

Drowning

BY JINEEN ODEH

Case Study 1

- A 15 year-old male is found submerged in a river after being missing for 12 hours. His body is recovered intact with no external injuries.



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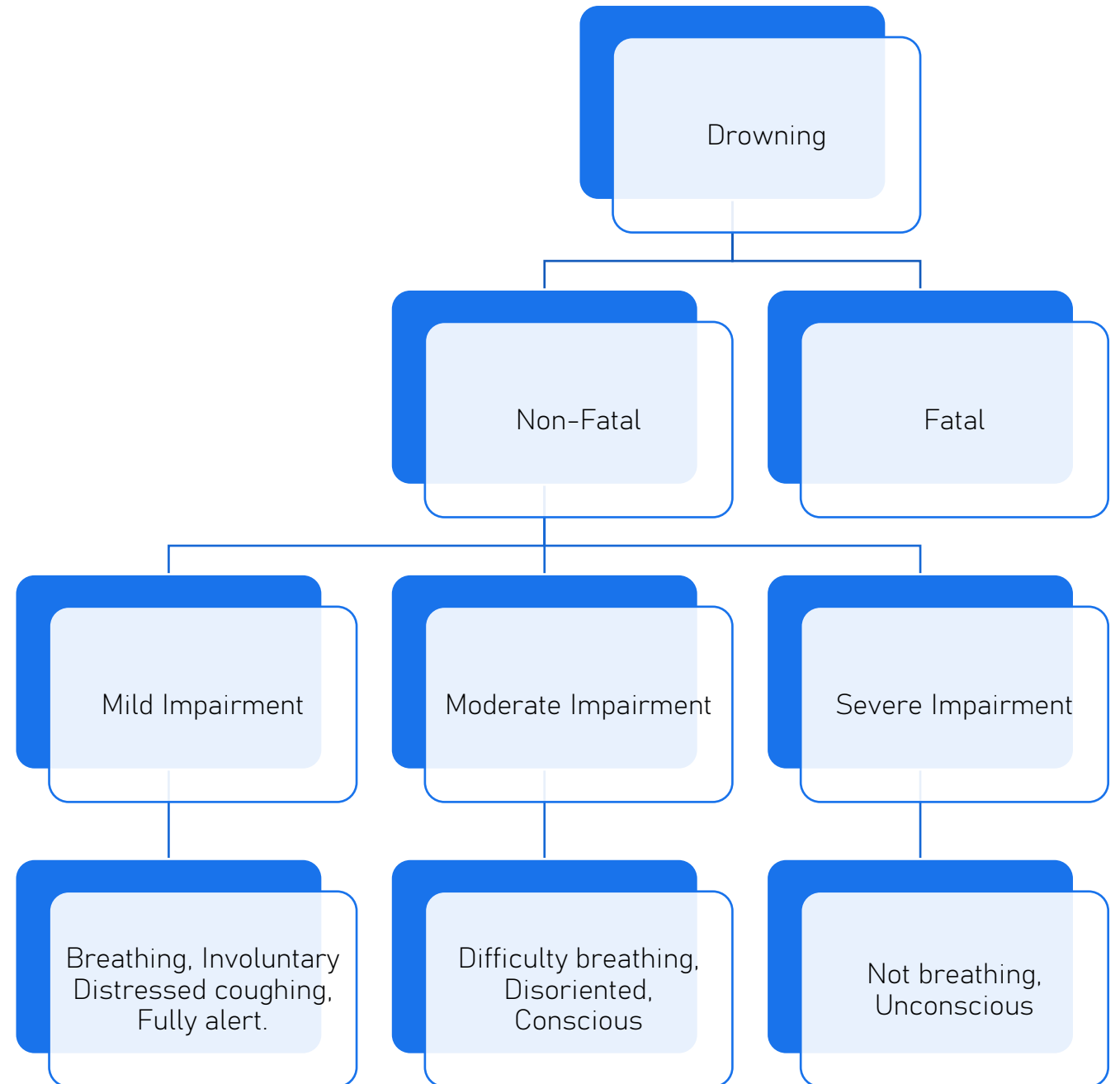
- A 15 year-old male is found submerged in a river after being missing for 12 hours. His body is recovered intact with no external injuries.

- What is the cause of death?

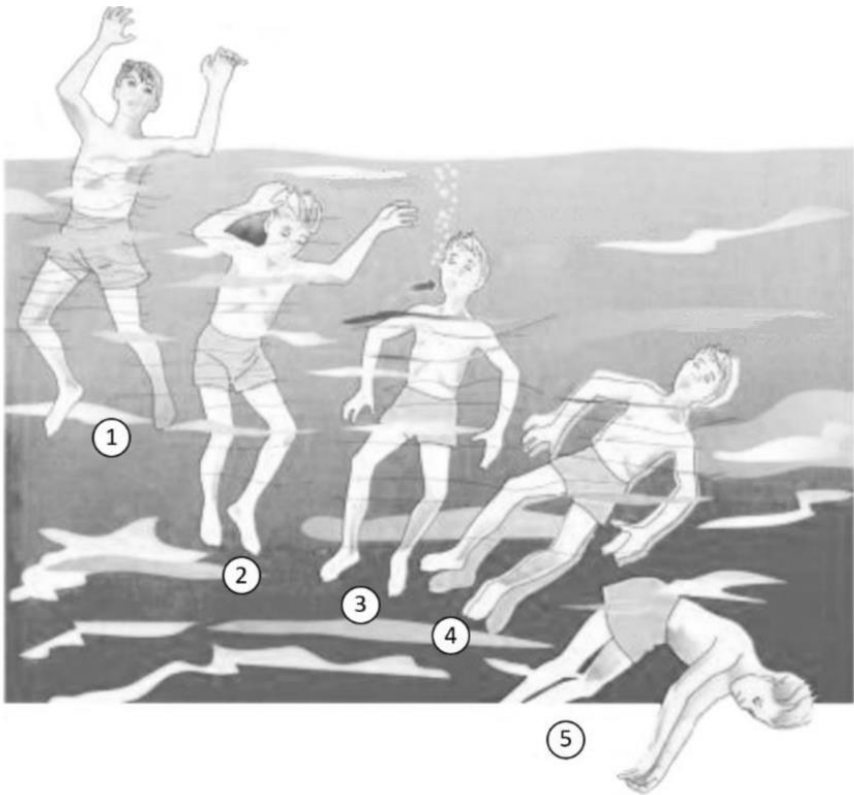
Drowning

Drowning Terminology

- Drowning is a process of experiencing respiratory impairment from submersion or immersion in liquid.
- Fatal Drowning results in fatal outcome
- Non-fatal drowning is a process of respiratory impairment stopped before death.



Phases of Drowning



- Breath holding
 - a. lasts for variable length of time
 - b. CO₂ accumulation
 - c. Stimulation of respiratory center in the brain
 - d. Inhalation of large water volumes
- Swallowing of water
 - a. Coughing, Vomiting, progressive loss of consciousness
 - b. Escape of remaining air in the lungs, replaced by water.
- Profound Unconsciousness
 - a. Gasping
 - b. Respiratory Standstill
 - c. Heart failure
 - d. Irreversible brain changes
 - e. Death

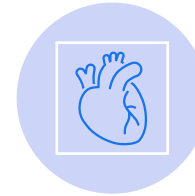
Causes of Death



Asphyxia: most common cause



Vagal Inhibition: due to impact with water



Cardiac Arrest: in sea water drowning



Ventricular fibrillation: in fresh-water drowning



Laryngeal spasm



Concussion and head injury

Causes of Death



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.



Secondary causes: septic pneumonia and sudden bursting of aneurysm.

Case Study 1

- A 15 year-old male is found submerged in a river after being missing for 12 hours. His body is recovered intact with no external injuries.
- Knowing that the victim is a beginner mountain stream climber :
- What is the most likely manner of death?

Accidental

Epidemiology



Drowning is a common cause of accidental death in the United States, and a prominent cause of childhood fatalities worldwide, especially in children under the age of five in states where swimming pools and beaches are readily accessible.



Low and middle-income countries have the highest rates of drowning, accounting for over 90 percent of cases worldwide.

Epidemiology

In Jordan, only 85 drowning related death reports conducted through a 5 year period (2015-2019) in the Forensic Medicine Teaching Centre which serves Northern Jordan including Irbid, Jerash, Ajloun, and Al-Mafraq.

Fatal drowning cases were related to males(80.4%). Age group from (2 to 27 years of age). Specifically, age 2 had the highest occurring frequency.

While (17.6%) of drowning fatalities occurred in August.

The dominant manner of death among all cases was accidental

Case Study 1

- A 15 year-old male is found submerged in a river after being missing for 12 hours. His body is recovered intact with no external injuries.
- Knowing that this incident has occurred in August :
- What are the risk factors?

Drowning Risk Factors

Male Gender

Young age and children

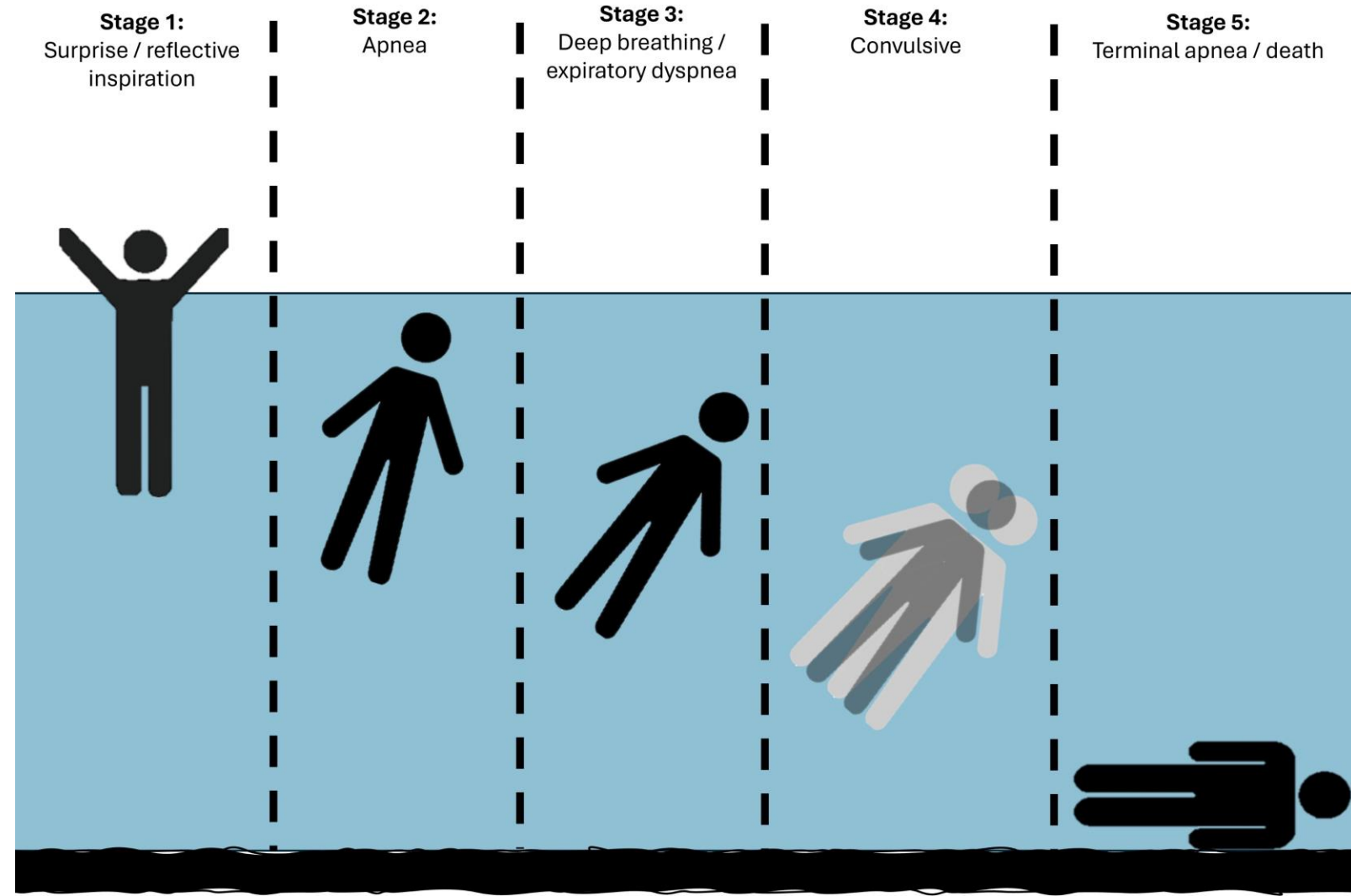
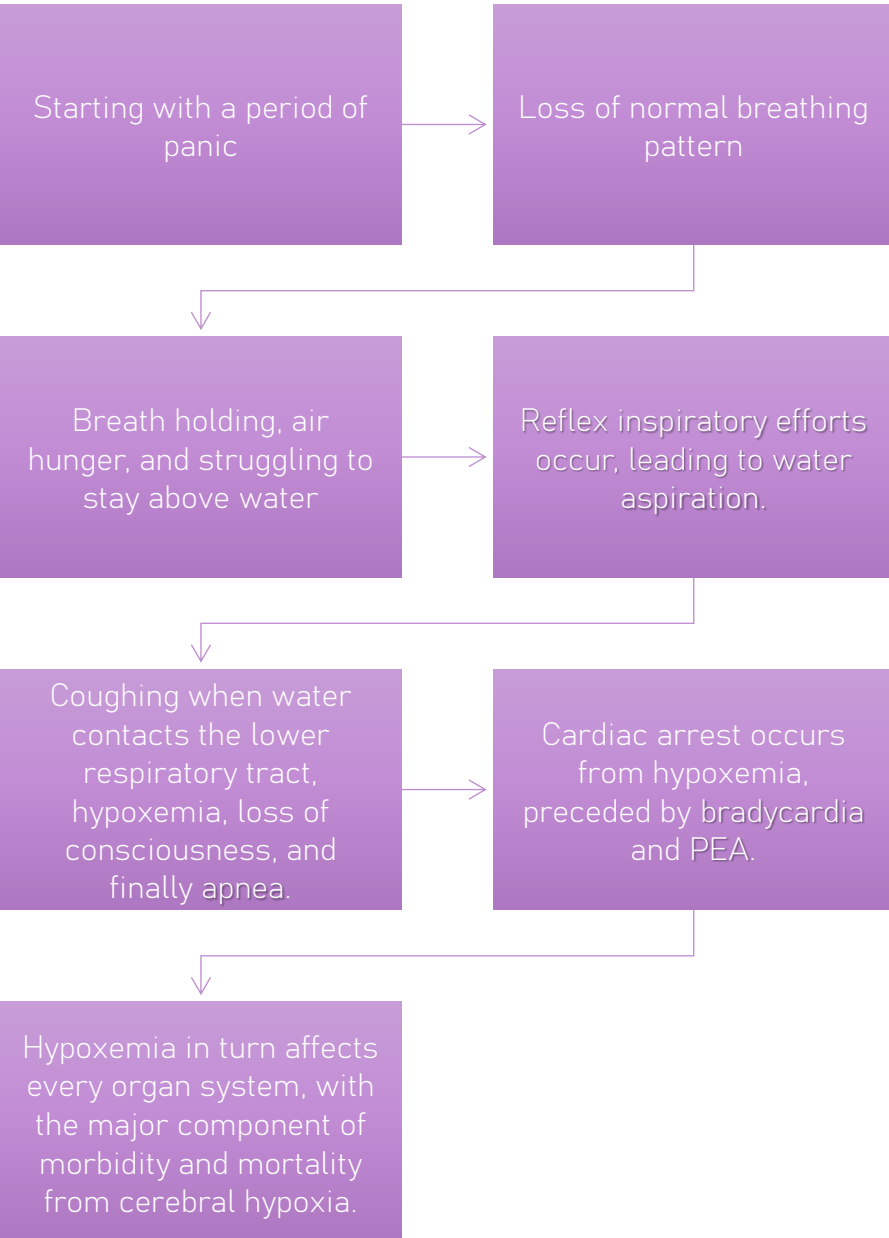
Summer Months

Drugs and alcohol

Case Study 1

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- What is the mechanism of death?

General Mechanism



Water Composition



The composition of aspirated fluid is less important than the quantity.



Aspiration of 1 to 3 mL/Kg of liquid compromises the function of pulmonary surfactant and leads to respiratory compromise and hypoxemia.

Water Composition



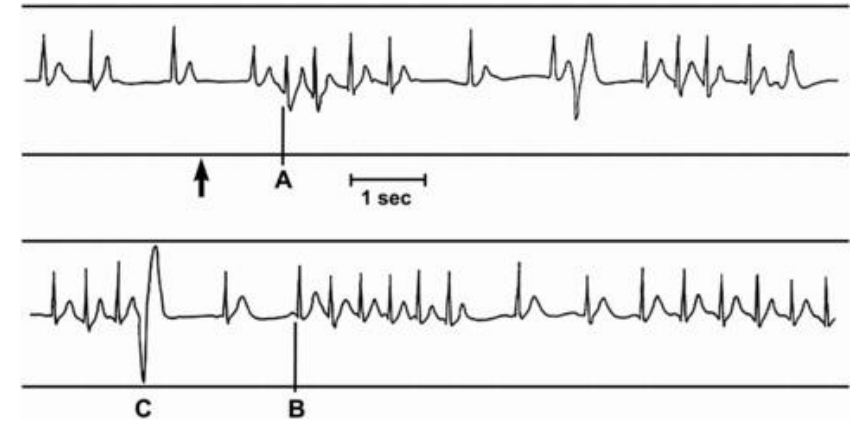
Temperature: cold water can cause ventricular dysrhythmia



Tonicity: salt water cardiac arrest seemingly has worse outcomes.



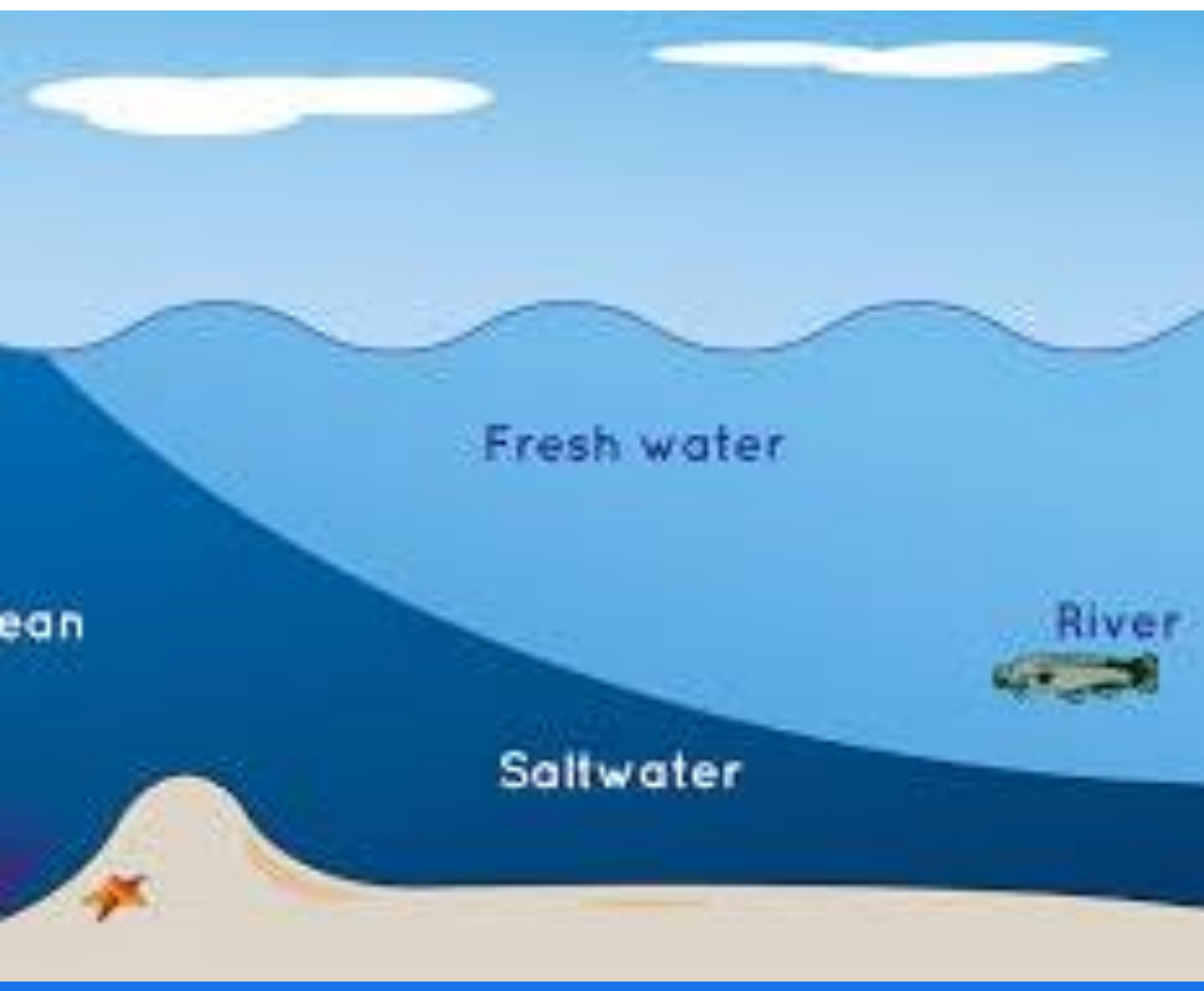
Contamination: increases risk of infection and sepsis.



Classification of Drowning

Typical: fresh and
salt water

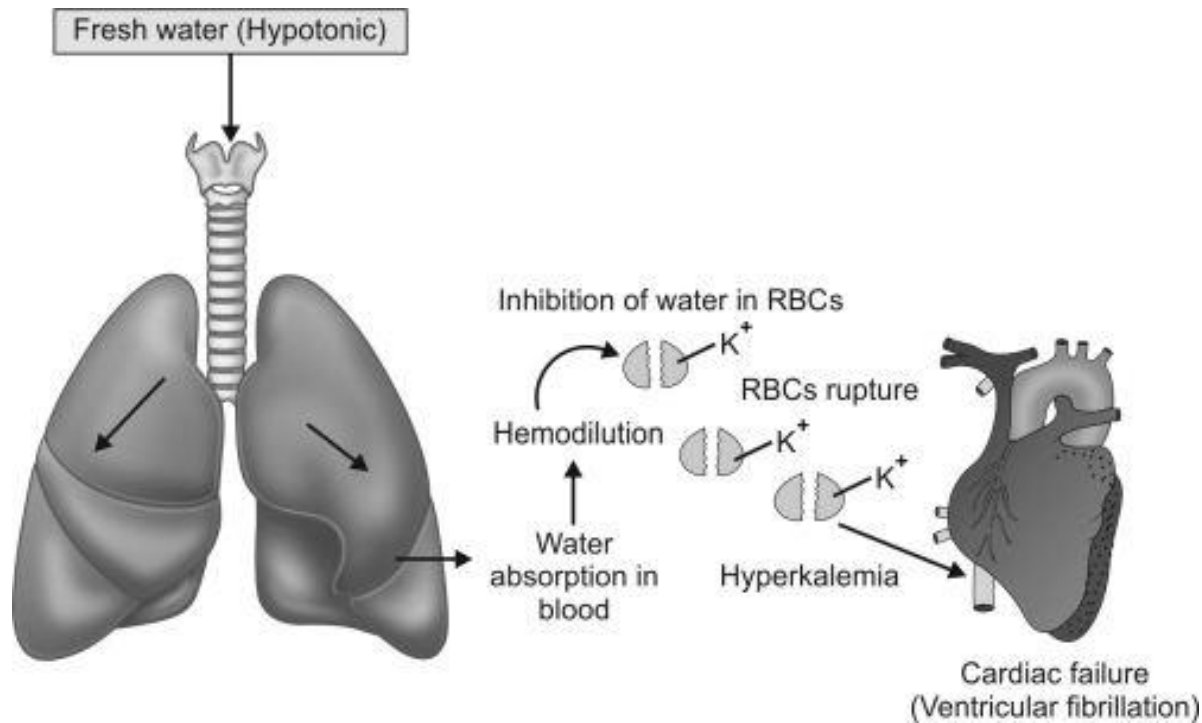
Atypical: dry
drowning, immersion
syndrome, secondary
drowning, shallow
water drowning.



1. Typical Drowning

- a. Freshwater drowning
- b. Salted/ sea water drowning

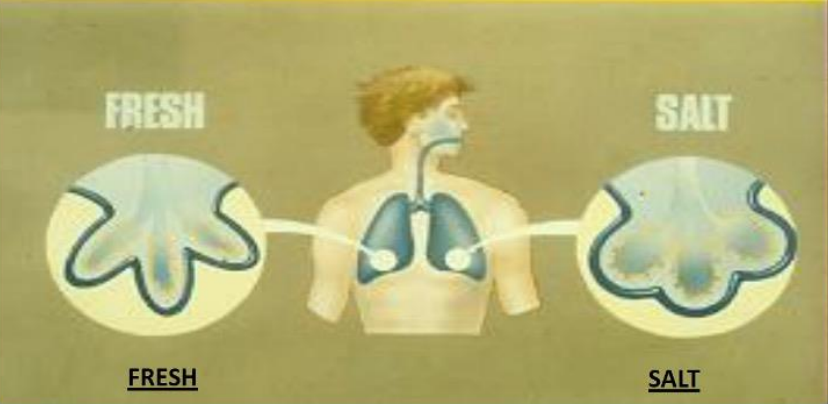
a. Freshwater Drowning



- Freshwater drowning: freshwater enters the alveoli, since it's a hypotonic solution; it passes through the alveolar wall to circulation by osmotic forces → hemodilution, hemolysis, resulting in hyperkalemia, cardiac arrhythmias and thus ventricular fibrillation and death.

b. Salted/ Sea Water Drowning

Fresh and Salt Water Drowning



FRESH

Some residual fluid, or collapsed alveoli. Surfactant diluted or washed out, leading to alveolar collapse, poor ventilation / perfusion, pulmonary shunt.

SALT

Some residual fluid early; later fluid filled as hyperosmotic fluid causes transudation of fluid into the alveoli. Alveolar membrane damage, inflammatory reaction: reactive exudate.

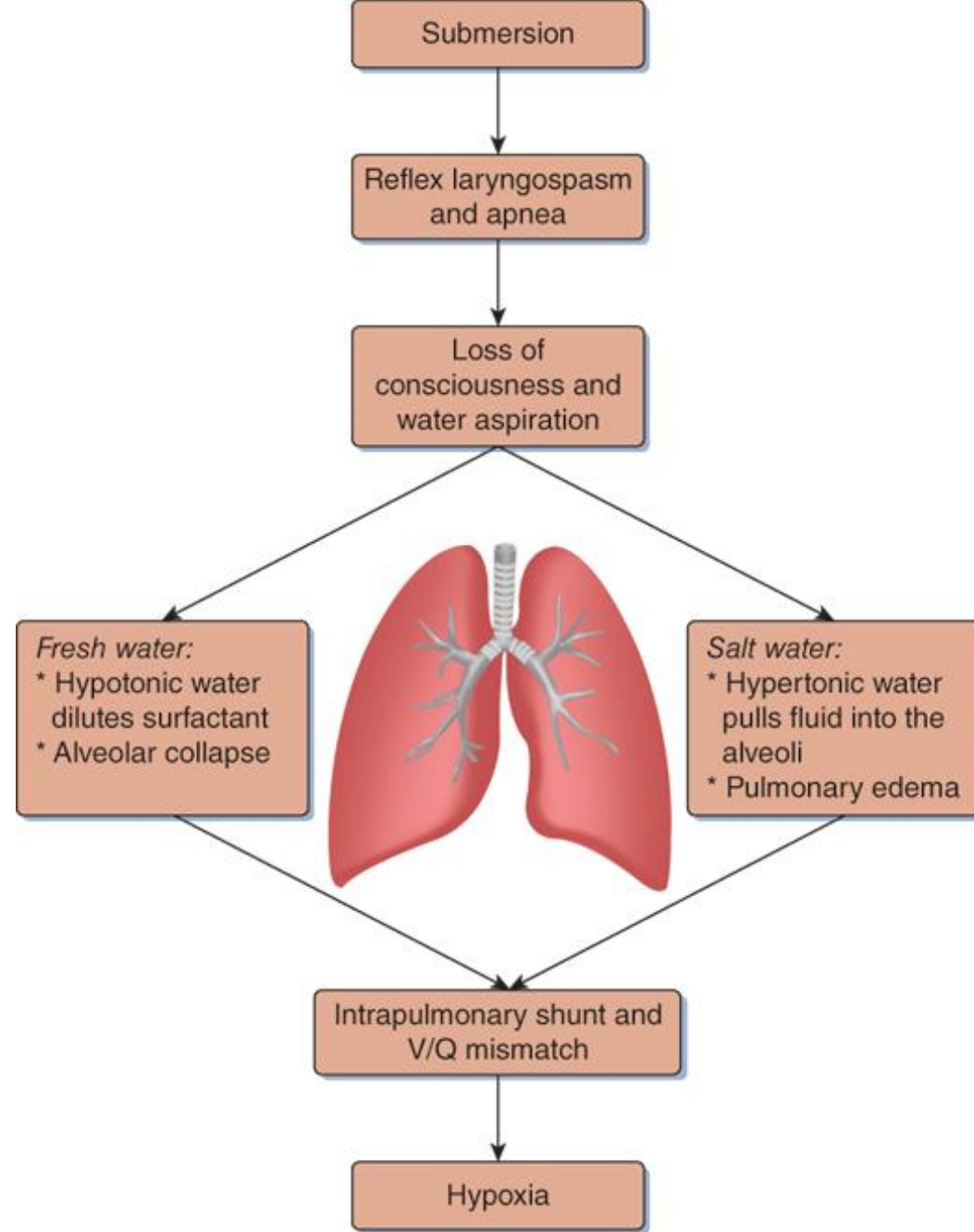
Right to left shunt: Hypoxaemia

↓ PaO_2 ↑ PaCO_2 ↓ pH

Right to left shunt: Hypoxaemia

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- Salted/ sea water drowning: aspiration of hypertonic water results in the withdrawal of water from the pulmonary circulation into the alveolar spaces as result of osmotic forces. Leading to pulmonary edema and death.



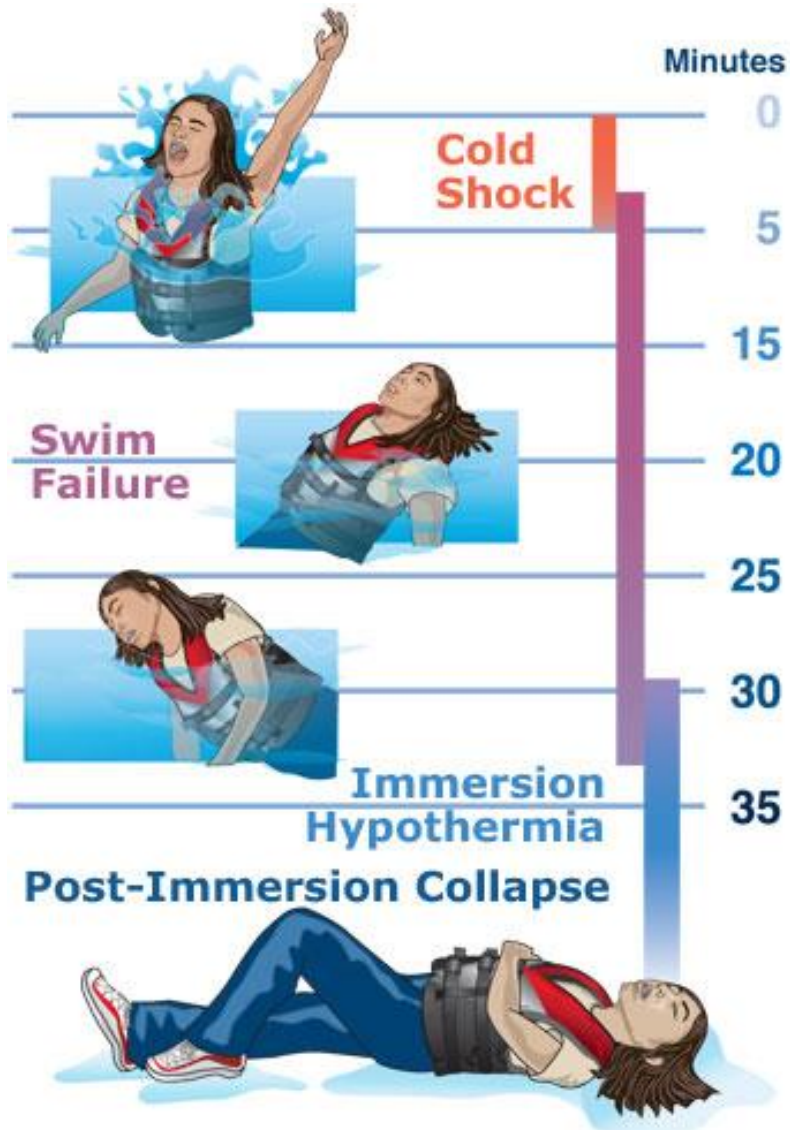
2. Atypical Drowning

- a. Dry drowning
- b. Immersion Syndrome
- c. Near drowning
- d. Shallow water drowning



a. Dry Drowning

- water does not enter the lungs but instead causes laryngeal spasm / cardiac arrest induced by small amounts of water entering the larynx. Autopsy findings and tests for drowning are negative, and the lung fields are dry.



b. Immersion Syndrome

- vasovagal reflex that leads to cardiac arrest due to sudden immersion in cold water (less than body temperature by 5 c) The resultant loss of consciousness leads to secondary drowning, common among middle-aged alcoholic men.

c. Near Drowning

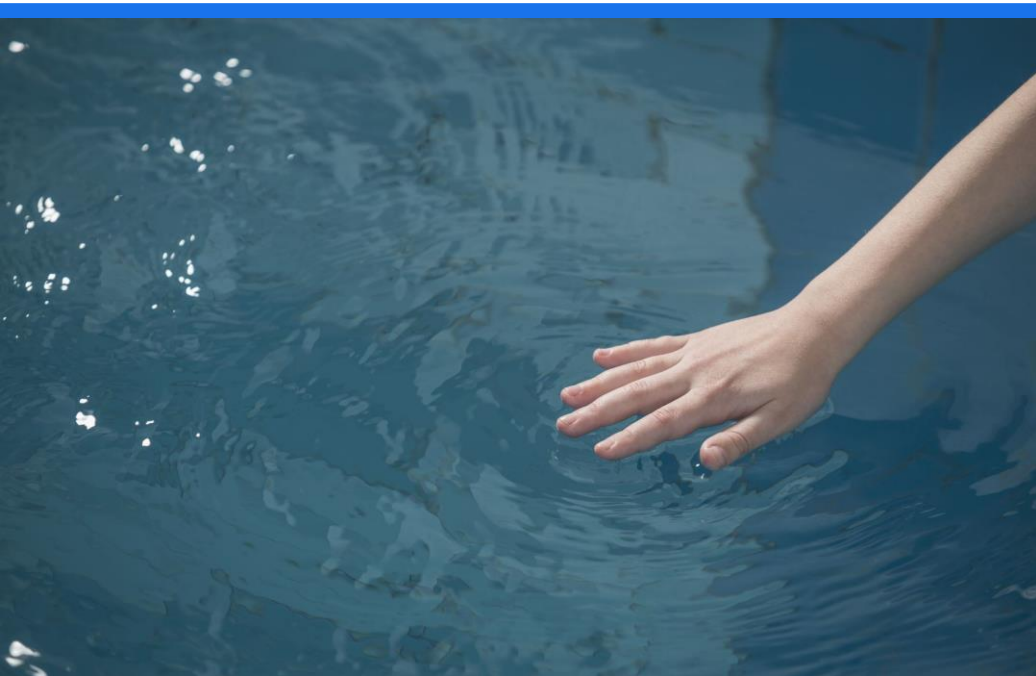
Clinical Features	Patients (N = 144)
Pre-hospital cardiac arrest	61 (41%)
Lactic acidosis	108 (75%)
Consciousness impairment	84 (58%)
Acute respiratory failure	77 (54%)
Cardiovascular failure	37 (27%)
Early onset bacterial pneumonia	35 (24%)
Acute respiratory distress syndrome	23 (16%)
Death	45 (31%)

- Near drowning: (post immersion syndrome) survival beyond 24hrs, death happen due to complications (ARDS, DIC, hypoxia induced encephalopathy)



d. Shallow Drowning

- Shallow water drowning: submersion of the unconscious (alcoholics, drugged, epileptic) in shallow water, in a pit ,or drain.



Fatal Period and Treatment

Symptoms:

- Mental confusion
- Auditory and visual hallucinations
- Tinnitus
- Vertigo
- Chest pain in wet drowning

Treatment:

- Application of artificial respiration with closed chest cardiac massage
- Defibrillator in Ventricular fibrillation

Fatal period:

- Fresh water drowning: 4-5mins
- Sea water drowning: 8-12mins



Postmortem Exam

Facial Changes:

- Pale
- Cyanosed
- Bloated



Postmortem Exam

Eye Changes:

- found half opened half closed



Postmortem Exam

Tongue Changes:

- maybe swollen and protruded

Postmortem Exam



PM Staining:

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



Postmortem Exam

Froth:

- external foam
- fine white and odorless, reflecting mixture of air water and mucus due to forcible respiration during drowning.



Postmortem Exam

RIGOR MORTIS

Postmortem Exam

GOOSEBUMPS



Postmortem Exam

Injuries:

- fall into the water, along the tank, or by striking against a hard object while diving in shallow water. Examination of blunt injury when drying.





Postmortem Exam

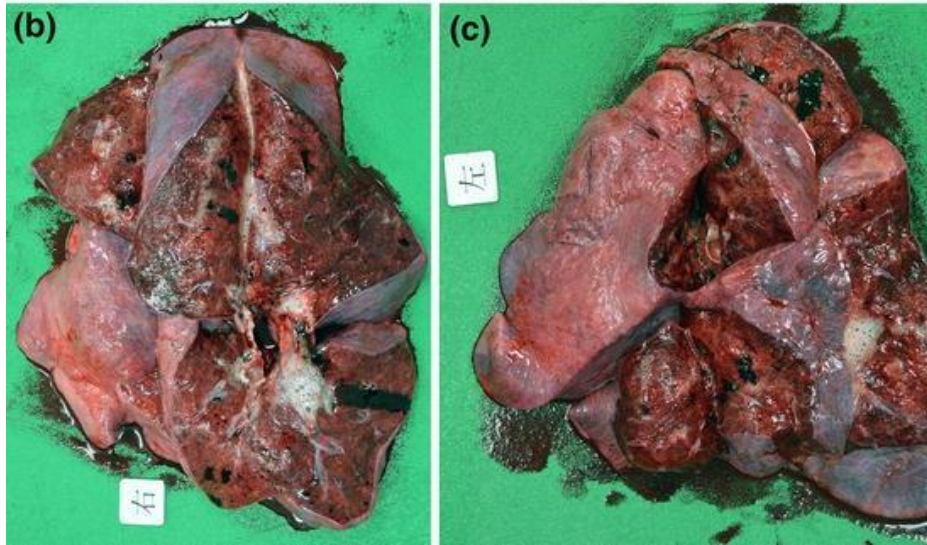
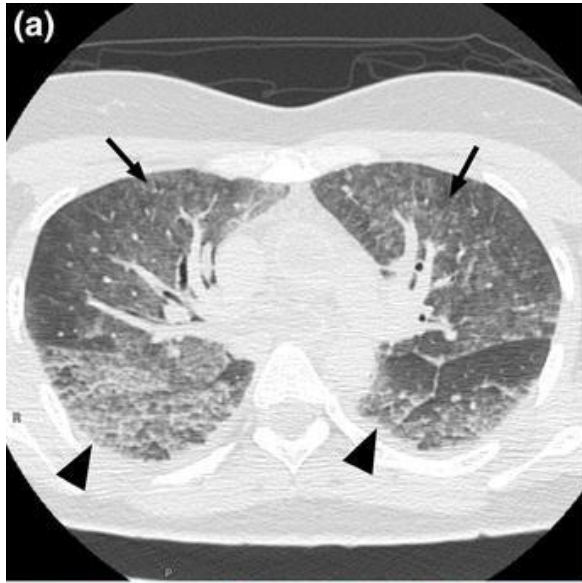
CADAVERIC SPASM WITH MUD ,SAND ,AQUATIC VEGETATION, GRASS, GRAVEL, OR WEEDS (VITAL PROOF OF ANTEMORTEM DROWNING)

Postmortem Exam

Washerwomen hand

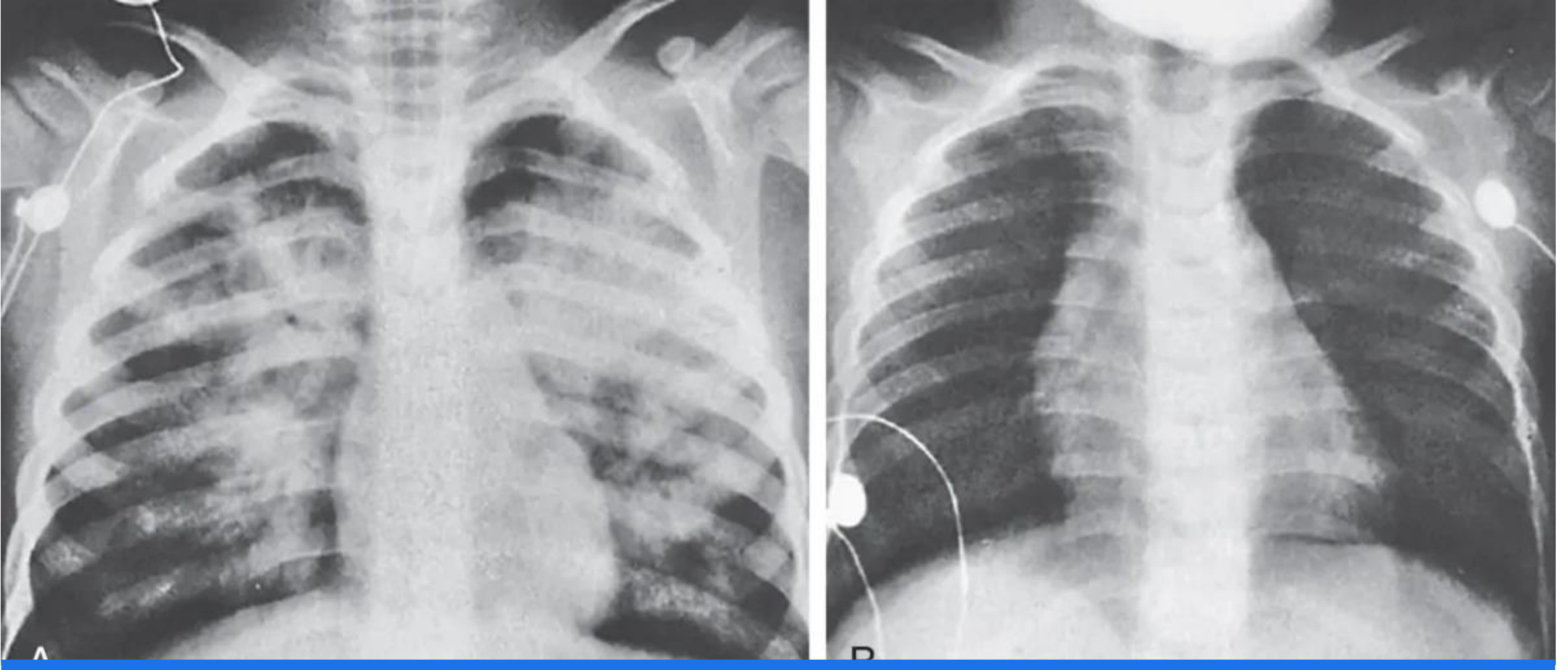
- wrinkling of the skin , skin becomes sodden thicken and white in color)
bleaching of the cuticle is quite evident after 12 hours of immersion (due to osmotic action of water on thickened epidermis





Postmortem Internal Findings

- Lungs are voluminous
- Distended and show ballooning, i.e. bulge out of the chest on removal of sternum



Postmortem Internal Findings

- Lung:-emphysema aquasum: wet drowning hyper expanded and waterlogged lungs . Rib imprints may be present on the surface of lungs

Postmortem Internal Findings

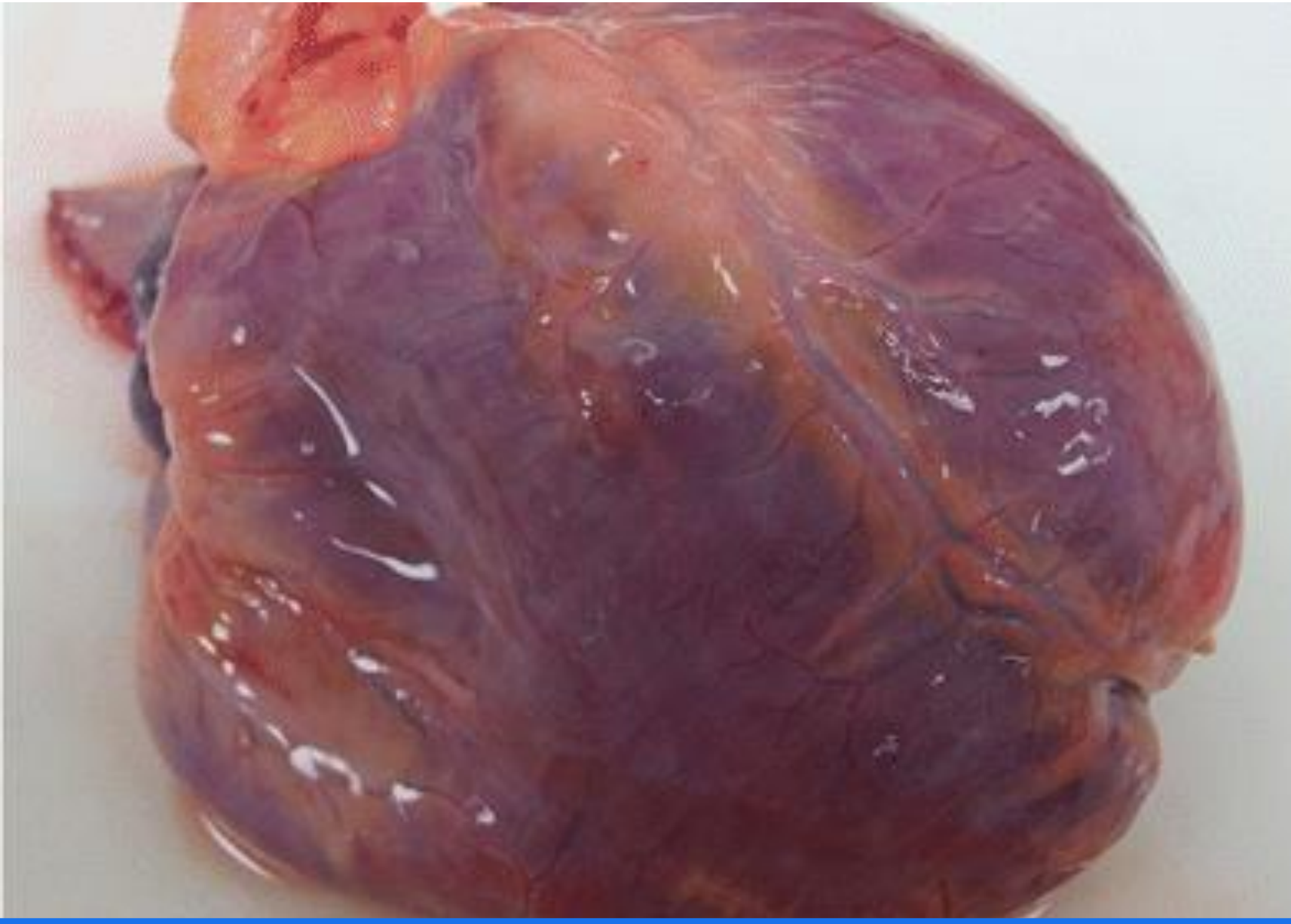
- Paltauf's hemorrhage: mottled areas of red and gray distended alveoli (reflects intra-alveolar hemorrhages)



Postmortem Internal Findings

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





Postmortem Internal Findings

- 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.

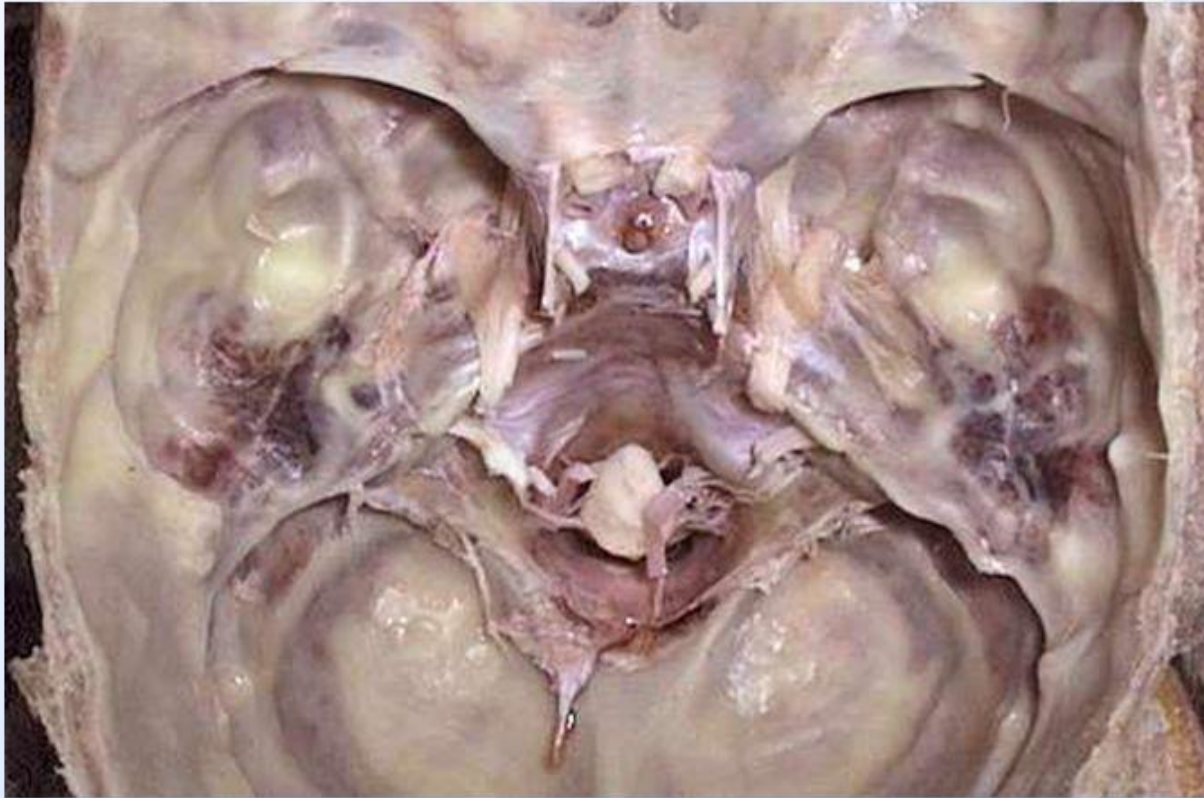
Postmortem Internal Findings

Gettler test: 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.



Drowning: Middle ear hemorrhage.

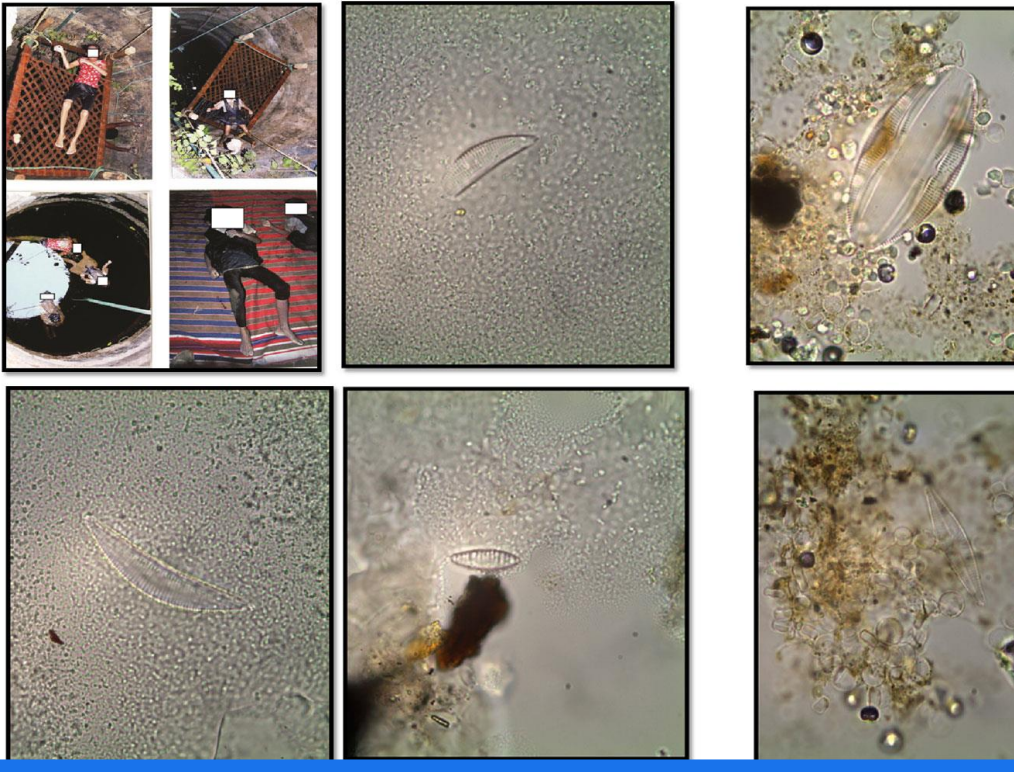


Postmortem Internal Findings

- Hemorrhages in the middle ear and mastoid air cells

Postmortem Internal Findings

- **Diatom test:** Diatoms belong to the class Bacillario-phyceae and are microscopic unicellular algae that secrete silicon skeletons called frustules (They are chemically inert and almost indestructible, being resistant to strong acids. During drowning, diatoms (size up to 60 enter the circulation via the lungs through the ruptured alveolar walls, lymph channels and pulmonary veins into left heart and then into general circulation) when the person is alive.
- 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. The test is negative in dead bodies thrown in the water and in dry drowning.



Medicolegal Aspect

Differentiation 10.4: Antemortem drowning and postmortem submersion

S.No.	Feature	Antemortem drowning	Postmortem submersion
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

- Whether death was due to drowning
- Whether drowning was accidental, suicidal or homicidal (new-born , infanticide)
- Duration of submersion in water