Drowning

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Terminology:

- ***Drowning*** **is the process of experiencing respiratory impairment from submersion or immersion in liquid.**

- ***Fatal drowning:*** A drowning event with a fatal outcome.

- ***Non-fatal drowning:*** A drowning event in which the process of respiratory impairment is stopped before death, and the victim survives. According to the WHO it was defiened based on the severity of respiratory impairment immediately after the drowning process has stopped into:

✓ - **Mild impairment**: Breathing, involuntary distressed coughing and fully alert

✓ - **Moderate impairment**: Difficulty breathing and/or disoriented but conscious

✓ - **Severe impairment:** Not breathing and/or unconscious

Epidemiology

- Drowning is a common cause of **accidental death** in the United States (US) and a prominent cause of childhood fatalities worldwide, especially children **under five years** of age in states where swimming pools or 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, Jarash, 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**

Risk factors

01

Males

02

Young and children

03

Summer months

04

Drugs and alcoholics

General mechanism

- ✓ Starting with a period of panic.
- ✓ loss of the normal breathing pattern.
- ✓ breath-holding, air hunger, and struggling to stay above the water.
- ✓ Reflex inspiratory efforts eventually occur, leading to aspiration of water
- ✓ coughing when water contacts the lower respiratory tract, and within minutes, hypoxemia, loss of consciousness, followed by apnea.
- ✓ Cardiac arrest occurs from hypoxemia and is preceded by bradycardia and pulseless electrical activity rather than a ventricular dysrhythmia.
- ✓ Hypoxemia in turn affects every organ system, with the major component of morbidity and mortality from cerebral hypoxia.

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Water composition

temperature

Cold water can cause ventricular dysrhythmia

Tonicity

Salt water results in cardiac arrest seemingly has worse outcomes, although multiple confounders exist

Contamination

Water with high load of pathogens (eg, sewage) increases risk for infection and sepsis

The composition of the 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

Classification:

Typical drowning

Freshwater drowning

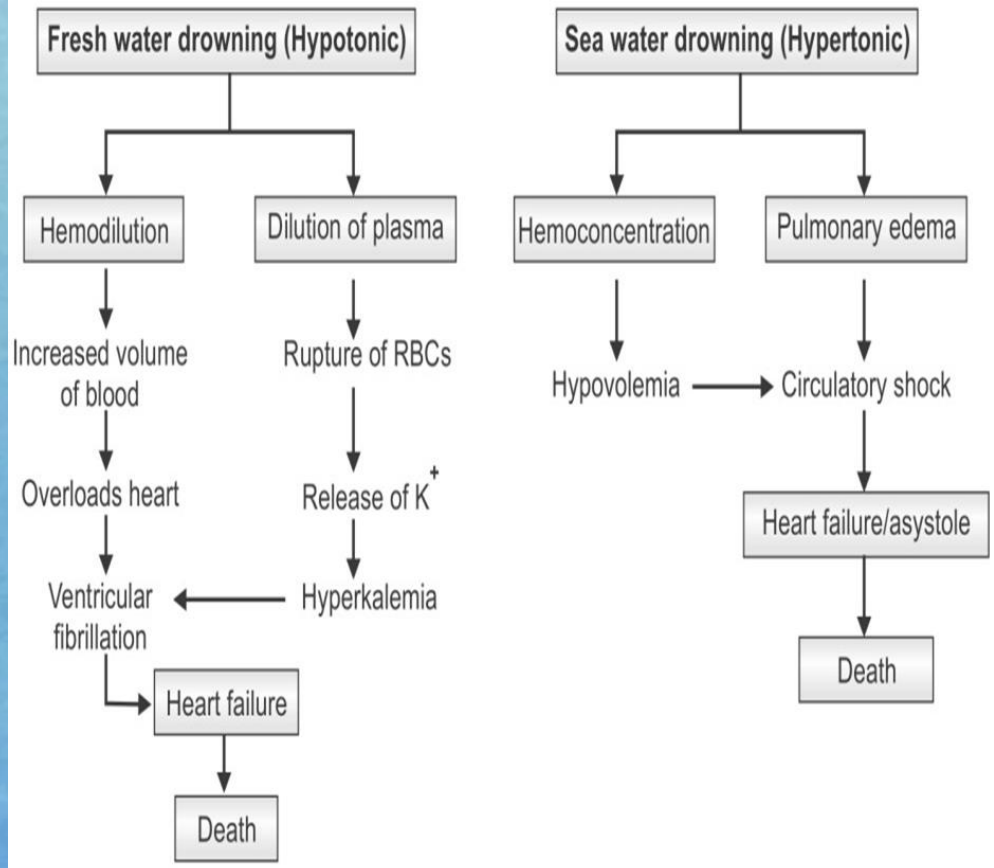
freshwater enters the alveoli which is a **hypotonic solution** that passes through the alveolar wall to circulation by osmosis; which leads to:

hemodilution and thus hemolysis, which results in hyperkalemia with consequences of cardiac arrhythmias and thus ventricular fibrillation and death.

Salted / see water

the aspiration of water results in the withdrawal of water from the pulmonary circulation into the alveolar spaces as a result of the osmotic. leading to pulmonary edema which lead to death.

Flow chart 10.4: Mechanism of fresh and sea water drowning



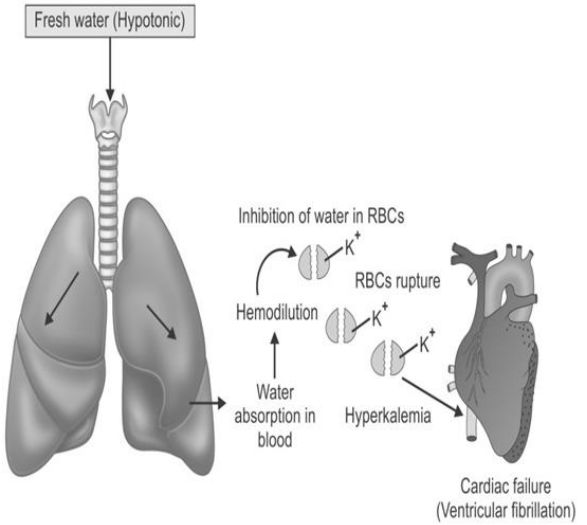
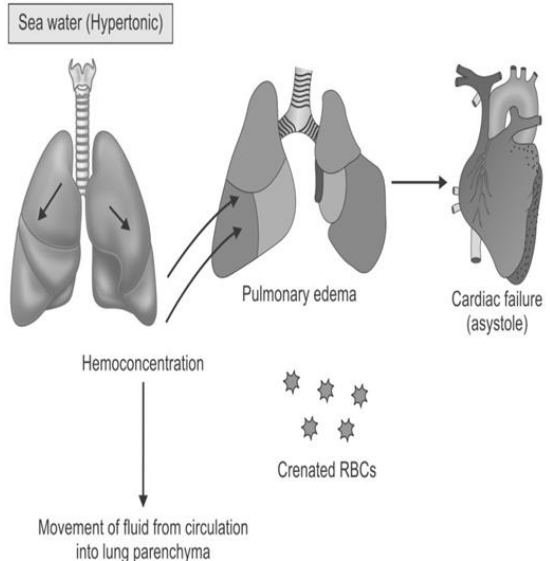


Fig. 10.14: Mechanism of death in fresh water drowning



Atypical drowning

Dry drowning: water does not enter the lungs due to 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.

Immersion syndrome (Hydrocution, submersion inhibition or cold water drowning) : 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.

Atypical drowning

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

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

Phases of drowning

1- breath holding

- Lasts for variable length of time
- Co2 accumulation
- Stimulation of resp centre in brain
- Inevitable inhalation of large volumes of water

2- swallowing of water

- Coughing, vomiting progressive loss of consciousness
- Escape of air remaining in the lungs replaced by water

3- profound un consciousness

- gasping
- Respiratory standstill
- Heart failure
- Irreversible changes in the brain
- death

Causes of death

Vagal inhibition

Due to impact with water

Asphyxia

Most common cause

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 heamorrhage br the rupture of cerebral vessels from sudden on rush of blood to the brain due to excitement or sudden fall from height into cold water

Secondary causes

Due to septic aspiration pneumonia

And

Sudden bursting of aneurysm

Fatal period and treatment

Symptoms: Apart from recalling of memory of past events, there may be mental confusion along with auditory and visual hallucinations, tinnitus and vertigo. In wet drowning, there is chest pain.

Treatment: First and immediate step consists of application of artificial respiration with closed chest cardiac massage, even in absence of pulse and respiration and irrespective of injuries sustained during drowning. Defibrillator should be used when there is ventricular fibrillation.

Fatal period

- Fresh water drowning: 4–5 min.[36]
- Sea water drowning: 8–12 min.

Postmortem exam

Face

Pale ,cyanosed and bloated

Eyes

are found half opened half closed

Tongue

maybe swollen and protruded

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

Froth

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

Rigor mortis (appears early)

Cont

Goosebumps

due to spasm of the erector pili muscles and due to exposure to cold water at the time of death. Skin appears granular and puckered , with hair standing on the end , extremeties mainly affected.

Cadaveric spasm

With mud ,sand ,aquatic vegetation,grass ,gravel,or weeds (vital proof of antemortem drowning)

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.

Washerwomen hand

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


a

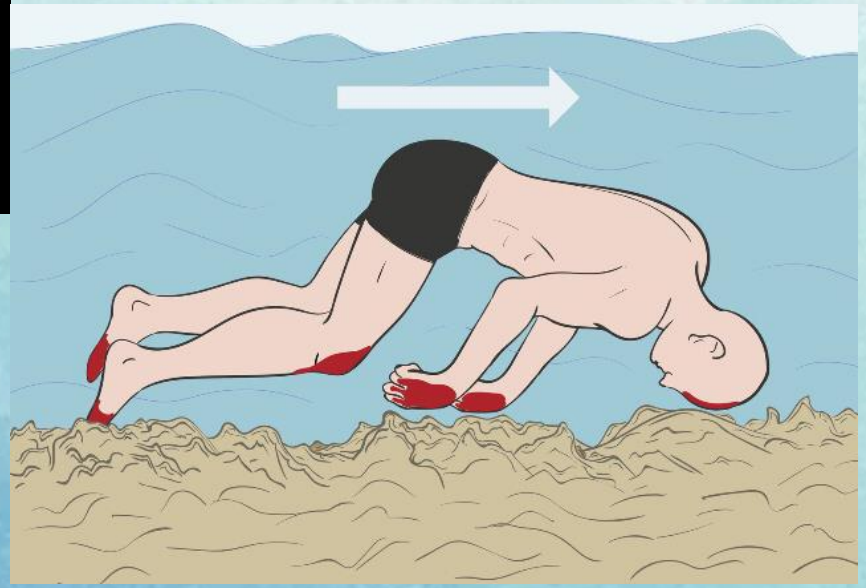

b

Cadaveric spasm:

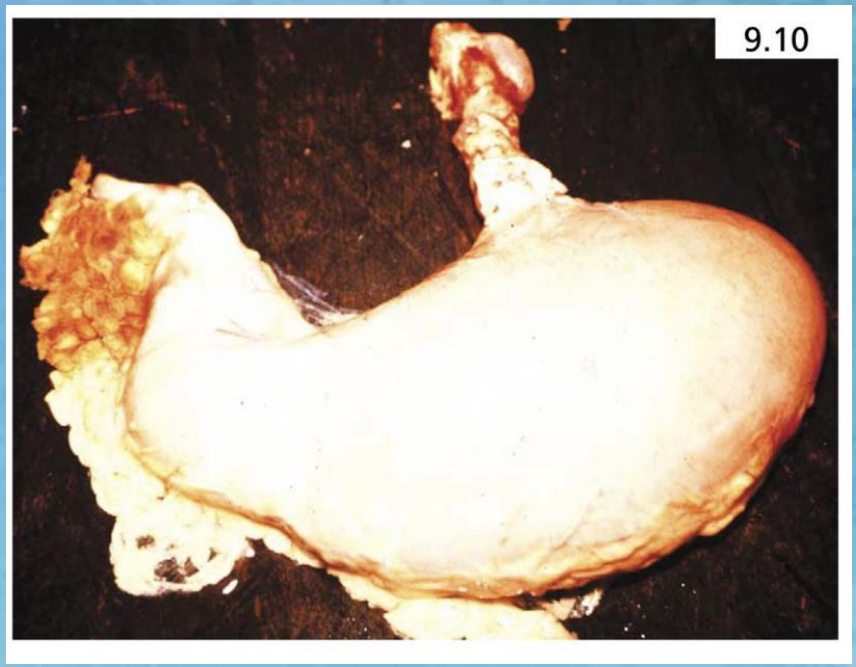
volving the hand (firmly grasping weeds or sands)
dicating the victims was alive when immersed

Cadaveric spasm （ the hand firmly grasp weeds and muds)

Source; bones do not lie （website）



Degloving: 2 weeks

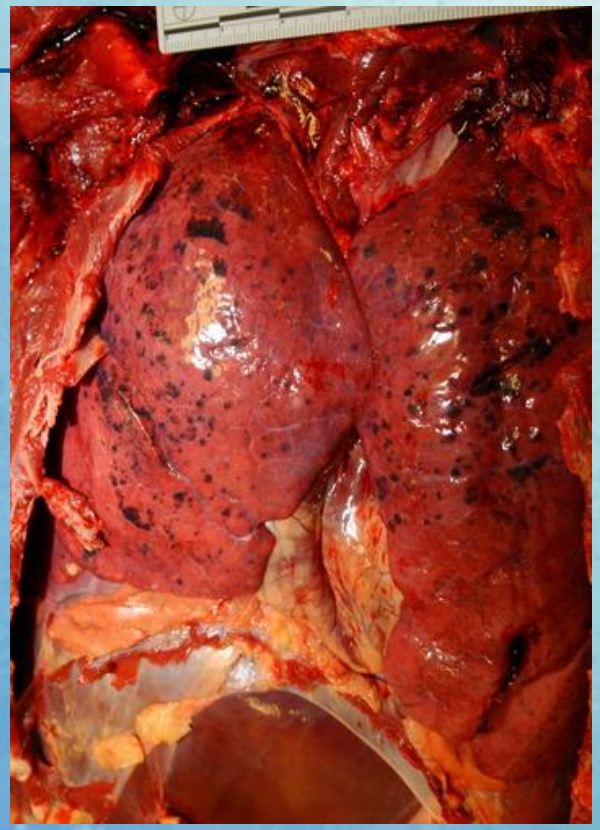


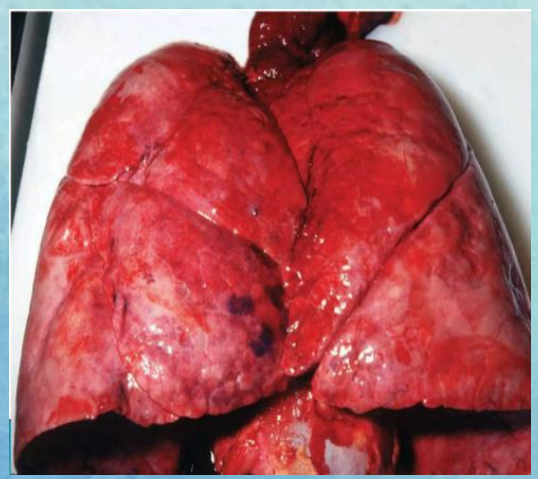
Postmortem internal finding

- Lungs are voluminous, distended and show ballooning, i.e. bulge out of the chest on removal of sternum
- Paltauf's hemorrhage: mottled areas of red and gray distended alveoli (reflects intraalveolar hemorrhages)
- Lung:- emphysem a aquasum: wet drowning hyper expanded and waterlogged lungs . Rib imprints may be present on the surface of lungs
- larynx, trachea, and bronchioles: The presence of sand, mud, slit, dirt, aquatic vegetations, classical water for a, algae, and diatoms in the trachea and lower bronchial tree are characteristic positive findings of antemortem drowning.

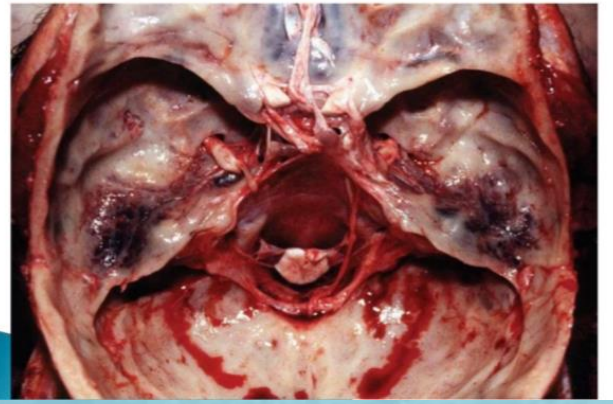
Cont

- heart and blood vessels: Like in other forms of asphyxia, left side of heart will be usually empty; the right heart will be full with the venous system engorged with dark blood, unusually fluid in consistency because of admixture with water.
- Gettler test: Normally, the chloride content of theright 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
- Hemorrhages in the middle ear and mastoid air cells



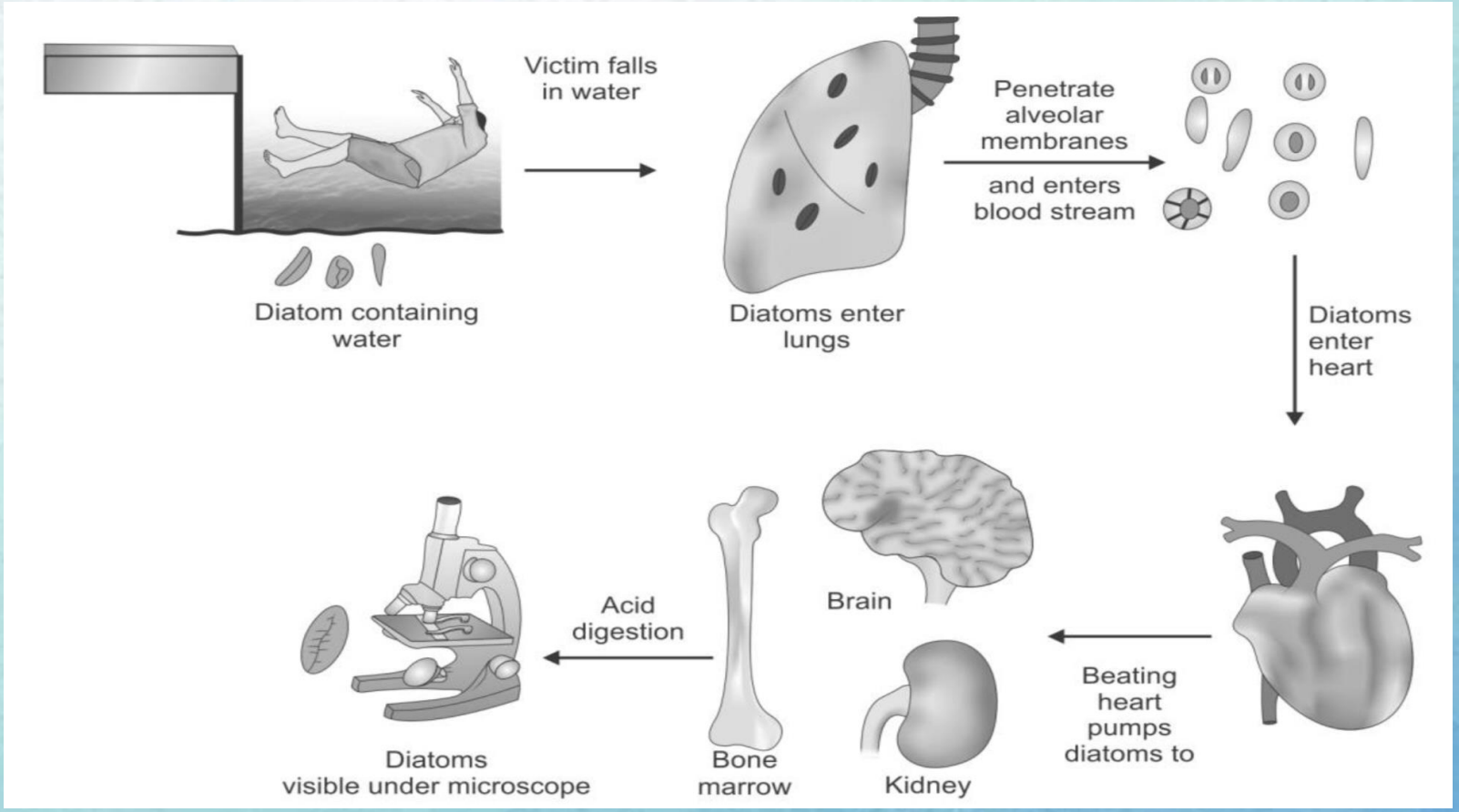


Bilateral haemorrhages within the petrous temporal bones in drowning

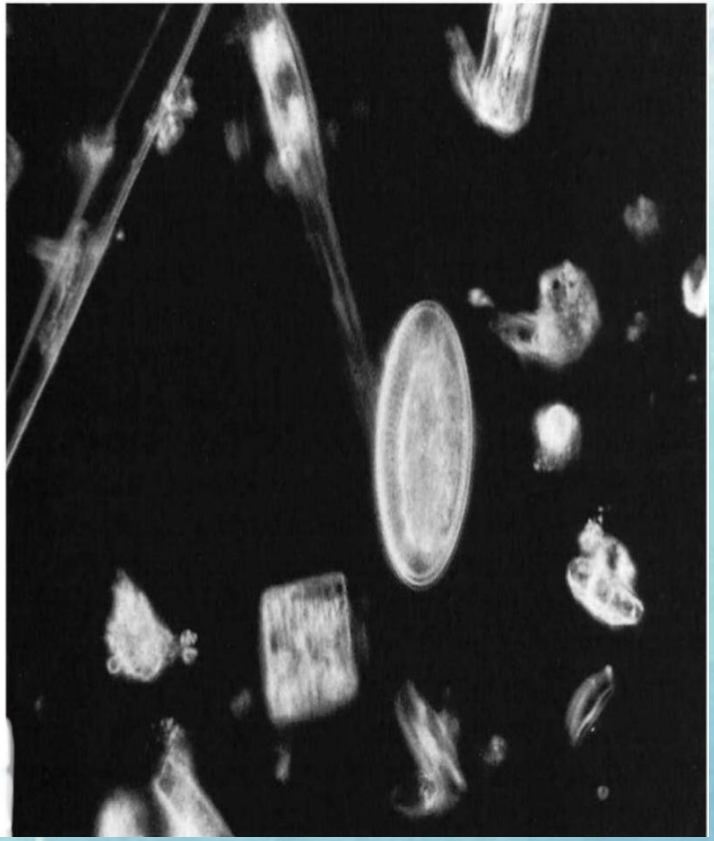


Cont

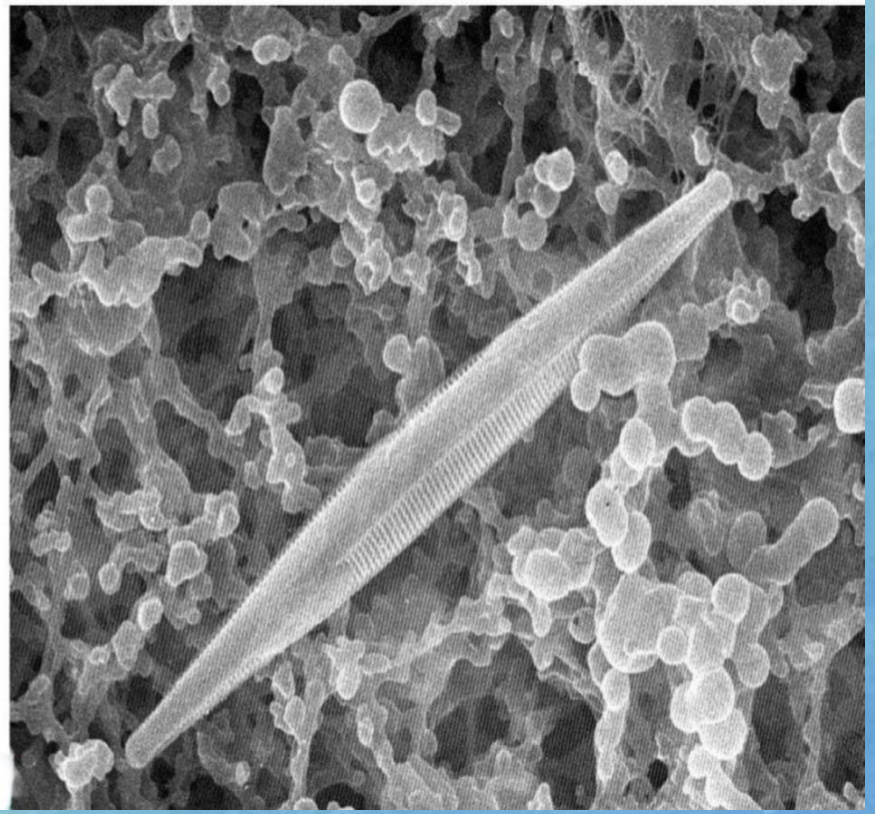
- Diatom test: Diatoms belong to the class Bacillario- phyceae, and are microscopic unicellular algae that secrete silicon skeletons called frustules(ig.They are chemically inert and almost indestructible, being resistant to strong acids. During drowning, diatoms (size up to 60 enter the circulation 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.


Victim falls in water
Diatom containing water
Diatoms enter lungs
Penetrate alveolar membranes
and enters blood stream
Diatoms enter heart
Beating heart pumps diatoms to
Brain
Kidney
Bone marrow
Acid digestion
Diatoms visible under microscope

Diatoms seen under dark-ground illumination



Scanning electron micrograph of a diatom



Medicolegal aspect

- Whether death was due to drowning?Whether drowning was accidental, suicidal or homicidal (neoborn , infanticide)duration of submersion in water

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 clothing, mud and sand	Water is never present in middle ear; others are not valuable and corroborative findings

Thank you