency	Emphysematous	Soft and jelly like
Shape after removal from body	Retained, not collapsed	Not retained, tend to flatten out
Sectioning	Crepitus is heard, little froth and no fluid	No crepitus, copious fluid and froth
Blood volume	Haemodilution	Haemoconcentration
Electrolyte	Hyponatraemia, hyperkalaemia	Hypernatremia
Alveolar lining	Denatures or alters Cardiac arrhythmia leads ventricular tachycardia and fibrillation	Dilutes or washes out Cardiac anoxia leads to cardiac arrest
RBC	Lysed	Crenated

DRY DROWNING

(Atypical Drowning)

Dry drowning is an atypical form of drowning in which **water does not enter the lungs** due to **reflex laryngospasm** (vocal cord closure) induced by a small amount of water entering the larynx. Death occurs due to asphyxia and cardiac arrest.

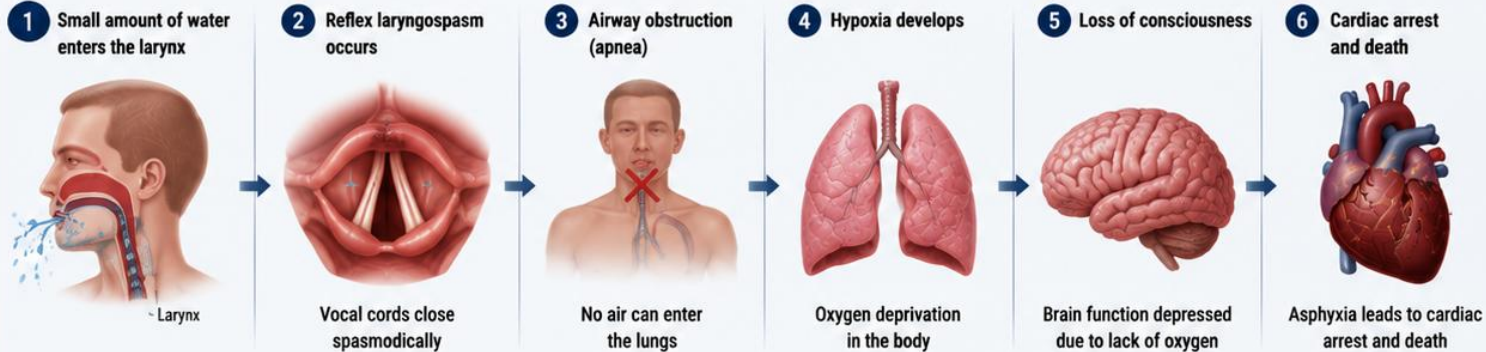


REFLEX LARYNGOSPASM



Vocal cords tightly closed
(airway blocked)

MECHANISM / PATHOPHYSIOLOGY



IMPORTANT FEATURES

- Water **does not** enter the lungs.
- Caused by **reflex laryngospasm** triggered by small amounts of water in the larynx.
- Airway is blocked; no air exchange occurs.
- Death is due to asphyxia and cardiac arrest.
- More common in children and young adults.



AUTOPSY FINDINGS



- Lungs are **dry** or relatively dry.
- Absence of frothy fluid in the airways.
- No or minimal pulmonary edema.
- **Negative diatom test.**
- Stomach and paranasal sinuses usually **do not** contain water.
- Classical signs of drowning may be absent.

NOTE: Autopsy findings and tests for drowning are **negative or inconclusive**.

FORENSIC IMPORTANCE

- Diagnosis is difficult as typical signs of drowning are absent.
- Scene investigation and history are very important.
- Consider in sudden death after submersion where little or no water is found in lungs.



SITUATIONS / RISK FACTORS



Children and young adults



Sudden submersion



Small amount of water in larynx



Hyperreactive laryngeal reflex



Asthma or airway hyperreactivity



Panic and struggling



IMMERSION SYNDROME

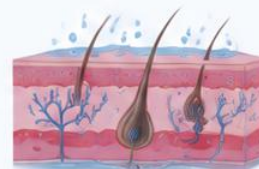
(COLD WATER DROWNING / HYDROCUTION)

Immersion syndrome is an atypical form of drowning caused by a **vasovagal reflex** leading to cardiac arrest after **sudden immersion in cold water** (temperature less than body temperature by 5°C or more). Death may occur before significant water aspiration.



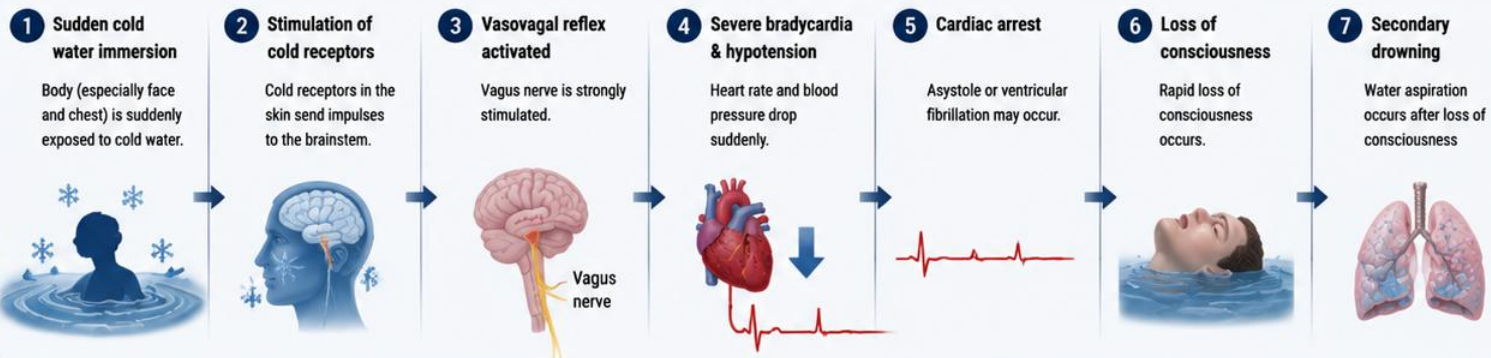
PHYSIOLOGIC TRIGGER

Sudden cold water immersion stimulates cutaneous and facial cold receptors.



Triggers a powerful **vasovagal reflex**.

MECHANISM / PATHOPHYSIOLOGY



COMMON SCENARIO



Sudden jump or fall into very cold water (lake, river, sea, or pool).

KEY POINTS

- Occurs within seconds to minutes.
- Death may occur before significant water aspiration.
- Lungs may contain little or no water.
- May be mistaken for other causes of sudden death.
- More common in cold water (< body temp by 5°C or more).

RISK FACTORS

- Middle-aged individuals
- Alcohol consumption
- Underlying heart disease
- Sudden unprepared exposure to cold water



IMPORTANT FEATURES

- Triggered by **vasovagal reflex**.
- Sudden, unexpected cardiac arrest.
- Minimal or no water in lungs.
- Often occurs in otherwise healthy individuals.



AUTOPSY FINDINGS



- Lungs are usually light, non-congested, and contain little or no water.
- No or minimal froth in airways.
- No pulmonary edema.
- Drowning tests may be negative.
- Death is due to cardiac arrest (neurogenic mechanism).

FORENSIC IMPORTANCE

- Consider in sudden death in cold water.
- Scene investigation is crucial.
- History of sudden immersion in cold water is important.
- Differentiate from typical drowning, cardiac disease, epilepsy, etc.



Also called "**Hydrocution**" – death due to cold water shock and cardiac arrest from a powerful **vasovagal reflex**.

NEAR DROWNING

(POST-IMMERSION SYNDROME)

Near drowning is a form of drowning in which the victim initially **survives after a submersion** event, but later **dies (usually after 24 hours)** due to **complications** resulting from hypoxia-induced injury and systemic effects.



KEY IDEA

The patient survives the initial submersion and resuscitation but may die later due to delayed complications, usually within days.



Survival > 24 hours

PATHOPHYSIOLOGY / SEQUENCE OF EVENTS

1. SUBMERSION

Water enters airways → respiratory impairment and hypoxia.



2. INITIAL RESUSCITATION

Victim is rescued and resuscitated successfully.



3. SURVIVAL PERIOD (> 24 HOURS)

Patient survives the initial event and remains alive for more than 24 hours.



4. DEVELOPMENT OF COMPLICATIONS

Ongoing hypoxia, inflammation, and systemic effects lead to multi-organ involvement.



5. DEATH DUE TO COMPLICATIONS

Patient may die due to ARDS, DIC, or hypoxic encephalopathy and organ failure.



MAJOR COMPLICATIONS

1. ARDS

(Acute Respiratory Distress Syndrome)

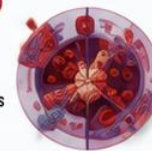
- Severe inflammation of lungs
- Increased capillary permeability
- Non-cardiogenic pulmonary edema
- Severe hypoxemia and respiratory failure



2. DIC

(Disseminated Intravascular Coagulation)

- Widespread activation of clotting cascade
- Formation of microthrombi
- Consumption of clotting factors and platelets
- Bleeding and organ dysfunction



3. HYPOXIC ENCEPHALOPATHY

- Brain injury due to prolonged hypoxia
- Cerebral edema
- Neuronal death
- May lead to coma, seizures, or persistent neurological disability



RISK FACTORS

- Prolonged submersion
- Delayed resuscitation
- Cold water
- Aspiration of large volume of water
- Children, elderly, and those with pre-existing illness



AUTOPSY FINDINGS

- Lungs: heavy, congested, edematous
- Frothy fluid in airways and cut surface
- Pulmonary edema
- Other findings may depend on complications (e.g., brain edema, petechiae in DIC)



FORENSIC IMPORTANCE

- Death is not due to initial drowning alone but due to delayed complications.
- Detailed history and medical records are important.
- Requires evaluation of treatment and timing of death.



Key Point: Near drowning (post-immersion syndrome) = survival beyond 24 hours, death occurs due to complications (ARDS, DIC, hypoxia-induced encephalopathy, multi-organ failure).



SHALLOW WATER DROWNING

DEFINITION

Drowning that occurs when an unconscious person becomes submerged in a small amount of water.



IMPORTANT: The depth of water is not important; submersion of the airway is sufficient.



MECHANISM

Loss of consciousness



Face / nose / mouth submerged



Unable to breathe



Respiratory impairment



Hypoxia



Death



COMMON SITUATIONS



Alcohol intoxication



Drug effects



Epilepsy



Bathtub drowning



Pits or drains

FORENSIC IMPORTANCE

Requires evaluation of:



Scene circumstances
(e.g., location, water source, position of body, evidence)



Medical history
(diseases, epilepsy, medications, etc.)



Toxicology results
(alcohol, drugs, poisons, etc.)



Possibility of accidental, suicidal, or homicidal drowning



Key Point: Shallow water drowning can occur in very little water. The depth is not the key factor—submersion of the airway is. Always consider medical history, toxicology, and scene factors.

COLD WATER IMMERSION AND HYPOTHERMIA



COLD WATER EFFECTS

- Cold water is usually associated with poor prognosis.
- It can cause:



Hypothermia



Cardiac dysrhythmias



Reduced physiological reserve



However, **rare cases** of prolonged icy water submersion have shown **neurological recovery**.



POSSIBLE PROTECTIVE MECHANISM OF HYPOTHERMIA

If cooling occurs rapidly
before severe hypoxia:



Reduces cellular
metabolic rate



Decreases
oxygen demand



May protect
the brain temporarily



IMPORTANT FORENSIC / CLINICAL POINT

Hypothermia is protective only when:



Core temperature falls rapidly



Cooling occurs before irreversible
hypoxic brain injury

**Once brain cells are damaged by
prolonged oxygen deprivation:**



(Approximately 5–6 minutes),
hypothermia **cannot reverse**
the injury.



KEY MESSAGE: Hypothermia may be protective only if cooling is rapid and occurs before severe hypoxia. After ~5–6 minutes of oxygen deprivation, brain injury is irreversible.

Symptoms

- ❖ Mental confusion
- ❖ Auditory & Visual hallucinations
- ❖ Tinnitus
- ❖ Vertigo
- ❖ Chest pain

Treatment

- ✓ Artificial respiration with closed chest cardiac massage
- ✓ Defibrillator when there is ventricular fibrillation

Postmortem Findings (External)

Facial Changes:

- Pale
- Cyanosed
- Bloated



Postmortem Findings (External)

Eye Changes:

Half opened half
closed



Postmortem Findings (External)

Tongue Changes:

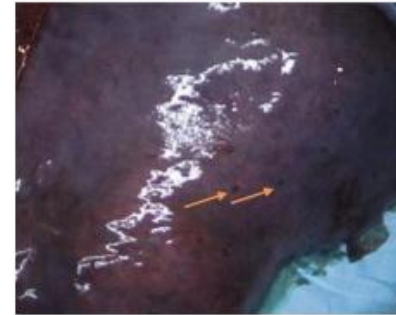
Swollen and
Protruded



Postmortem Findings (External)

PM Staining:

- Light pink in color, present over face, neck, front of upper part of chest, upper and lower limbs.
- The body usually floats face down, buttocks up, legs and arm hanging down in front of the body.



Postmortem Findings (External)

Froth:

- External foam
- Fine white & odorless, reflecting mixture of air water and mucus due to forcible respiration during drowning.



Postmortem Findings (External)

Rigor mortis:
Appears early



Postmortem Findings (External)

Cutis Anserina:

Skin appears granular with hair standing on the end; due to spasm of erector pili muscles.



Postmortem Findings (External)

Washerwoman hand:

Wrinkling, thickening of the skin & white in color.

Bleaching of the cuticle is quite evident after 12-18 hours of immersion (due to osmotic action of water on thickened epidermis).



Postmortem Findings (External)

Degloving:

The epidermis of hand and feet get separated in form of gloves and stockings – 2 weeks.



Figure 16.2 Peeling of the epidermis from the foot (degloving) following a few weeks of immersion.

Postmortem Findings (External)

Cadaveric spasm:

With mud, sand, grass,
gravel.

****Vital proof of
antemortem drowning****

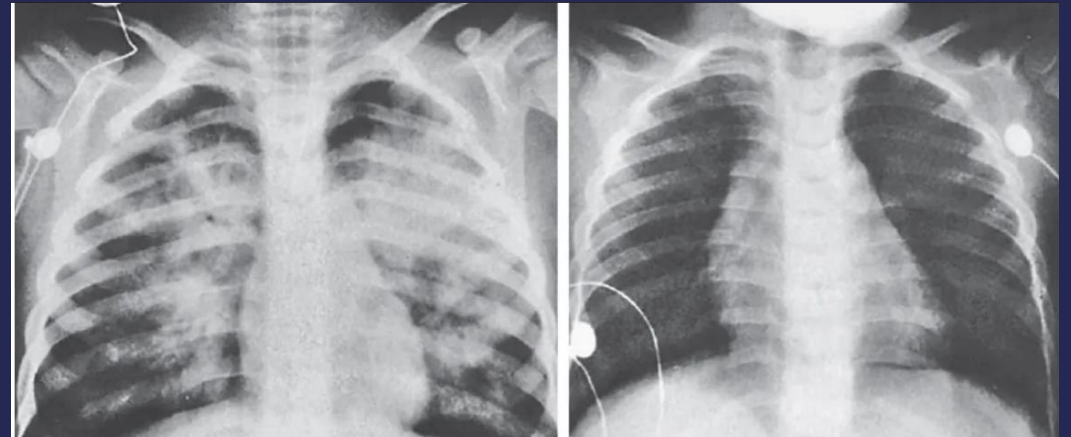


Postmortem Findings (Internal)

Emphysema Aquasum:

Wet drowning hyper expanded and waterlogged lungs.

Rib imprints may be present on the surface of lungs.

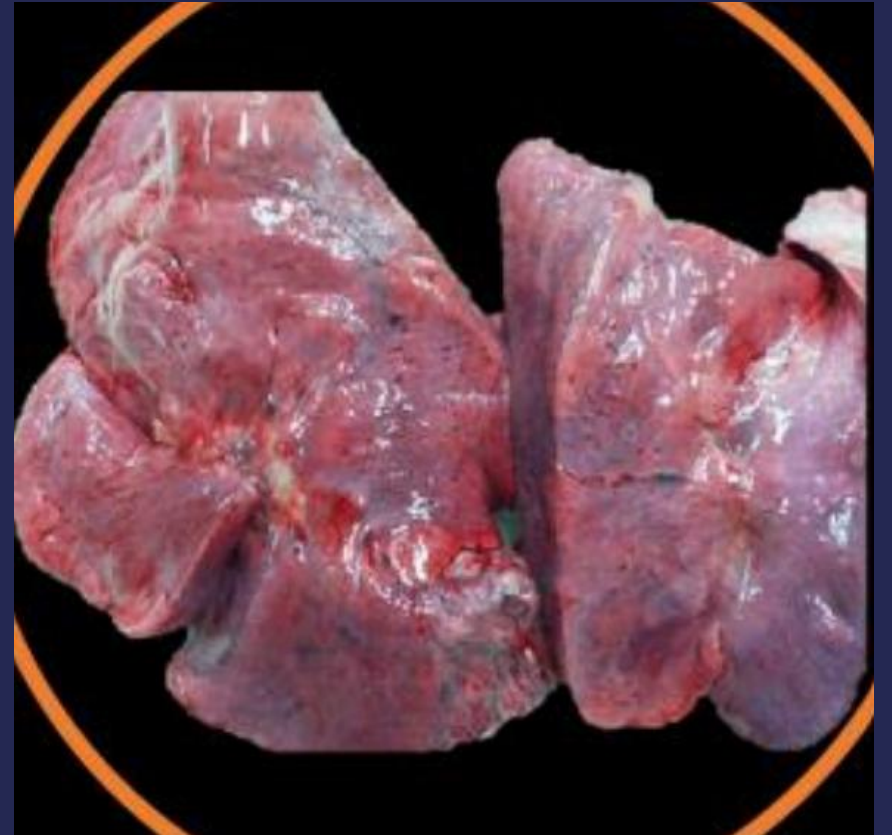


Postmortem Findings (Internal)

Paltauf's hemorrhage:

Mottled areas of red and gray distended alveoli.

Reflects intra-alveolar hemorrhages.



Postmortem Findings (Internal)

Larynx, Trachea, and Bronchioles:

The presence of sand, mud, slit, dirt, aquatic vegetations, classical water flora, algae, and diatoms in the trachea and lower bronchial tree are characteristic positive findings of antemortem drowning.



Postmortem Findings (Internal)

Heart and Blood vessels:

Like in other forms of asphyxia, left side of heart will be usually empty; the right heart will be full of the venous system engorged with dark blood, unusually fluid in consistency because of admixture with water.



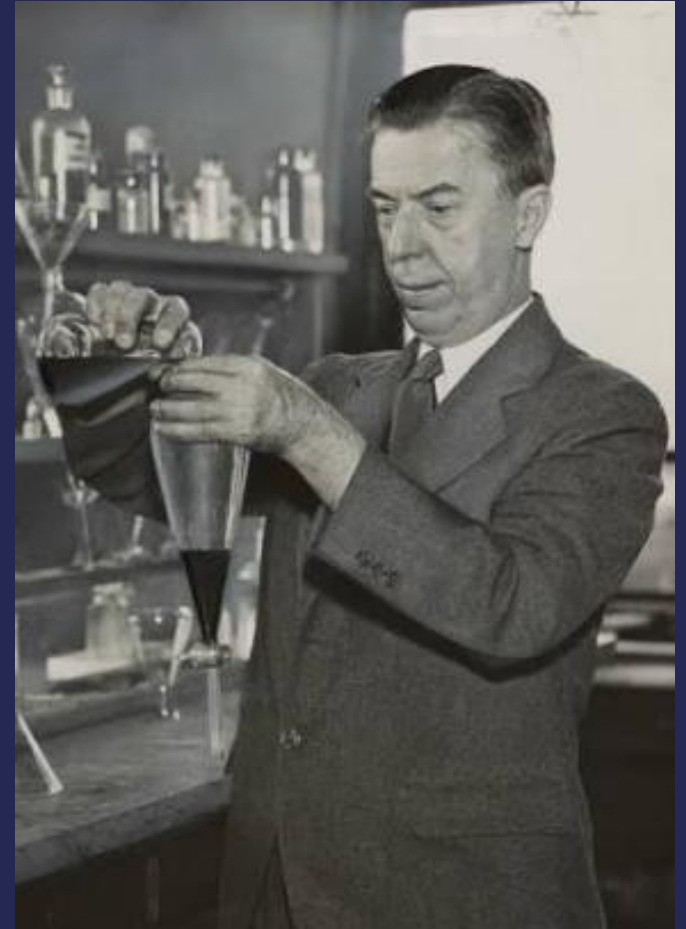
Postmortem Findings (Internal)

Gettler Test:

A forensic postmortem procedure that measures chloride levels in blood samples taken from the left and right ventricles of the heart to help distinguish between freshwater and saltwater drowning.

Normally, the chloride content of the right and left side of heart is nearly same, about 600mg/100 ml. If difference is 25 % or more, it is suggestive of antemortem drowning.

Stomach filled with water in 70% may contain watery fluid or even foreign material such as weed or sand.



Postmortem Findings (Internal)

Middle Ear Haemorrhage:

Hemorrhages in the middle ear and mastoid air cells.



Postmortem Findings (Internal)

DIATOMS IN DROWNING



Diatoms under microscope



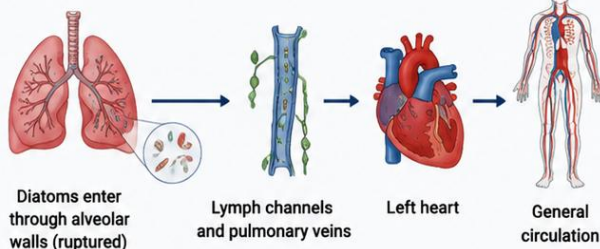
Diatom frustule

WHAT ARE DIATOMS?

- Diatoms belong to the class Bacillario-phyceae and are microscopic unicellular algae.
- They secrete silicon skeletons called **frustules**.
- Frustules are chemically inert and almost indestructible, being resistant to strong acids.

PATHWAY DURING DROWNING (ANTEMORTEM)

- During drowning, diatoms (**size up to 60 μm**) enter the circulation via the lungs through the ruptured alveolar walls, lymph channels and pulmonary veins into left heart and then into general circulation.



FORENSIC SIGNIFICANCE



- The presence of diatoms in the lung substance, bloodstream, brain, liver, kidneys, bone marrow of femur (best site for analysis) or humerus or in the skeletal muscle has been claimed to be **suggestive proof of antemortem drowning**.
- Since diatoms resist putrefaction, the diatom test may have some value in the examination of decomposed bodies.

BEST SITES FOR ANALYSIS



WHEN THE TEST IS NEGATIVE



- In dead bodies thrown in the water
- In dry drowning (no aspiration of water)



KEY POINTS

- Diatoms are microscopic algae with siliceous frustules resistant to strong acids and putrefaction.
- They enter the circulation only when a person is alive (antemortem drowning).
- Their presence in internal organs, blood, or bone marrow supports the diagnosis of antemortem drowning.
- The test is negative in postmortem immersion and dry drowning.

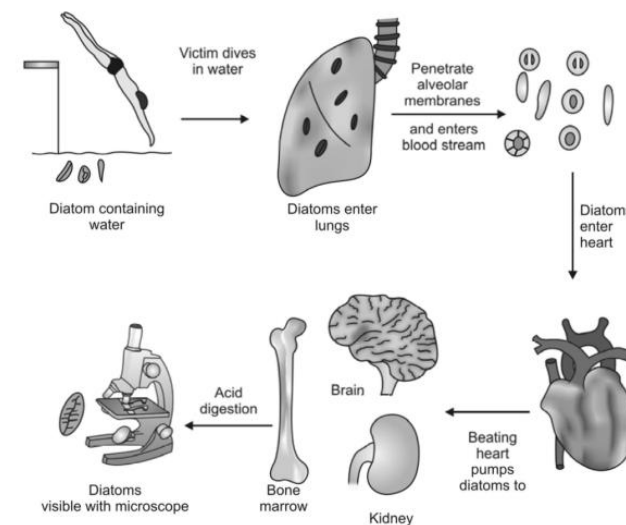


Fig. 10.18: Principle of diatom test



WAS THE DROWNING ACCIDENTAL, SUICIDE OR HOMICIDAL?

FREQUENCY



- **Accidental** drowning is the most common.
- **Suicide** is less common.
- **Homicidal** drowning is rare and difficult to prove.

ACCIDENT



EVIDENCE MAY INCLUDE:

- ✓ Wearing bathing costume.
- ✓ History of epilepsy or medical illness.
- ✓ No evidence of foul play.
- ✓ Circumstances consistent with an accident.

SUICIDE



EVIDENCE MAY INCLUDE:

- No struggle signs.
- Suicidal note (may be present).
- History of psychological illness.
- History of financial or personal problems.

HOMICIDE



EVIDENCE MAY INCLUDE:

- Victim may have been killed before being thrown into water.
- Signs of resistance or struggle.
- Injuries suggesting assault before immersion.
- Scene findings inconsistent with accidental drowning.



Note: Determine manner of drowning by evaluating the scene, medical history, autopsy findings, and all circumstantial evidence.

Differentiation 10.4: Antemortem drowning and postmortem submersion

<i>S.No.</i>	<i>Feature</i>	<i>Antemortem drowning</i>	<i>Postmortem submersion</i>
1.	Froth over mouth and nostrils	Fine, lathery froth, appears spontaneously	Absent, even if present, it is coarse, not spontaneous
2.	Cadaveric spasm in hands	Aquatic vegetations, mud may be present	Not observed
3.	Trachea and bronchioles	Presence of algae, mud along with frothy mucus	Absent
4.	Lungs	Ballooned up, bulky, edematous, bear indentations of ribs	Collapsed, decomposed
5.	Mud and algae in stomach and small intestine	May be present	Absent
6.	Diatom and Gettler tests	Positive	Negative
7.	Injuries	If present, need to be consistent with drowning	Injuries inconsistent with drowning
8.	Other suggestive signs	Water in middle ear, retracted genitals, cutis anserina, washerwoman's hands, wet	Water is never present in middle ear; others are not valuable and corroborative findings



THANK YOU

FOR LISTENING



DROWNING IS PREVENTABLE.
AWARENESS **SAVES LIVES.**



**SUPERVISE
AT ALL TIMES**



**WEAR
LIFE JACKETS**



**LEARN TO SWIM
STAY SAFE**

